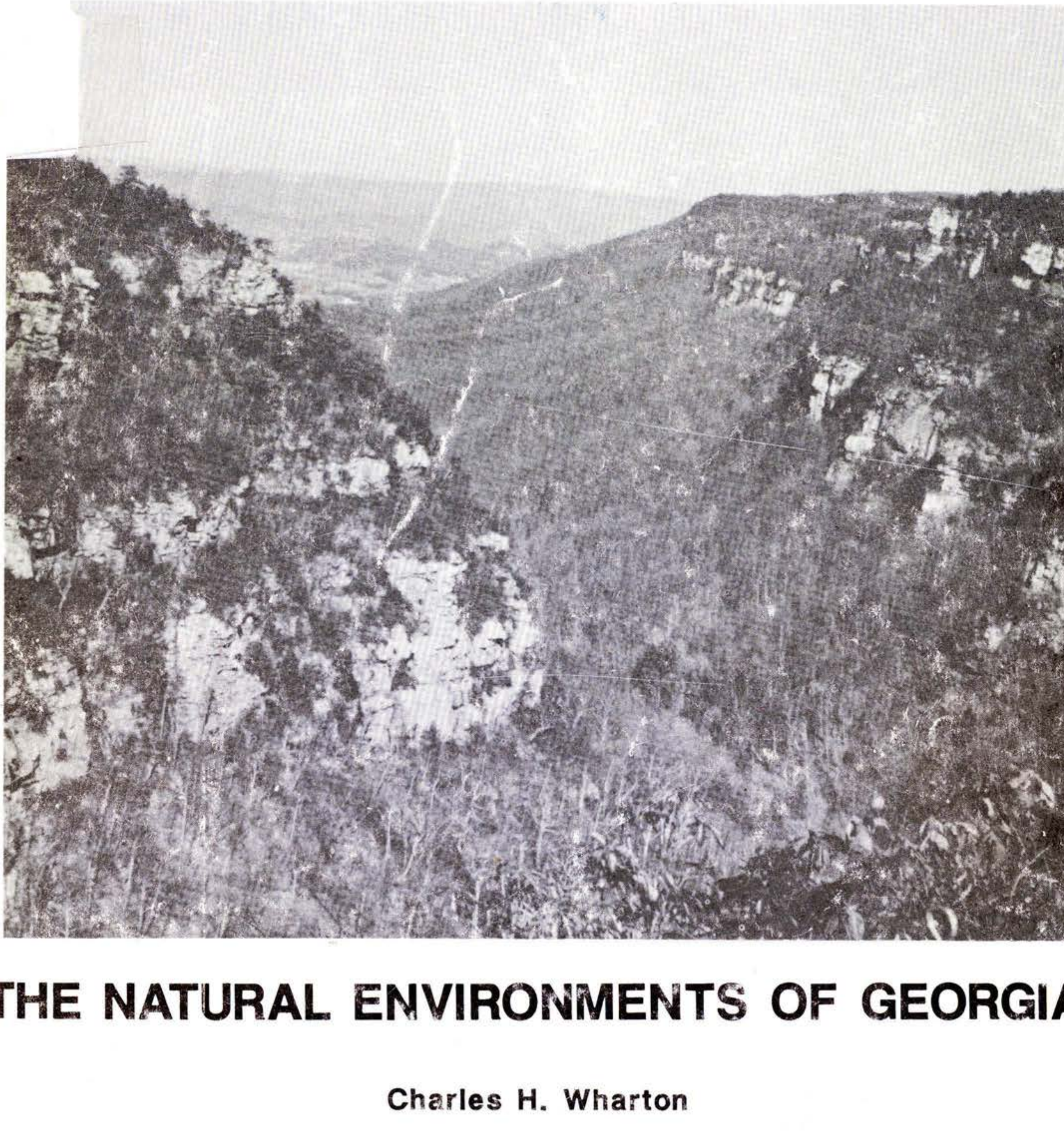

# THE NATURAL ENVIRONMENTS OF GEORGIA

Charles H. Wharton

DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION
GEORGIA GEOLOGIC SURVEY

BULLETIN 114

# THE NATURAL ENVIRONMENTS OF GEORGIA

*By*

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# The Natural Environments of Georgia

## PREFACE

Almost three years ago the Department of Natural Resources (DNR) recognized that as a part of our stewardship of Georgia's natural resources a study such as *The Natural Environments of Georgia* was needed. Although many persons and institutions had not only longed for such comprehensive information, but had already gathered many of the necessary pieces, to date, there had been no attempt to look in some detail at the State as a whole and to both classify and define the various natural environments. While much had been done, it was still a very large undertaking to get all the information in one place, reformat it for compatibility and uniformity and then attempt to fill in the many gaps. According to our best information, Georgia is one of the first states in the country to undertake such a project.

DNR cannot take credit for the actual product. While it is a DNR sponsored project, it is not a DNR document. Dr. Wharton has been given a free hand. The document or parts of it have been reviewed by some professional people in DNR but it has not been subjected to any type of official, detailed departmental review. Consequently, all personal observations and editorial comments are those of Dr. Wharton or a quoted source and do not necessarily reflect the position, opinion or policies of the DNR. As Dr. Wharton has often said, classification schemes could be done in as many different ways as there are competent people to devise them. This study represents but one logical approach.

Even though it has taken several years to put this document together, it is not "finished." It probably never will be. New information is forthcoming daily from the scientific community which will allow for a better and more detailed job to be done. This new work needs to be included. Realistically however, there comes a point at which one just has to stop and go to press. We have had to do this here, but I believe have produced at a minimum a workable classification that can be modified in the months and years to come. We have taken the first step and hopefully have provided a framework within which other studies can be set.

James R. Wilson
Chief, Resource Planning Section
OPR, DNR

**COVER PHOTO — Cloudland Canyon is a gorge eroded in the west side of Lookout Mountain (Dade County). Its perpendicular sandstone cliffs have ledges where shortleaf and Virginia pines obtain a precarious foothold. Moist talus slopes and ravines (45) support mesic forest with hemlock near streams. Oddly, catawba rhododendron *(Rhododendron catawbiense)* occurs here in the ecological niche filled by rosebay rhododendron in the Blue Ridge.**

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# INTRODUCTION

Recognition of plants, animals, and environments is basic to human survival.* Classification of local environments is necessary for a statewide inventory. Presenting nature's organization is critical for teachers and the public alike. I have attempted to define *natural* environments, as opposed to those created (cities) or altered (fields, tree farms) by man. Only a few environments (some high mountain forests, and coastal salt marsh, and some rock outcrops) probably appear much as they have always been. Hardwood forested floodplains, some sand hills, and some mountain slope forests appear nearly original in the kinds of life they support.

Urban life is dependent upon some environments for waste disposal, pure water, minerals, food and commercial products, as well as education and recreation, so called "life support" functions.

Odum and Odum (1972) estimate that at least one-half of Georgia must be kept in an undeveloped condition if we are to maintain the quality of our life. After an area becomes 50% developed, it begins to destroy the irreplaceable life-support work done by natural systems which surround it. Natural systems have performed much work for us, free and unnoticed, Odum (1973) states, "Even in urban areas, more than half of the useful work on which our society is based comes from the natural flows of sun, wind, waters, waves, etc., which act without money payment. An economy must maximize its use of these energies to compete and survive, not destroy their enormous free subsidies." Wholesale alterations of certain environments are now possible with modern technology. The long term loss from the destruction of an irreplaceable natural system must be weighed against the often temporary gains of substituting an artificial one. To change from a society based on growth and economic expansion to one of survival based upon a steady state, our dependence on the free work of nature will increase. Natural environments can no longer be regarded as simply outdoor curiosities, samples of which should be preserved, but as very necessary natural allies to our needs.

Certain environments should receive top priority in inventory mapping and protection. Some, like hardwood ridges, ponds and Carolina Bays, can be located by satellite photography, but most will require special efforts to locate.

Fig. 1. A PHYSIOGRAPHIC CLASSIFICATION AND MAP OF GEORGIA.

- APPALACHIAN HIGHLANDS
  - SEDIMENTARY REGION
    - APPALACHIAN PLATEAU PROVINCE
      - A CUMBERLAND PLATEAU
    - RIDGE AND VALLEY PROVINCE
      - D CHICKAMAUGA VALLEY
      - E ARMUCHEE RIDGES
      - F GREAT VALLEY
  - METAMORPHIC REGION
    - BLUE RIDGE PROVINCE
      - B BLUE RIDGE
      - C COHUTTAS
      - G TALLADEGA UPLANDS
    - PIEDMONT PROVINCE
      - H UPLAND (Includes Cherokee, Dahlonega, Central Uplands, and Hightower-Jasper Ridges)
      - I PINE MOUNTAIN RIDGES
      - J MIDLAND (Includes Winder, Washington and Greenville slopes)
      - K GAINESVILLE RIDGES
- ATLANTIC PLAIN
  - COASTAL PLAIN PROVINCE
    - L FALL LINE SANDHILLS
    - M1 FALL LINE RED HILLS
    - M2 FORT VALLEY PLATEAU
    - O TIFTON UPLAND (Miocene)
      - 01 TIFTON UPLAND
      - 02 VIDALIA UPLAND
    - N LIMESINK REGION
      - N1 DOUGHERTY PLAIN
      - N2 PELHAM ESCARPMENT
    - P TALLAHASSEE HILLS
    - Q VALDOSTA LIMESINK REGION
    - R COASTAL PLAIN MARINE FLATLANDS (Pliocene-Pleistocene)
      - R1 COASTAL MARINE FLATLANDS
      - R2 OKEFENOKEE BASIN
      - R3 TRAIL RIDGE
      - R4 TIDAL MARINE AREA

*The Philippine Hanunoo recognize 93% (nearly 2,000 species) of local plants; insects are grouped in 108 categories and some 461 vertebrate types are named.

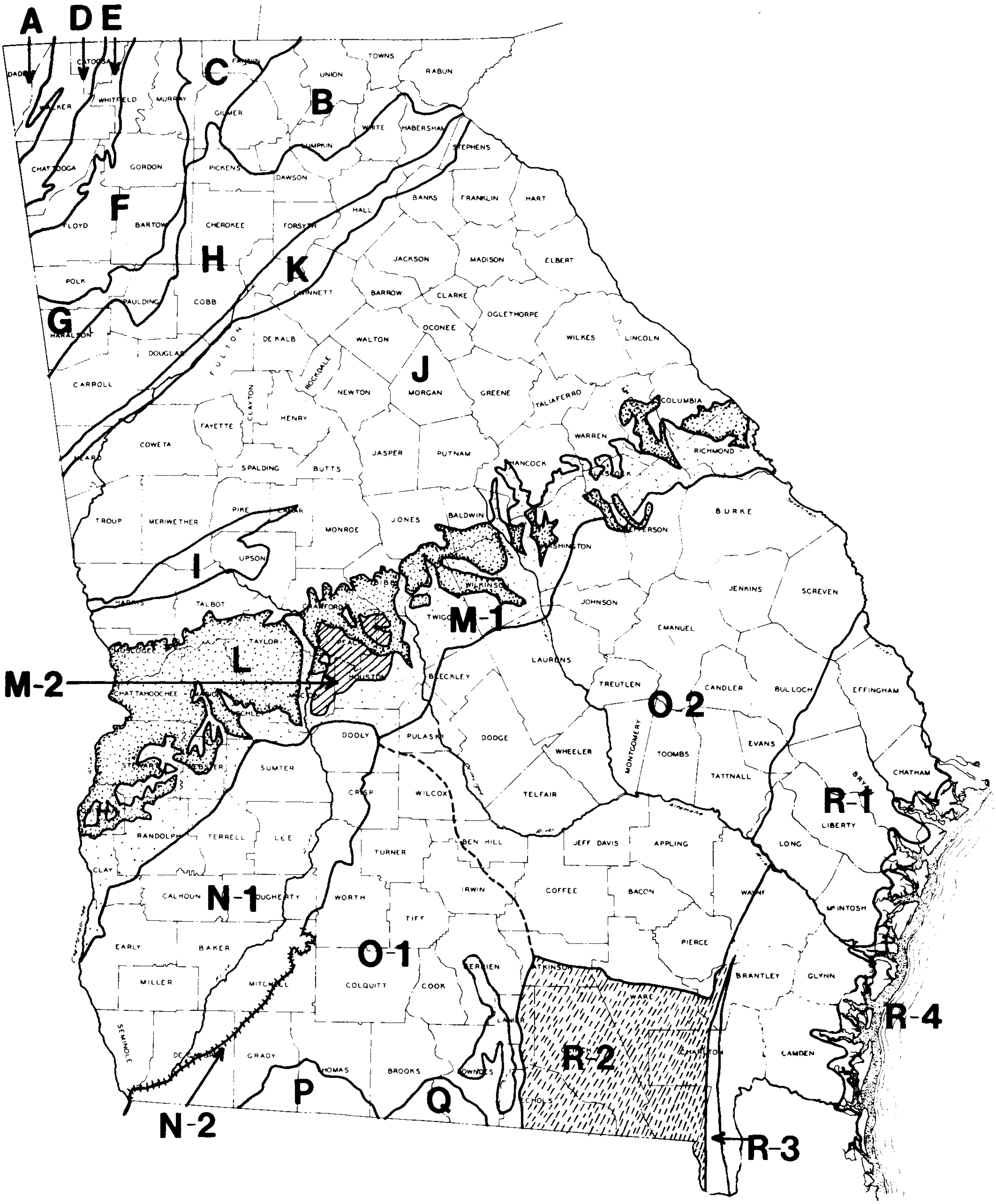


Fig. 1. A physiographic map of Georgia. See facing page for key to symbols.

This study points out the large gaps in our knowledge of these environments. Although one can briefly describe the *structure* of a given environment, our knowledge of its *function* is limited. This is a major reason why scientists suggest halting certain practices which appear to drastically change natural systems.

My goal was to pull together scattered information on geology, soils, hydrology, and biota (most of the information, particularly on soils and fauna, is simply not yet known). Comments on natural values and man's impact have been added. Hopefully, readers will call attention to studies that have been overlooked.

Classification schemes are arbitrary in their semantics and divisions. I have used existing terminology. Starting with the basic work of Braun (1950), Penfound (1952), and Kuchler (1964), and I have added the ideas of many colleagues.

The study is divided into four main parts: (1) the wetlands of the entire state, (2) mountains, terrestrial (3) Piedmont terrestrial and (4) Coastal Plain terrestrial systems.

Figure 1 is a Physiographic Map of Georgia based upon the 1976 USGS Slope Map, the 1976 Geologic Map of Georgia, the USGS Satellite Image Mosaic (1973-74), the 1976 Physiographic Map of Georgia, GSWRD, 1:2,500,000 scale, information from colleagues, and my own observations. Most zones are based on field-visible geology or physiography. The "provinces" only crudely reflect the ecology. For example, one can find in both Piedmont and Coastal Plain north-facing bluffs with a near-mountain flora. In other words, local climate often takes priority over geographic location and often over geology and soils in determining the biotic community, A few synonyms need to be mentioned. I may refer to the Tifton Upland as the "Miocene"* and the coastal sand plain as the "Pleistocene." The Fall Line Sand hills are sometimes referred to as "Cretaceous." These synonyms, so long perpetuated in the literature, are frowned upon by geologists. Miocene should actually be Plio-Miocene (see footnote) and Pleistocene should be Plio-Pleistocene.

I have also reproduced Roland Harper's (1930) regional map, Figure 2. Harper had earlier (1906) published a detailed study of the Tifton Upland which he called "*The Altamaha Grit Region*" and later (see 1930 map) the "Rolling Wire-Grass Country." Still later, Harper (1943) published the *Forests of Alabama* for the Alabama Geological Survey.

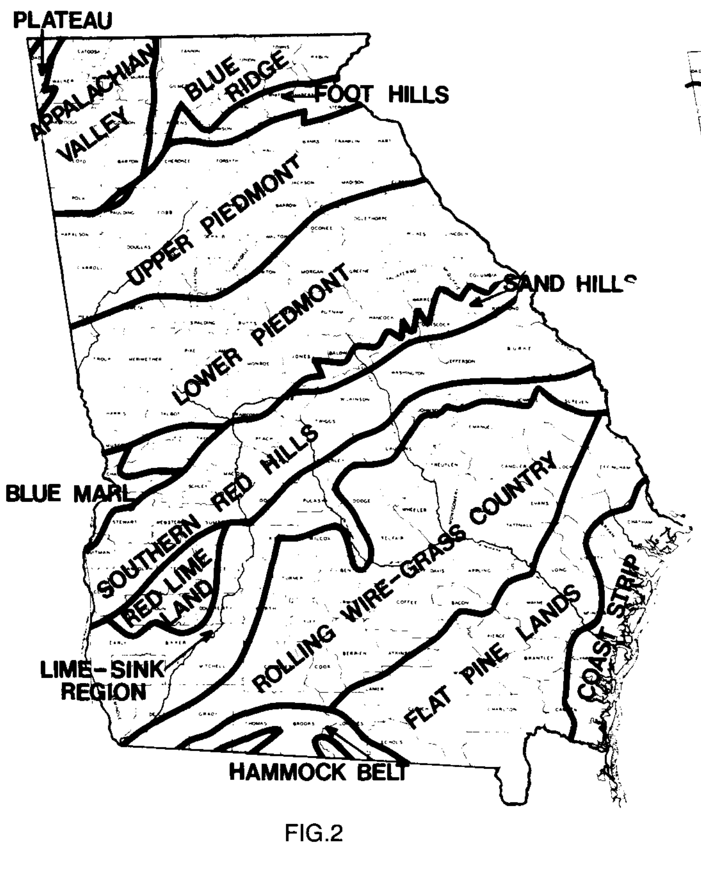


FIG.2

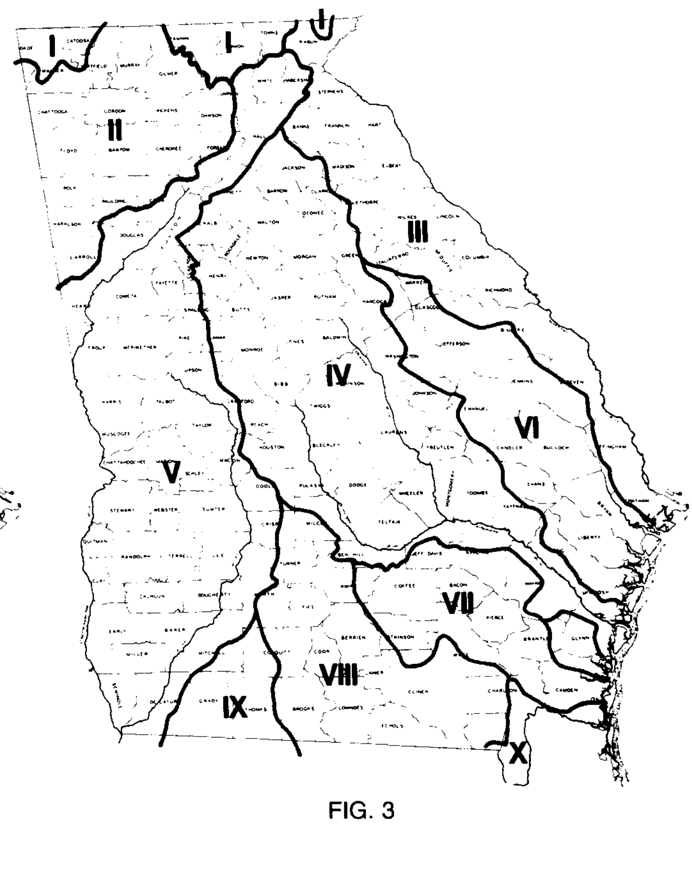


FIG. 3

Fig. 2. Regional map of Georgia by Roland Harper (1930).

Fig. 3. Major drainage systems of Georgia: I Tennessee, II Alabama, III Savannah, IV Altamaha, V Apalachicola, VI Ogeechee, VII Satilla, VIII Suwannee, IX Ochlockonee, X St. Mary's. Terminology from Dahlberg and Scott (1971).

*May have sand and gravel on inter-river areas of possible Pliocene Age. Generally referred to as "Neogene Undifferentiated" composed of floodplain channel deposits and Miocene Hawthorne originating as marine lagoon and sound deposits.

My approach uses moisture factors when possible (hydric systems with visible surface water acting as a control on the biota; mesic meaning moist and xeric meaning dry). Drier (mesic to xeric) systems are best recognized by their plant communities; hence these are used along lines employed by Penfound (1967), where attention is paid to life-form (tree, shrub, or vine), leaf shape (needleleaf or broadleaf), and function (evergreen or deciduous). In many aquatic communities plants are either microscopic, submerged or absent, and these systems may be better described in terms of animal components. Some of the environments would qualify as distinct ecosystems, others might not. "Ecosystem" implies a functional relationship between all parts of a particular community—our knowledge is reasonably complete for only a few ecosystems.

The text is organized to present a series of specific environments, each of which is given a number in brackets. What is an "environment"? A rotting log in a forest is certainly an environment for the organisms living within it, but it is scarcely a workable unit at the desired level. I consider environments described herein to be self-perpetuating (climax) biotic units which resemble those encountered by the first Asiatic or European arrivals. By the time Caucasian man reached Georgia, agriculture had become a prominent part of the lives of the Indians of the Southeast, and forest destruction by ringing the bark of trees, coupled with the use of fire, had strongly modified reasonably large areas of the state. Lacking the use of fertilizer and with abundant land, Indians apparently moved their villages when the soil fertility dropped as a result of repeated cropping. Also, certain nut-bearing trees like walnuts were protected and other plants and animals may have been introduced.

Bracketed categories that I term "environments" are not always discrete, fixed, or unvarying entities. Their boundaries are seldom sharp; many are simply at opposite ends of some ecological gradient such as moisture, and climatic changes seem to be affecting others.

In describing the flora of a given environment, I have tried to list only the **dominant** trees, shrubs, vines, and herbs—those that, if you walked out in the area, you would likely see. This is not easy. In reality many botanists and zoologists, in their detailed studies of an area, produce simply a list of plants or animals. What is abundant, common, or rare is frequently not indicated.

Another difficulty arises when one thumbs through reference books giving distribution maps of the biota. In the distribution of colt's foot (*Galax*), for example, a normally classified mountain species, reference books will show it in several Piedmont counties (often one small locality will cause it to be listed from that county). This is misleading. *Galax* occurs in the ravine of Whooping Creek in southern Carroll County. Not knowing this, one might hunt a week in Carroll County and never find it. The point is that many plants, and some animals, are very site-specific. If there is a tiny area in southern Carroll County whose microclimate approaches that of the mountains, then certain mountain forms may live there. Other classic examples are the survival of certain northern salamanders in ravines along the Chattahoochee in extreme southwest Georgia, mountain laurel on the Savannah bluffs at Two Sisters Ferry in Effingham County, Coastal Plain plants and animals in the Coosa Valley north of Rome, and cottonmouths and green tree frogs in the Flint River system high in the Piedmont. Such zoogeographic anomalies are the sorts of things that make a study of Georgia's environments so exciting.

Equally as fascinating is the tremendous diversity and unique character of some of our little-known resources. This study is no place for the lyric prose that would adequately describe the incredible blue marl gorges of Clay County, the gigantic buttresses of the cypress of Ebenezer Creek, or the hoary beauty of the great birch forest on the north face of Brasstown Bald. During this study, even after 30 years of field experience in this state, I have come upon environments that have left me profoundly incredulous. I fervently hope that this study can gain recognition for the rapidly shrinking areas that represent the remaining splendor of our natural endowment.

Dominant plants or animals are , when possible, marked (D) immediately preceding the name. An index of common plant names lists the scientific name (Latin binomial) in Appendix II. Common names have been taken from Kelsey and Dayton (1942) and do not always conform to local names.

Except in hydric environments, information on invertebrate animals is extremely limited. Vertebrates, with the exception of fish and some amphibians, are not only mobile and range through several habitats, but the warm-blooded (endothermic) birds and mammals are less habitat-specific than are the cold-blooded (ectothermic) vertebrates. For these reasons, and rather than monotonously repeating lists of vertebrates under **Fauna** for each environment, vertebrates are listed in Apendix **VI** by common name, with a symbol (see first page of appendix **VI, key to fauna**) which gives their regional distribution (CP for Coastal Plain, etc.), and a symbol for the general type of environment where they may be found. For example, SH signifies sandhills, M means very mesic forest, and so on.

Besides my own notes I have drawn upon the following: Martof (1956), Conant (1958), and Golly (1962). I have not attempted to list birds in the same manner as other vertebrates but treat them within the text under **Fauna** for some environments.

### Paleobiotic History of Georgia's Natural Environments

In an effort to understand the origins in time of Georgia environments, I have assembled (table 1) a chronology of the paleobiotic history of Georgia from a variety of sources based largely on pollen analysis supported by carbon-14 datings. To broadly summarize Table 1, we find the coldest impact of the last (or Wisconsin) glacial advance about 20,000 years ago with northern Georgia covered with a boreal forest of jack and red pine (*Pinus banksiana* and *P. resinosa*) and some spruce (*Picea*). Presumably Piedmont and Coastal Plain forest were also markedly different from the present day. Between 14,000 and 11,000 B.P. (before present), the boreal forest in nothern Georgia gave way to a mesic and more modern type with a dominance of broadleaf deciduous trees. The great megafaunal assemblage of mammoths, mastodons, bison, ground sloths, etc., apparently remained in Georgia until 11,000 to 10,000 B.P. when a drying climate, vegetational changes to closed canopy, and the entrance of the paleo-Indian on the scene—with his group hunting techniques (such as fire drives)—may all have contributed to its extinction. Some of these Pleistocene creatures may have survived in the more open oak savannahs of Florida and extreme south Georgia later than 10,000, but there is as yet no concrete evidence. The Wisconsin Ice Age is generally agreed to have terminated circa 10,000 B.P. Watts (1975) gives no dates for his essentially modern hardwood forest in northwest Georgia, but we can presume that a hardwood forest might have covered much of the Piedmont between 9000 and 5000 B.P. In extreme south Georgia, according to the only evidence we now have, between about 9000 and 5000 B.P. a thick-leaved scrubby oak forest or oak savannah covered the area south of Valdosta, with either openings between oak groves or the oaks spaced widely apart. In either event bluestem prairie grasses and sagebrush were present. About 5000 years ago rising sea levels, the corresponding decrease of stream gradient, and the rising ground water table apparently led to the establishment of modern Coastal Plain environments in the areas around Valdosta. Obviously, additional research on the age and origin of the modern flora and fauna is needed, especially between the widely spaced points of Lake Louise in the rather anomalous limesink area near Valdosta and the marsh on top of Pigeon Mountain, before we can extrapolate to widespread regional forest patterns for the remainder of the state.

Table 1 Vegetation and Climatic Change in the Southeast Since the Sangamon Interglacial (dates are B.P. —before present)

| Dates | Reference | Environment and Vegetation |
|---|---|---|
| 475 | | Little ice age — post 16th century glacial advance |
| 2500 | Deevey (pers. comm.) | Colder in n. latitudes until 600 B.C. |
| 3000 | | Sea level at minus 1.5 meter |
| 4000 | Deevey (pers. comm.) | Sea level at minus 2 meters |
| | | Longleaf forest predominant on upland sites (presumably with wild fire). Rising water tables result in cypress swamps and bayheads. Beech *(Fagus)* also becomes abundant for first time. Essentially modern environments continue until present day, Watts (1971). |
| | | Sclerophyllous oak forest, scrub or savannah with patches of bluestem prairie. Some sage (*Artemesia*) present. Water table estimated 12m below present, Watts (1971). |
| 7000 | | Sea level stops rapid rise, begins steady but slower rise. |
| | | No critical evidence of time of megafauna extinction, sites in Florida give improbably young date of 2040 B.P., Watts (1971). |
| 8500 | Watts (1971) Lake Louise (Lowndes Co.), Scott Lake and Mud Lakes, Fla. | Clovis points of Paleo-Indians present in Suwannee and Santa Fe Valley (S.W. U.S. Clovis points date 12,000-11,000 B.P.) |
| 9000 | | Hypsithermal of Deevey and Flint begins 9000; lasts until 2500 B.P. Spalling ends, silt deposition begins in Russel Cave, Alabama, Hack (1969). |
| Holocene | Watts (1975) Pigeon marsh | Youngest zone of pollen has oak, chestnut, sweet gum and blackgum representing the modern somewhat xeric forest; pine apparently confined to sandstone bluffs. |
| 9520 | Craig (1969) Shenandoah Valley, Va. | Jack pine - spruce followed immediately by hemlock (Tsuga) - oak-hickory forest climate drier than present in Florida, Deevey (pers. comm.) |
| 10,000 | Wright (1971) | (First evidence of man in Florida) Driest time begins and lasts until 6000 B.P. |
| 10,500 | Watts (1975) Pigeon marsh Walker Co., Ga. | Mesic forest: Beech *(Fagus)* 10-20%; Hornbeam (*Ostrya*) type 6%, butternut (*Juglans cinerea)* 1%; Spruce (*Picea*) 2-3%; *Pinus* (20%); oak and hickory next most important deciduous trees. No modern analogues for this forest |
| 11,000 | Guilday (1971) | Acceleration of warming process; megafauna intact in Southeast. |
| 14,000 | Wright (1971) | Abrupt decimation of boreal forest between 14,000 and 11,000. Sea level begins rapid rise, Watts (1971). |
| 19,520 | Watts (1975) Pigeon marsh Walker Co., Ga. | Full Glacial Forest Pine [some is *Pinus banksiana* and *Pinus resinosa* (red pine] ranges from 25% to 45%; oak ranges from 30% to 40%. Hickory and chestnut present. Spruce (*Picea*) 1-2%. Top of Pigeon Mountain is presumed bare, with pollen transport from valley coniferous and deciduous forests. |
| 20,000 | Watts (1970) | Main (full) Wisconsin Glacial Stage northern jack pine (*Pinus banksiana*), spruce (*Picea*), oaks, hornbeam (latter three in small amounts). All of the aquatics resemble modern northern New England species. |
| 22,900 | Watts (1970) Bob Black and Quicksand sagponds Bartow Co., Ga. | Pine, oak, and spruce (*Picea*) |
| 23,000 | Watts (1973) | More diverse forest with pines and some spruce (*Picea*). Cypress locally abundant, as well as shrubs of Coastal Plain swamps. Near-temperate flora ends. |
| 25,000 | Watts (1973) | Oak-hickory forest predominates. Age placed as mid-Wisconsin (interstadial). Very late interstadial, after Broecker (1970) |
| 29,630 | Watts (1973) Green sagpond, Bartow Co., Ga. | |
| 35,000 | Watts (1969) | Sangamon interglacial (warm temperate), pines alternating with oak-hickory-sweet gum forest with sugar maple, beech, and basswood in north central Florida. Mid-Wisconsin interstadial placed at 50,000-30,000 B.P. Broecker (1970). |

**Acknowledgements**

The editor has asked that I delete 90% of my acknowlegements. Accordingly, I can only collectively thank the many individuals, agencies, and wildlife rangers who made this task possible. I am deeply grateful to the following who took their time to accompany me in the field: Wayne Faircloth, John Bozeman, Robert Lane, Wilbur Duncan, Bruce Means, Robert Godfrey, Phillip Greear, Francis Thorne, Andre Clewell, Donald Scott, James Skeen, Dan Pittillo, William Murdy, Robert Platt, Milton Hopkins, Samuel Candler, Carol Ruckdeschel, Ed and Roy Komarek, Eugene Cline, Marie Mellinger, Leonard Foote, Leo Barber, Jr., Fred Marland, Eugene Love, Barry Staples, and Steve Bowling. I gratefully acknowledge help with flora and fauna from Lewis Berner, E.L. Snoddy, Horton Hobbs, Paul Carlson, William Beck, Jr., J. Bruce Wallace, Robert Woodall, John Adams, Thomas French, Fred Parrish, Arthur Benke, and William Heard. Marcus B. Morehead edited an early draft of the manuscript. Special recognition must be given to the Georgia Department of Natural Resources, especially the *Resource Planning Section.* The support and encouragement of dedicated **DNR** staff, exemplified by Joe Tanner, Jim Wilson and Robin Jackson, has made this project possible.

## I. HYDRIC SYSTEMS

A. FLOWING WATER SYSTEMS
- 1. NON-FLUCTUATING WATER LEVEL ECOSYSTEMS
  - [1] MOUNTAIN AND PIEDMONT SPRINGS
  - [2] COASTAL PLAIN SPRINGS
  - [3] UNDERGROUND AQUIFERS
  - [4] WET CLIFFS AND OUTCROPS
- 2. FLUCTUATING WATER LEVEL ECOSYSTEMS
  - a. FRESH WATER ENVIRONMENTS
    - (1) BIOTIC INDEPENDENT SYSTEMS
      - [5] MOUNTAIN RIVER
    - (2) BIOTIC DEPENDENT SYSTEMS
      - (a) NON-ALLUVIAL CLEARWATER RIVER
        - [6] SPRING-FED STREAM
      - (b) NON-ALLUVIAL (BLACKWATER) RIVER SYSTEM (SOIL ORGANICS HIGH)
        - [7] BLACKWATER RIVER AND SWAMP SYSTEM
        - [8] BLACKWATER BRANCH OR CREEK SWAMP
      - (c) ALLUVIAL RIVER SYSTEMS (SOIL ORGANICS LOW)
        - [9] ALLUVIAL RIVER AND SWAMP SYSTEM - PIEDMONT
        - [10] ALLUVIAL RIVER AND SWAMP SYSTEM - COASTAL PLAIN
        - [11] COOSA RIVER AND SWAMP SYSTEM
      - (d) WATER DAM SYSTEMS
        - [12] TIDEWATER RIVER AND SWAMP SYSTEM
        - [13] BACKWATER STREAMS
        - [14] RIVER MARSH AND FRESH WATER MARSH
  - b. SALT WATER ENVIRONMENTS
    - (1) COASTAL MARINE MARSH TIDAL GRASS SYSTEMS (SALT MARSH)
      - (a) HIGH SALINITY MARSH
        - [15] SMOOTH CORDGRASS MARSH
        - [16] SALT GRASS MARSH
      - (b) LOW SALINITY MARSH
        - [17] NEEDLERUSH MARSH
        - [18] EDGE ZONE MARSH
        - [19] BRACKISH MARSH
    - (2) COASTAL MARINE AQUATIC TIDAL SYSTEMS
      - [20] TIDAL POOL
      - [21] OLIGOHALINE CREEK
      - [22] TIDAL CREEK, CANAL, AND RIVER
      - [23] ESTUARY AND SOUND
      - [24] OYSTER REEF
      - [25] BEACH

B. NON-FLOWING WATER SYSTEMS
- 1. DEPRESSED SURFACE HYDRIC FEATURES
  - [26] CYPRESS POND
  - [27] GUM POND
  - [28] CAROLINA BAYS
  - [29] BAY SWAMP
  - [30] BOG SWAMP (OKEFENOKEE)
  - [31] CYPRESS SAVANNAH
  - [32] HERB BOG (PITCHER PLANT BOG)
  - [33] SHRUB BOG
  - [34] MOUNTAIN AND PIEDMONT BOGS; SPRING SEEP
  - [35] LIMESINK
  - [36] SAGPOND
  - [37] MARSH POND (IN PART)
- 2. NATURAL LAKES AND PONDS
  - [38] NATURAL LEVEE TYPE
  - [39] BEAVER DAM TYPE

### KEY TO GEORGIA'S NATURAL WETLAND ENVIRONMENTS

1a - Water fresh. (Select 2a or 2b)

2a - surface water moving in wet and dry seasons, usually in well-defined channels at low water, occupying a floodplain continually or at high water. (Select 3a or 3b)

3a - water moving as a branch, stream or river, usually in a single, natural channel; may cover floodplain at high water, flow rate steady, determined by volume and gradient, not dammed or lakelike. (Select 4a or 4b)

4a - swift streams, white water common, in mountains,

[5] MOUNTAIN RIVER

4b - sluggish streams, white water uncommon, in Piedmont and Coastal Plain. (Select 5a, 5b or 5c)

5a - low water crystal clear, at least in summer and fall, limestone bed may be prominent in limesink regions,

[6] SPRING-FED STREAM

5b - water reddish in shallows, black at depths, floodplain either black muck or sand, dominated by gum-cypress,

[7] [8] NON-ALLUVIAL RIVER SWAMP

5c - water opaque with silts and clays, floodplain with high percentage of clay, bottomland hardwoods a dominant community,

[9] [10] [11] ALLUVIAL RIVER SWAMP

3b - moving water often in multiple channels, or in lakelike channels (Select 6a or 6b) or current slows down twice daily.

6a - plant community of emergent herbs and grasslike plants,

[14] FRESH WATER MARSH

6b - plant community dominantly cypress or gum-cypress. (Select 7a or 7b)

7a - cypress with normal bases, trunk diameter normal to huge, Coastal Plain streams within 20 airline miles of coast, water flow speed and height tidally altered twice daily,

[12] TIDEWATER RIVER

7b - cypress with abnormally swollen bases, deeply inundated (up to 8 feet) in wet season in lakelike basins; trunk diameter small,

[13] BACKWATER STREAM

2b - surface water still, as in a pond, but if a current, moving very slowly; not moving in well-defined channels; in wet season water may move as sheet flow; no surface water in dry season in some environments. (Select 8a or 8b)

8a - occupies natural depressions or low ground, normally not in stream valleys. (Select 9a or 9b)

9a - depression appears as an open water pond lacking shrubs and trees growing in water; aquatic vegetation, if present, limited to herbs, except for some shrubs in marsh pond. (Select 10a, 10b or 10c)

10a - a rounded pond or, if dry, with upland vegetation growing in it, in limesink region,

[35] LIMESINK

10b - an oval pond with NW-SE axis, emergents grasslike, or lilies,

[28] CAROLINA BAY (IN PART)

10c - a rounded or irregular open water pond in coastal dune areas,

[37] MARSH POND

9b - depression appears as a pond in the wet season, full of trees or shrubs or herbs or combination of all three; may be dry in dry season. (Select 11a or 11b)

11a - depression with deciduous trees, or pine trees growing in it. (Select 12a or 12b)

12a - tree canopy normal, stunted, scattered or absent. (Select 13a or 13b)

13a - tree canopy, normal in height and number of individuals. (Select 14a or 14b)

14a - depression round or oval, containing deciduous trees. (Select 15a or 15b)

15a - trees cypress or gum, growing to edge of depression. (Select 16a, 16b or 16c)

16a - dominant tree cypress,

[26] CYPRESS ("DOME") POND

16b - dominant tree swamp black gum, Coastal Plain,

[27] GUM POND (IN PART)

16c - dominant tree swamp black gum, NW Georgia,

[36] SAG POND

15b - trees cypress, growing in center of pond only,

[28] CAROLINA BAY (IN PART)

14b - depression irregular in outline, containing deciduous trees. (Select 17a or 17b)

17a - dominant canopy tree cypress,

[26] CYPRESS POND

17b - dominant canopy tree swamp black gum,

[27] GUM POND

13b - tree canopy, stunted, scattered or absent. (Select 18a or 18b)

18a - trees, if present, scattered; shrubs are dominant vegetation; pines if present either pond or slash. (Select 19a or 19b)

19a - composed of usually a single species of giant evergreen shrub (usually titi) with twisted trunks, through which walking is feasible; sphagnum moss often present,

[33] SHRUB BOG (LOW DIVERSITY TYPE)

19b - a dense thicket of evergreen shrubs of many species through which walking is difficult, sphagnum moss often present,

[33] SHRUB BOG (HIGH DIVERSITY TYPE)

18b - trees scattered, or stunted, or absent, shrubs generally absent, depression not obvious to the eye. (Select 20a or 20b)

20a - trees scattered or stunted cypress, generally in pine flat woods,

[31] CYPRESS SAVANNAH

20b - trees absent, or if present, stunted; pitcher plants present,

[33] HERB BOG

12b - tree canopy, if present, a normal cypress forest but associated with marshes (often dominated by emergent broad-leaved herbs), shrub bogs and open water. (Select 21a or 21b)

21a - diameter greater than 5 miles,

[30] BOG SWAMP (OKEFENOKEE)

21b - diameter less than 5 miles,

[28] CAROLINA BAY (IN PART)

11b - depression filled with broadleaf evergreen trees or shrubs. (Select 22a or 22b)

22a - tree canopy dominant, composed of 2 or 3 species of evergreen bay trees (leaves have sweet, lemon or bay odor when crushed), ground usually boggy, sphagnum moss and evergreen shrubs may be present,

[29] BAY SWAMP

22b - shrub canopy is dominant, some bays may be present, ground usually boggy, sphagnum moss often present,

[33] SHRUB BOG

8b - occupies low ground in stream valleys, but water contained by a dam. (Select 23a or 23b)

23a - natural levee forms dam across tributary mouth,

[38] NATURAL LEVEE POND

23b - dam built by beavers,

[39] BEAVER DAM

1b - Water brackish to salt, coastal region. (Select 24a or 24b)

24a - a marsh. Dominated by grass-like plants.

25a - a high salinity marsh, usually dominated by a single grass species. (Select 26a or 26b)

26a - grass is smooth cordgrass,

[15] SMOOTH CORDGRASS MARSH

26b - plants are sprawling grasses or succulent herbs,

[16] SALT GRASS MARSH

25b - low salinity marsh usually not dominated by a single species of grass-like plant but if so, blades are very dark green, round and with sharp tips (blackrush) or needlerush (*Juncus roemerianus*) (Select 27a, 27b or 27c)

27a - marsh dominated by a blackrush (*Juncus sp.*),

[17] NEEDLERUSH MARSH

27b - zone of contact between tidally influenced marsh and shore of high ground,

[18] EDGE ZONE

27c - marsh dominated by several species of highly adaptable grasses, rushes and herbs growing on or near fresh water sources such as river deltas,

[19] BRACKISH MARSH

24b - appears as open water, tidally inundated seaward shore, or community of bivalve crustaceans. (Select 28a, 28b or 28c)

28a - open water. (Select 29a or 29b)

29a - open pools in salt marsh.

[20] TIDAL POOLS

29b - appears as tidally-flowing, non-pooled water, or as a creek.

30a - low salinity watercourse draining mainland,

[21] OLIGOHALINE CREEK

30b - watercourses draining salt marsh area,

[22] TIDAL CREEK, CANAL AND RIVER

30c - wide expanse of water between and shoreward of the coastal islands,

[23] ESTUARIES AND SOUNDS

28b - tidally influenced sandy shores receiving wave energy,

[25] BEACH

28c - community of bivalve crustaceans, in clusters, often exposed at lowtide

[24] OYSTER BAR

## I. HYDRIC SYSTEMS

Hydric systems are water-controlled systems. The division between them and mesic systems is arbitrary. Floodplains are characterized more by plant communities; animal components commonly define aquatic environments. In hydric systems, standing or flowing surface water (as opposed to subsurface or groundwater) should be visible for substantial portions of the day, month, or year.

A. FLOWING WATER SYSTEMS

These systems are characterized by marked geologic (abiotic) import and export of clays, silts, sands, gravel, and boulders and by biotic import and export of organic matter in both dissolved and particulate form including leaves, twigs, logs, and dead animals. There are marked differences—some mountain streams tend to be nutrient-poor (oligotrophic), while Piedmont and Coastal Plain streams have more nutrients. In flowing waters the primary producers (photosynthetic plants) tend to be attached to the bottom or to limbs and rocks as algae or moss (periphyton). Few higher plants are important in this regard. One, the riverweed (*Podostemum ceratophyllum*) is prominent. In contrast, non-flowing water environments have the primary producer organisms largely in the form of unicellular plants (phytoplankton) although many shallow ponds and slow streams become choked with submerged aquatic plants, such as the hornworts (*Ceratophyllum*), parrot's feather (*Myriophyllum*), and the dreaded hydrilla (*Hydrilla verticillata*), and two introductions, the emergent alligator weed (*Alternanthera philoxeroides*) and the floating water hyacinth (*Eichornia crassipes*).

1. NON-FLUCTUATING WATER LEVEL ECOSYSTEMS

## [1] MOUNTAIN AND PIEDMONT SPRINGS

**Location and Description.**

Most large springs occur in the Ridge and Valley province and the Pine Mountain area. McCallie (1913) maps the distribution of the major mineral springs in Georgia. Most are confined to the northern half of the state.

In the Piedmont there are various well-known mineral springs, such as Lithia Springs (Douglas Co.), which is a salty as sea-water (2,286 ppm of dissolved salts including NaCl 1785, $CaCO_4$ 156, $CaSO_4$ 183, $MgSO_4$ 45, Lithium C1 34). This spring emerges from granite gneiss, Georgia Mineral Newsletter (1951).

McCallie (1913) divides Georgia's mineral springs into five classes, defined as follows: I. Alkaline springs (presence of alkaline carbonates, and carbonic acid-gas); II. Alkaline-saline springs (a combination of alkaline-carnbonate, with sulfates or chlorides); III. Saline springs (dominance of sulfates and chlorides); IV. Chalybeate springs (much iron combined with sulfates, chlorides, or alkaline carbonates); V. Neutral springs; McCallie (1913) gives a chemical analysis of Georgia's major mineral springs. Normally, springs from 70-98°F are termed warm—those above 98°F, hot, Warm Springs has a temperature of 85 to 87°F. Thundering Spring (76°F) and Lifsey Spring (77°F) are the only other two warm springs, McCallie (1913). Examples of undeveloped springs are Willingham Springs (Upson Co.), Deep Springs and Gordon Springs (Whitfield Co.), and Cave Springs (Catoosa Co.).

**Flora.**

Generally oligotrophic (except in Ridge and Valley province); mosses and liverworts represent an impoverished plant community. In the Pine Mountain area some springs have a variety of rooted submerged plants.

**Fauna.**

Some springs are readily invaded by crayfish, and salamanders of the genera *Desmognathus, Pseudotriton,* and *Gyrinophilus* (the spring salamander). Two fishes are largely restricted to springs: the cold water darter (*Etheostoma ditrema*) in the Coosa watershed and the flame chub (*Hemitremia flammea*) in springs of the Chickamauga basin (Catoosa Co.).

Springs in limestone regions, such as NW Georgia, generally have a richer fauna and are not oligotrophic, but the fauna is poorly known.

**Natural and Cultural Values.**

Both in the Ridge and Valley province and in the Pine mountain area are a number of beautiful, large, unspoiled springs, some of which should be preserved. William Thompson raises rainbow trout in the water flowing from Willingham Spring. Other springs issuing from the Hollis quartzite, such as Warm Springs, have temperatures of 66°F and over. Sometimes, as at Cave Springs (Catoosa Co.), there is evidence of continuous heavy usage by Indians.

## [2] COASTAL PLAIN SPRING

**Location and Description.**

Most Coastal Plain springs are confined to the Dougherty Plain. Other examples occur in Screven County and in the Tifton Upland wherever major streams cut down to the limestone aquifer.

**Examples.** A number of large and beautiful springs occur in the Coastal Plain but are known largely only to the local people. Bartram's Blue Spring is near Brier Creek, a few miles south of Highway 73 (Screven Co.), and a commercial Blue Spring is found in the extreme southern part of the county. One of the most beautiful Georgia springs is Osciewitchee (Wilcox Co.), about ½ mile from the Ocmulgee River. There are more springs in the Dougherty Plain than in any other region. Radium Springs (Dougherty Co.) has been commercialized. Blue Springs in Crisp County, formerly surrounded by native loblolly pine forest (now clear-cut), has been rock-walled. Collier Spring in Dooly County is an excellent example of a small, undeveloped natural spring of great beauty. Several large springs adjoin Spring Creek (Decatur Co.). One of these is Brinson Spring (one mile south of the Highway 84 bridge on the east side), but the run does not flow into the river.

Photo A. Collier Springs in Dooly County is an example of an undeveloped Coastal Plain spring. [2]. The deep, blue boil in the center usually swarms with fish. Snails are abundant on the sandy bottom, and turtles are often seen in these natural aquaria. Unfortunately, few of Georgia's larger springs remain in their natural state — they are natural treasures and examples should be protected.

**Flora.**

Osciewitchee is a large bowl-shaped depression about 25 feet in diameter, perhaps 10 feet deep with a blue "boil" in the center. Water is crystal clear and flows in a "run" about 20 to 30 feet wide in which grow cypress and gum. Collier Spring issues from a limestone grotto. Underwater submergents are not identified, but they resemble *Ceratophyllum.* A plant that closely resembles *Edodea, Anacharis densa,* has been introduced and has spread down the run. A streamside hammock is dominated by sweet gum, cypress, sugarberry, and water oak with much dwarf palmetto as ground cover. Collier Spring's run has *Ceratophyllum* as a submerged aquatic and a seepage-type creek swamp forest composed of southern magnolia, water hickory, poplar and spruce pine, southern sugar maple, ironwood, and pond pine. Brinson Spring is a striking, nearly circular basin 100 feet in diameter lying below a high bluff. The forest on top of the bluff is modified **upland broadleaf evergreen forest** with laurel oak and some southern magnolia. The dominant trees immediately around the spring are green ash and planer tree, with some water oak, hornbeam, and southern sugar maple. The subcanopy includes much Walter's viburnum (*Viburnum obovatum*), dogwood, wild olive, holly, and spruce pine. Common shrubs are button bush, sparkleberry, and a shrubby St. John's wort. At the herb level are foxglove (*Aureolaria* sp.), *Smilax pumila, Sebatia* sp.,and *Aristolochia serpentaria.*

**Fauna.**

Fish are abundant and readily visible, largely bass, sunfish, and suckers. In Osciewitchee's run, gill nets are often stretched across the mouth at the Ocmulgee to catch mullet. *Goniobasis* is the most abundant snail, D.C. Scott (pers. comm.); the larger *Vivipara georgiana* is sometimes found in piles, assembled by the Limpkin or "crying bird." Spring runs, with their abundant snail fauna (probably owing to high calcium levels), are the favored habitat of the Limpkin. The snail *Ferrissia dalli* is known only from Blue Springs, Decatur County. The only Georgia occurrence of the large applesnail (*Pomacea paludosa*) is from Sealey Springs, 7½ miles SW of Reynoldsville. See fauna of **spring-fed streams** for a discussion of the abundant molluscan fauna of springs. A land snail, *Mesodon thyroides,* is common in adjacent forest.

For invertebrates see Appendix III. There is a limited representation of vertebrates; Appendix III. (CP, H). Some springs are invisible under the waters of the rivers. There is large underwater spring in a slough (Lake Rhodes) of the Ocmulgee at Jordan's Bluff near Abbeville. Large striped bass (*Morone saxatilis*) congregate over this spring, and it is heavily fished. Spawners up to 55 pounds have been taken there. Dahlberg and Scott (1971) record a 63 pounder from the Oconee 22 miles south of Dublin.

**Natural and Cultural Values.**

Large springs are hydrologic and geologic treasures. They are botanically and zoologically valuable in their scarcity and uniqueness. They are pure, emergent, underground rivers, usually well mineralized and supporting a highly productive flora and fauna. The spring and the spring run below it and the adjacent forest must be considered together as an ecological unit.

Esthetically beautiful and highly educational, the clear water allows observation of flora and fauna and offers excellent skin-diving and underwater exploration. Some springs and spring runs possess the fossil teeth and bones of the Pleistocene megafauna, especially in the lower Coastal Plain and in Florida. Nearby archaeological sites are highly probable.

**Man's Use.**

Most springs are ruined by commercialization. If accessible, they are heavily used for picnics and swimming. Florida has lost almost all of its beautiful natural springs. One of the finest springs along Spring Creek is used as a private swimming pool by the landowner, who has built his house adjacent. Others have had the cypress forest around them heavily logged. Few large springs exist in the natural state—every effort should be made in their preservation.

## [3] UNDERGROUND AQUIFERS

**Location and description.**

These occur from the Fall Line Red Hills south in the western half of the Coastal Plain and south of the Fall Line Sand Hills in the eastern part of the state. The main recharge areas for the deep underground (Ocala) aquifer are the Limesink Region in SW Georgia and the Valdosta Limesink Region. This recharge zone is thought to cross the Coastal Plain north of the Tifton plateau. One can observe on maps that Coastal Plain rivers straighten their courses as they cross the recharge zone; elsewhere they resume the characteristic meanders. Here it is believed that they recharge the principal limestone aquifer during high water and are, in turn, fed by it at low flows, S. Pickering (pers. comm.). Such a phenomenon is relatively common in Florida, Wharton *et al* (1976). In addition, streams recharge the superficial sand aquifers nearer the surface. This relationship was demonstrated in a study of the Gordon River in Florida, Wharton *et al* (1976). The principal artesian aquifer, the major source of drinking water for the coastal zone, is largely in the Ocala limestone of Eocene age. This stratum dips beneath the Miocene and younger sediments so that, in coastal Georgia, it lies hundreds of feet below the surface. Artesian or surface-flowing wells are still seen in some areas of the coastal zone. Other aquifers lie above in the Hawthorne formation and are very important for irrigation and other purposes.

In Appling County near Baxley, the G.P.C.E.L. (1971) reports that the Ocala aquifer is overlaid by 250 feet of the Hawthorne and Chipola formations. Most wells in the area penetrate to between 100 and 200 feet. Because of the plastic clay residuum in the surface soils of the Limesink Region, rainwater runs across the land surface to the nearest limesink and enters the aquifer.

**Fauna.**

In the Limesink Region the major drainage is subterranean—some surface streams emerge as springs, then disappear underground. A limited subterranean fauna is present. Blind crayfish are known. A distinctive blind, white salamander, *Haideotrition wallacei,* has been described from a specimen accidentally pumped from a deep well west of Albany, Georgia. Bruce Means has secured additional specimens from a Georgia Coastal Plain cave, and numerous specimens have been taken from caves near Marianna, Florida, where the aquifer is more accessible and caves more abundant.

**Natural and Cultural Values.**

Obviously, the subterranean aquifers are of enormous value to society. Their sparse life is unique. They represent a vast, underground river system. In fact, many surface features are dependent upon them. If one surveys the Landsat satellite images of SW Georgia, one striking feature is that west of the Pelham escarpment (the **Limesink Region**) the shape of the fields is not determined by the surface drainage (being square), while east of this escarpment the fields are highly irregular and lie between the dendritic stream tributaries and creek swamps. Seldom does one find a more dramatic example of the interplay of man and nature, and of the physical differences between an area of aquifer recharge and an area of almost total surface runoff. Most limesinks and many surface depressions are caused by the collapse of underground chambers eroded by the dissolving power of underground aquifers.

**Man's Impact.**

Artesian waters have tremendous value for domestic and industrial use. The total resource has scarcely been touched, but local, intensive use has created problems with lowered pressures and salt intrusions; but this could be solved by distributing wells in networks. This is a rapidly renewable resource; we are not mining fossil water as it is in Arizona, D.C. Scott (pers. comm.). The primary local dangers are overdrawing waters from the Ocala aquifer by large industry. Minor losses result from uncapped artesian wells. At the recharge end, polluted agricultural drainage into limesinks constitutes a positive threat. Channelization poses a possible threat if it involves drainage of the great swamps lying to the north of the recharge zone. These swamps act to remove wastes from water before it enters the aquifer, if it does, and also act as a giant sponge to absorb surplus water, retarding run-off and perhaps metering out a steadier supply during the dry season. Industrial channelization, such as done by Kimberly-Clark in the great Oconee swamp south of Milledgeville, in addition may increase silt and bed load sand with the possibility of effects on aquifer recharge capacity of the Oconee river bed.

The channelization of other Coastal Plain watersheds results in depriving shallow Miocene and Pleistocene aquifers of recharge and may reduce the water available for irrigation in the agricultural areas of the Coastal Plain. The addition of a few acres of pineland does not offset the loss in water quality and quantity posed by channelization. Carter *et al* (1973) documented that groundwater recession rates quadrupled in the vicinity of drainage canals in southern Florida, stating that nearly two million people could have been supported (at 100 gals./person/day) on the fresh water wasted by the Fahka Union Canal during the 1970-1972 period. See discussion under **man's impact** on the alluvial stream systems for additional information.

The mathematics of calculating surface aquifer recharge from a stream channel and vice versa are given by Dickinson (1975).

Reservoirs, by flow regulation, may damage the normal recharge capacity of the floodplain ecosystems, as well as cause increased bank erosion downstream.

## [4] WET CLIFFS AND OUTCROPS

**Location and Description.**

These may be present in steep terrain adjacent to waterfalls or supplied by ground water seepage, or occur as the gorge walls of certain streams where the cliffs may be composed of clay (Kolomoki Creek), limestone (Flint River, Sumter Co.), sandstone, and shale (in NW Georgia and rarely along the rivers of the Coastal Plain) or of igneous or metamorphic rocks (quartzites, etc., along the Flint in Upson, Meriwether and Talbot counties, and in Tallulah Gorge).

The flora and fauna are poorly known. On limestone (and clay) outcrops in the Coastal Plain, the Venus hair fern is outstanding. In the mountains one finds additional fern species and various saxifrages. Mosses (such as *Mnium* sp.) and liverworts thrive in this environment.

One finds an abundant salamander fauna here, usually of the desmognathus group, principally *Desmognathus fuscus* or *D. ochrophaeus.* In the Blue Ridge the moist seep is a favored habitat of *Desmognathus aeneus.*

The green salamander is found in the Tallulah gorge area in crevices of the quartzite rock. Other fauna are listed in Appendix VI.

2. FLUCTUATING WATER LEVEL ECOSYSTEMS

a. FRESH WATER ENVIRONMENTS

**Physical and chemical data on Georgia streams.** It is more useful to consider our major streams together. Four mountain streams, Chattooga, Chattahoochee, Etowah, and Hiawassee, possess similar water chemistry, EPP (1974). Their acidity (ph) is moderate (6.4-6.9), and their phosphorus and nitrogen levels low (p: $<$0.02-0.04, N: $<$0.02-0.07). Blue Ridge mountain streams are low in calcium, manganese, and iron, and are not especially rich in the other minerals. In fact, the electrolytes are so low that electrofishing is difficult. Piedmont streams, in contrast, are more basic (pH 6.9-7.2) with slightly more organic matter (TOC 3-6) and are more turbid, averaging about 44. It is interesting that the two Piedmont streams with swamps (the Flint at Flat Shoals and the Alcovy at Newton Factory Shoals) show the same low turbidity (15), harder water (av. 18), and considerably more phosphorus and nitrogen (P up to 1.2; N up to .43), the latter probably showing some effects of agriculture. In this regard, it is fortunate that we have a water sample from Falling Creek (Jones Co.), an Ocmulgee tributary lying wholly inside of the Piedmont National Wildlife Refuge where the effects of agriculture should be minimal. Although it was sampled only once, apparently at very high water with high turbidity, it shows consistently low levels of phosphorus and nitrogen (at low water 0.02). Its very high hardness and high calcium, magnesium, and sodium levels apparently are an anomaly, for calcium levels surpass that of the Ichawaynochaway, which traverses a limestone area.

On the basis of water chemistry we can divide Coastal Plain streams into three groups. The large rivers originating in the Piedmont seem to fall in one group. They are weakly acid (about 6.8, average), their organic matter moderate, with average turbidity (15), hardness moderate (av. 17), with fairly high phosphorus (.07) and nitrogen (.24) levels.

The second group of Coastal Plain streams is exemplified by Rocky Creek (Laurens Co.) and Ichawaynochaway (Baker Co.). These streams have a basic pH (7.25), are low in organics (5), are moderately turbid (15.5), are very hard (28), and have moderate loads of phosphorus and nitrogen. The hardness and pH are probably due to the course of these streams in or through the basic lime rock of the aquifer recharge zone. The Kinchafoonee does not reflect this because at the station selected in mid-Webster County, this stream is flowing off an entirely different geological division, the red hills.

The third group is the lower Coastal Plain streams exemplified by the Little, Alapha, Satilla, St. Marys, and Suwannee. These streams are relatively acid; both the Little and the Alapaha are slightly anomalous in this regard, probably reflecting their contact with the basic limestones in the vicinity of Valdosta; the ultimate acidity is shown by the Suwannee (4.3), deriving its acid from the Okefenokee peat and the cypress-tupelo floodplain along its upper portions. These five streams are high in organic matter, being black water streams. The Suwannee is so organic that potassium permanganate used to neutralize the fish poison, rotenone, is needed in large quantities, 18 ppm being often necessary to achieve neutralization. Hardness is low, approaching that of mountain streams, and phosphorus and nitrogen are quite low (0.02-.05). The Alapaha is low in calcium (especially in the spring). This offers support to our contention that streams coursing largely across the Pleistocene sea floor tend to have dwarfed trees, in contrast to those of the nutrient-rich rivers, such as the Altamaha. The locking up of organic matter owing to the slowness of mineral cycling (as in peat accumulation) may contribute.

(1) BIOTIC INDEPENDENT SYSTEMS

In biotic independent streams, inundations of the floodplain are irregular and may vary considerably in height, unlike those of Piedmont and Coastal Plain streams. In such streams kinetic energy is high, often moving huge boulders and eroding solid rock by the abrasive action of bed load material during highwater. Sediment movement is largely limited to non-nutrient bed load, such as sand and gravel. Floodplain accretion of "soil" is due to colluvium washed or tumbled from valley sides and the action of vegetation, as well as to irregular deposition from floods. An important distinction is that the biota is largely independent of inundations. Inundations exceeding bankfull are not necessarily yearly phenomena. The floodplain forest, if present, shows no dependence on the effect of inundation. In the stream itself we cannot say that the biota is completely independent—some fishes, such as trout, may use higher waters to reach breeding areas in the spring, and others may feed upon macroinvertebrate drift brought about by rain-swollen streams. Aquatic life, however, does not move out of the stream channel or onto the floodplain, nor has it been shown that nutrient input from the floodplain is essential to stream life. Floodplains in these headwater streams are limited and narrow.

In these highly oxygenated streams trophic energy levels are usually low. Most of these streams exhibit a pronounced longitudinal diversity gradient. Headwaters are distinctly oligotrophic (with only one or two species of fish), while the waters downstream gradually add more species (as the temperature also climbs). Enrichment is largely eliminated by oxidation rather than biotic means. Periphyton algae on rocks is the dominant primary producer.

## [5] MOUNTAIN RIVERS

**Location, description and examples.**

Examples of mountain streams are found throughout the Mountain Province, principally in the Blue Ridge Sector where originate the headwaters of the Savannah (Chattooga, Tallulah), Chattahoochee (Chestatee), Etowah, Toccoa, and the Jacks and Conasauga in the Cohutta Sector. All are cold enough for trout. Brook trout is the only native species; later rainbow trout, native to the Sierra Nevada, were brought in from California, and still later European brown trout were introduced from Germany. Cold, well-oxygenated water coursing over a rocky substrate is the picture of the typical mountain stream.

Photo B. Mountain streams [5] have a characteristic border of hemlock and the evergreen heaths, rosebay rhododendron, and mountain laurel. The cold, well-oxygenated but food-limited water cannot support many fish species. There was originally a single dominant predator, the brook trout (*Salvelinas fontinalis*), now in turn dominated by the introduced west coast rainbow and European brown trout.

Stream systems (fig. 3) are separated on the basis of faunal characteristics. Geologically, hydrologically, and botanically (on the basis of submerged aquatic plants or streamside flora), however, they are quite similar. Therefore, all of the headwater systems are treated under a general description. The larger floodplains are almost invariably cleared and well-drained enough to grow corn. A typical, fertile intermountain floodplain is found along the Chestatee below Turners Corner (Lumpkin Co.). The soils are classified as the Cartecay-Toccoa-Congaree Association, USDA (1972).

**Flora.**

The only submerged vascular plant is *Podostemum ceratophyllum.* Various algae as periphyton on rocks can be found. I once encountered a remarkable growth of filamentous algae in the Chattooga River above Big Bend Falls—presumably increasing upstream and possibly due to some enrichment, probably in the Burrell's Ford area where much camping is done. Dumond (1970) noted that alluvial forest develops on tiny floodplains of the Chattooga River (Rabun Co.), essentially white pine—deciduous forests similar to upland kinds. There is a streamside shrub-herb zone and, on loose quartz sand on bars and shores, herbaceous annuals or young perennials are found: largely knotweeds *Polygonum sagittatum, P. persicaria, P. pennsylvanica, Holcus lanatus, Agrostis perennans,* several species of *Panicum,* and jewelweed (*Impatiens capensis*). On more stable rocky or gravelly river margins, the communities are dominated by alders (*Alnus serrulata*) and yellowroot (*Xanthorhiza simplisissima*), along with elderberry (*Sambucus canadensis*), bush honeysuckle (Diervilla *sessilifolia), Viburnum cassinoides, Rhododendron minus* and flame azalea (*R. calendulaceum), Hypericum densiflorum,* Virginia willow (*Itea virginica*), and perennials, such as *Carex, Krigia montana* (in crevices), *Boykinia aconitifolia, Trautvetteria carolinensis, Saxifraga michauxii,* and the cinnamon fern (*Osmunda cinnamomea*).

**Fauna.**

There is difficulty in recognizing mountain forms as distinct from Piedmont forms occurring further downstream. North Georgia mountain stream fauna should be similar to that in small North Carolina streams at Coweeta near extreme northeast Georgia. Here Woodall and Wallace (1972) found the most abundant organisms to be: **Crustacea** (crayfish), *Cambarus bartoni;* **Plecoptera** (stoneflies), *Isogenus bulbosus, Peltoperla maria,* Pteronarcys sp.; **Odonata** (dragonflies), *Lanthus albistylus*; **Ephemeroptera** (mayflies), *Stenonema* spp., *Ephemerella funeralis, Paraleptophlebia* sp.; **Trichoptera** (caddis flies), *Rhyacophila* (6 sp. on moss mats), *Diplectrona modesta, Parapsyche cardis*; **Coleoptera** (beetles), *Optioservus immunis, Limnius latiusculus;* **Diptera** (true flies), Chironomidae (10 sp.) *Tipula* spp., *Eriocera* (3 species in sandy areas); **Amphibia** (salamander), *Desmognathus* spp. Crayfish and salamanders (detritivore and carnivore, respectively) comprise the largest standing crop biomass in these streams, Woodall and Wallace (1975). See **Fauna,** Coastal Plain streams, for remarks on general distribution of life in mountain streams.

Lists of species seldom convey either the kinds or numbers of animals making up the normal population of an environment. This is true of stream fishes and will be a continuing problem. What species whould you expect to catch by routine seining or electrofishing? Unfortunately, this type of information is scarce and even then we are not sure whether the sample represents the true faunal composition. I have consistently collected Cooper's Creek (Union Co.) since 1960. A normal "catch" (in decreasing abundance) usually consists of the creek chub (*Semotilis atromaculatus),* the saffron shiner (*Notropis rubricroceus*), the river chub (*Hybopsis micropogon*) the warpaint shiner (*Notropis coccogenis*), and the mirror shiner (*N. spectrunculus*), all of these largely in the pools. In the riffles occur the northern sculpin (*Cottus bairdi*), long-nose dace (*Rhinichthys cataractae*), northern hogsucker (*Hypentelium nigricans*), greenside darter (*Etheostoma blennioides*), and the redline darter (*Etheostoma ruflineatum*). Then (if lucky) one captures a rainbow or brown trout. The.numbers average around 10-20 chubs and shiners for each dace, darter, and trout. Some of the shiners appear localized in certain pools and, in some years, some species appear scarce or absent. The spring (or fall) spawning of fishes must be kept in mind. Upstream movement of suckers and brown trout is notable.

A modified version of Dahlberg and Scott's (1971) list of Georgia fishes is Appendix IV. Most of the endemic fishes are native to either the upper Piedmont and Ridge and Valley province (Alabama system) or the Tennessee tributaries arising on the north face of the Georgia Blue Ridge. For convenience, and since most of the Alabama tributaries head in the mountains, these two systems will be discussed together.

The Alabama has 32 endemic fishes, while the Tennessee has 30. Some of these fishes are quite distinctive. The possible arrival of the sturgeon in NW Georgia is indeterminate. Some game species (smallmouth bass, white bass, and sauger) are Tennessee endemics. Some of the smaller fish are very attractive, especially in breeding coloration. Students are always impressed with the beauty of the greenside darter (*Etheostoma blennoides*) and the red-line darter (*E. ruflineatum*), both present in Toccoa river (Tennessee drainage) headwaters (Union Co.).

Among about 14 species, the Tennessee-Alabama watersheds share the flat-head catfish (now abundant in the upper Flint following introduction), the walleye (*Stizostedium vitreum*), the spotted bass (*Micropterus punctulatus*), and the fresh water drum (*Aplodinotus grunniens*), whose remains are frequently encountered in Indian middens along these streams. The Chattahoochee shares with the Alabama about four species, including the quillback (*Carpiodes cyprinus*). The Tennessee-Chattahoochee-Savannah headwaters are the home of our only native trout, the brook or speckled trout (*Salvalinus fontinalis*). The Tennessee and Savannah, whose headwaters are especially close in Rabun County, share about six species, including the beautiful war-paint shiner (*Notropis coccogenis*). The Tennessee-Alabama-Chattahoochee systems share three fish, including the green sunfish, *Lepomis cyanellus.*

The shovel-nosed salamander is perhaps the most aquatic of the mountain salamanders, next to the large water-dog or hellbender (*Cryptobranchus*), which is native to the Tennessee system (some have been introduced in the Savannah headwaters). The large black-bellied salamander (*Desmognathus quadramaculatus*) is largely aquatic. All three of these skin-breathers require cold, well-oxygenated streams being, in Georgia, confined to the mountains. The seal-salamander (*D. monticola*), while it has been described from SE Alabama, is largely a mountain form. Its distribution and the distribution of the Blue Ridge Mountain salamander (*D. ochrophaeus*) are in question. *Ochrophaeus* is found in the highest, coldest branches of the Appalachians. The two-lined salamander

(*Eurycea bislineata*) is common along mountain streams. On April 16, 1960, we found this salamander breeding on the bottom in Cooper's Creek in a foot or more of water.

The purple salamander (*Gyrinophilus*) is found more commonly in branches and seeps at high elevations, although we have taken it in a rocky branch at Stone Mountain (Dekalb Co.). Two mountain forms, the Cherokee (*Desmognathus aeneus*) and the pygmy salamander (*D. wrightii*), occur in seeps and spring heads in mountain areas.

The northern red salamander (*Pseudotriton ruber schencki*) and the beautiful, northern, three-lined salamander (*Eurycea longicauda longicauda*) are streamside (and bottomland) forms.

About the only other vertebrate one consistently finds along mountain streams is the northern banded water snake (*Natrix sipedon sipedon*). See Appendix VI, (MTS) and (MT/H).

**Natural and Cultural Values.**

These streams are geologically outstanding areas with extremely scenic gorges, cascades, waterfalls, and pools. The distribution of some molluscs and fishes supports the theory of stream capture (of two Chattachoochee tributaries by the Savannah, and an Etowah-Chattahoochee confluence), presumably late tertiary or later (Johnson, 1970), explaining why certain species are shared by Gulf and Atlantic drainages in their headwaters. The endemic species of some of these streams are spectacular. One of these, the hellbender, competes with the greater siren of the Coastal Plain as our largest native salamander, reaching several pounds in weight and adapted to cold, highly oxygenated streams with flat rocks. Others are the colorful war-paint shiner and green and red-sided darters of the Tennessee River. These many endemic species make these streams ideal to demonstrate species restricted to cold water and to illustrate zoogeographic principles of distribution, speciation, and evolution. Because of their scenic grandeur, these streams are excellent for canoe trails, streamside trails, raft floats, swimming, and fishing. Their game fish (brook, rainbow, and brown trout), smallmouth bass (in the Tennessee), redeye bass (in most other watersheds), muskellunge (Tennessee), and a host of sunfish, suckers, and catfish make them valuable. The mountain trout fishery is highly unique. This sport demands a wilderness setting or, at the least, broad stream-side zones of forest. The esthetics of the "trout experience" are more important than the fish; hence proper forest management plays a large role in the cultural values that we receive from this environment.

Photo C. The Chattooga is a MOUNTAIN RIVER [5] of scenic and wild status. Here rafts descend into "Sock'em Dog Hole" in section four. At least three outfitters conduct float trips through the scenic gorges [63] of Rabun County's eastern boundary.

**Man's Impact.**

Clearcutting or "regeneration cutting" (partial or total) poses the largest problem (other than reservoir construction). The hydrology of the stream is dependent upon the surrounding forest. The natural function of the mountain forests is to anchor and build the soil, and, in doing so, to transpire. Transpired water is returned as summer convectional rain to the mountain slopes where it is returned again skyward. Water can be thus kept in the mountain area. It is true that clearcutting, by decreasing transpiration loss, increases stream flow, but it may allow water to go oceanward when it was nature's plan to retain it in the mountains. Insufficient data exist to support the practice of clearcutting. Clearcutting eutrophicates (or pollutes) streams with effects on stream life. As now practiced, it allows "cloud bursts" to de-vegetate and de-soil many tributaries, greatly increasing run-off and silt. Silt increase in streams is especially damaging to stream life which requires much oxygen for survival. The destruction of esthetic beauty and the effect on "wildlife" are other substantial objections to the clear-cut in scenic areas. Mountain streams seem especially susceptible to pollution —their organisms are designed to cope with a minimum of nutrients, and pronounced changes in stream flora and fauna occur with very moderate degrees of pollution.

Photo D. The gold-mining dredge represents only one of the many ways in which man has modified north Georgia stream valleys [5]. Cutting of the great hemlocks for their acid-yielding bark used in tanning was one of the earliest modifications along mountain streams.

(2) BIOTIC DEPENDENT SYSTEMS

In these systems the biota of either the stream itself or of both the stream and its floodplain is modified by or dependent upon annual high water, usually through some portion of the growing season. Inundations are largely in winter and spring. Continental or cyclonic air masses are of major importance. Excess nutrient disposal is due largely to the action of the biota rather than by oxidation. Primary aquatic production is largely periphyton based, except for marsh environments.

(a) NON-ALLUVIAL CLEARWATER RIVER

## [6] SPRING-FED STREAM

**Location and Description.**

Spring-fed streams receive much of their water from the larger springs in the Limesink Region and the Tifton Upland. These streams are quite different from the coffee-colored, acidic waters of the typical Coastal Plain streams. They are probably circumneutral in pH. When spring high-water subsides, visibility is good to fair underwater in fall especially, The clear water affords visibility of the bottom and of the numerous logs and stumps. Often the bottom is solid limestone, pitted by erosion, sometimes with jagged, cutting edges. Occasionally, blue spring "boils" (photo E) erupt in the stream bottom, or runs from adjacent springs join the main stream. Some streams may disappear underground to resurface later. Although bordered by cypress and other hydrophytes, a true floodplain forest seems lacking. Some spring streams at the edge of floodplains may be inundated by the river at high water. Limestone outcrops along the shore are picturesque, and shoals and rocky shallows are frequent.
Examples are Osciewitchee Spring run (Wilcox Co.), Spring Creek (Decatur, Miller and Early counties), and Collier Spring run (Dooly Co.).

Photo E. Spring "boil" in limestone bed of Spring Creek [6] between Brinson and Colquitt (Decatur Co.). This unique stream is rich in molluscs, and their predator, Barbour's map turtle (*Graptemys barbouri*), is common.

**Flora.**

Submerged aquatic plants present depend on forest overstory. Some occur in deep shade; *Ceratophyllum* and *Ludwigia*, *Myriophyllum* and *Utricularia* in sun (D.C. Scott, pers. comm.). There is variation among spring runs. Osciewitchee run has a dense growth of *Anacharis densa*. Spring Creek has few underwater plants, compared to the "runs" of Osciewitchee and Collier Springs. A floodplain and floodplain flora are lacking. Banks are relatively high and adjacent pine or upland hardwood or mesic bluff forest comes to the top of the bank. Cypress and planer trees are common along the banks.

**Fauna.**

The fauna of Spring Creek is that of the Flint-Apalachicola system. See Appendix III, symbols (CP) and (CP/H). A remarkable number of molluscs have been recorded from the clear waters of Spring Creek and adjacent springs, such as Brinson Springs. Among them are *Campeloma geniculum, Lioplax pilsbryi, Goniobasis floridensis, Physa pumilea, Pseudosuccinea columella, Lampsilis subanulata, L. calaibornensis, Villosa lienosa, V. vibex, V. villosa, Sphaerium stamineum, Byssanodonta singleyi* (on tree roots—¼ inch long), *Quincuncina infuscata, Elliptio strigosus* (most abundant), *Uniomerus obesus, Anodonta gibbosa,* and *A. imbecilis.*

**Natural and Cultural Values.**

Comments on Coastal Plain springs also apply here. In general the spring runs are too shallow for power boating, but are exciting environments to wade or canoe. Because of the crystal clear water, most life in the streams is highly visible. Therefore, these streams are precious resources for streamside trails, skin diving, and outdoor education. Their large mollusk fauna and visible limestone outcrops and spring boils make them a scenic wonderland. These streams are unique and rare natural aquaria; gizzard shad (*Dorosoma cepedianum*) are especially abundant. Spring Creek would make an exceptional canoe trail.

**Man's Impact.**

Since spring runs are shallow, they are not as heavily used for swimming as the springs themselves. Spring Creek has much usage at certain points, especially for swimming and fishing—although in exceptionally clear water, fishing may not be as good as in other streams. On the other hand, life is vulnerable to shooting and spearing from skin diving or surface spearing. Debris and garbage also are exceptionally visible—therefore these streams must be especially protected from solid pollution.

(b) NON-ALLUVIAL (BLACKWATER) RIVER SYSTEM

Non-alluvial stream swamps are generally restricted to the Coastal Plain, and a clear but tea-colored water is characteristic. Floodplain forests are neither consistently wide nor as continuous as along the larger alluvial streams—pinelands frequently come to the stream edge. Bottomland hardwoods, the most extensive vegetation of alluvial rivers are, on blackwater streams, restricted in area and diversity, being confined to old levees, narrow riverine strips, or sometimes adjacent "flats." A water oak-dominated forest with abundant pines occupies the Ohoopee floodplain at Highway 152 Bridge (Tattnall Co.). Apparently water table heights here are not high for long enough to produce typical diverse, bottomland hardwood forest, and trees (water oak, laurel oak, red maple, sweet gum) on such areas are tolerant of moisture extremes. In contrast, alluvial floodplains often support trees like overcup oak and water hickory that almost never grow in upland environments. Along non-alluvial streams inundation onto adjacent uplands is of short duration—in general, water rises and falls more rapidly than in alluvial systems. In contrast with alluvial floodplains, overbank deposits of sand, inorganic silt, and clay are negligible. Mineral transport, other than dissolved iron and aluminum, seems limited to bed load movement of sand, forming picturesque bars.

Other than sand in the streambed itself, the flooding regime of blackwater streams apparently deals largely with the movement of organic matter in both particulate and dissolved form. When high water recedes, a silt-like dark deposit may coat the sand bars. This material may settle out in low, quiet water areas and contribute to deposits of organic-rich mucks. Some clays may be deposited pre-historically or currently. In Florida I found dense clay layers beneath gum-cypress swamps of the Suwannee and the swamp black gum backswamp of the Escambia. Thus the similarity of blackwater floodplains to alluvial river backswamps far removed from the river and gum ponds can be seen.

Non-alluvial floodplains are sometimes surprisingly wide (Canoochee headwaters, Highway 121, Candler Co.). Floodplain topography suggests a fluvial (river-carried) origin, but the relative contributions of sands coming in as colluvium from adjacent sand-capped Miocene hills and the river's own transport are obscure. Since the floodplains are predominantly sandy, movement of stream meanders may be relatively rapid. Some wide non-alluvial floodplains with small streams might be explained if these streams were "misfits"—their diminished present-day flow being due to stream capture. Another theory suggests that they are "relict" floodplains, formed from much larger stream discharges during the late Pleistocene. Thom (1967), working in South Carolina, and W.G. McIntire (pers. comm.), studying Gulf Coast streams, authenticate a pluvial (rainy) period with higher rainfall than present, between 18,000 and 10,000 years ago during the retreat of the Wisconsin ice sheet.

In blackwater streams most nutrients appear of organic origin rather than dominantly inorganic, as with alluvial rivers. Availability of these organics to energize food chains is little known. The presence of dwarf cypress in backwater "lakes" and on the headwaters of certain streams (Alapaha) suggests low nutrient availability, with acidity, low oxygen levels, and minimal recycling as possible factors.

The water chemistry of lower Coastal Plain rivers has been studied by Beck *et al* (1975). Their work places blackwater rivers in a special category. The ratio of total dissolved inorganics to organics is 1.1, whereas in the average world river it is 10.1, and these authors indicate that this high percentage of organic matter plays an overwhelming role in the chemistry of these streams. The proportions of the major elements indicate that the stream water is derived from rainwater, with minor additions of calcium and potassium from soils, with the evapotranspiration loss of 100 cm of 125 cm annual rainfall accounting for the concentration. Blackwater streams are low in phosphate (20 ppb), nitrate, and lower in pH (4.59) than alluvial streams (pH 6.7). These organic-rich streams are also lower in silica. Iron and aluminum comprise the bulk of the inorganic load and are apparently derived from shallow groundwater. This research has important implications in the movement and distribution of pesticides and heavy metals. The high molecular weight humic acids tend to immobilize these substances; they are insoluble and tend to be incorporated in bottom sediments. The low molecular weight fulvic acids, however, which constitute the bulk of dissolved organic matter in southeastern streams, react with pesticides and toxic metals and keep them in solution. The fulvic acid molecules are apparently unavailable as microbial food and are thus passed on through the system (a fraction of these organic molecules do flocculate and settle in the downstream reaches of rivers and in estuaries). Further research is needed to verify the field significance of these implications.

The soils of non-alluvial floodplains appear different from those of alluvial streams. Limited soil sampling in Florida floodplains revealed that organic matter in surface soils appeared to be significantly higher in non-alluvial floodplains. Wharton (1976) found that eight samples from six non-alluvial floodplains averaged 45% organic matter (range 17.7-78%), while four samples from two alluvial floodplains averaged 3.9% (range 2.8-5.2%). Floodplain soils along the Satilla, a typical blackwater river, are classified in the

Lumbee-Swamp Association, USDA (1968 d). Almost all of the floodplain is in the Swamp soil category with the water table< 15 inches for> 10 months and supporting gum-cypress. Some slightly higher parts or "flats" are considered Lumbee soils, with the water table< 15 for> 6 months and supporting bottom land hardwoods. Small portions of the Satilla floodplain are considered the Rains loamy sand, often wet enough for gum-cypress or dry enough for slash pine, USDA (1965).

## [7] BLACKWATER RIVER AND SWAMP SYSTEM

### Location and Description.

Except for the large alluvial streams which drain the Piedmont, almost all Coastal Plain rivers fall into this category. Large alluvial rivers have, of course, blackwater tributaries as they cross the Coastal Plain. Deep water appears black—hence the name—but when shallow it appears reddish or tea-colored, the color derived from organic acids leached from countless swamps on tributary floodplains. Blackwater streams are very picturesque, since the major sediment is sand, glaringly white in many streams and contrasting with the dark water. These streams fluctuate widely, dropping so low in the fall that caonoeing becomes difficult because of logs and sand bars. Some, like the Alapaha and Suwannee, have limestone shoals. The Alapaha, Withlacoochee, and Little River are potentially enriched by passing through limestone strata in Echols, Lowndes and Brooks counties. Further study may reveal differences among blackwater river systems.

### Flora.

The most striking feature is the absence of floodplains with extensive tracts of bottomland hardwoods. Instead, the floodplain, if present, is mostly occupied by the very wet gum-cypress community which, along alluvial rivers, is confined to sloughs and ox-bows. According to Faircloth (1971), the Little, Withlacoochee, and Alapaha inundate their narrow floodplains for long periods of time. Swamp black gum seems to dominate the floodplains where water movement is restricted and more acid conditions prevail. Tupelo gum and cypress tend to grow in more open water areas with some circulation. The Satilla (Highway 252 Bridge, Camden Co.), for example, has a typical floodplain forest of swamp black gum, with scattered cypress. The river bank supports a complex of shrubs, often including titi (*Cyrilla*) and black titi (*Cliftonia*). In early spring black titi and an azalea (*Rhododendron canescens*) produce striking floral displays. On Little River, riverbank trees are predominantly ogeechee lime and water elm, the understory dominated by sebastian bush (*Sebastiana*) and deciduous holly (*Ilex decidua*). There is much to be learned about these streams. From observations of Florida blackwater streams Wharton *et al* (1976) found bottomland hardwoods growing on high levee ridges, but most hardwoods were growing, not on fluvial deposits, but on moist low sands from local erosion of nearby high ground.

Bozeman and Darrell's (1975) indicator species for non-alluvial, blackwater (class II) rivers are: CYPRESS-GUM DOMINANTS—pond cypress, swamp black gum, ogeechee lime, ash, red maple, water oak, laurel oak, bald cypress, sweet bay; UNDERSTORY—fetterbush, sweet pepper bush, wax myrtle, titi, myrtle holly, possum haw (*Viburnum nudum*), storax, Georgia fever tree; TYPICAL BOTTOMLAND HARDWOODS—swamp black gum, water oak, laurel oak, red maple. Duncan (1969) listed vegetation of the Satilla.

Photo F. Little River, a branch of the Withlacoochee (Lowndes Co.) is a blackwater stream [7] lacking a prominent floodplain. No tupelo gum occurs on streams of this type. The common trees here are ogeechee lime (*Nyssa ogeche*) and water elm (*Planera aquatica*). A common shrub is Sebastian bush (*Sebastiana*). Other blackwater stream floodplains are dominated by swamp black gum and cypress.

A survey of the Satilla (Col. Dan Kingman, U.S. Army Corps of Engineers, Nov. 15-Dec. 27, 1971) from the Atlantic Coast Line R.R. bridge (Waycross-Blackshear) to Magnolia Bluff at Burnt Fort (a distance of 114 miles) indicates the following abundance of hardwoods versus pine flatwoods: two miles of hardwood bluff forest, 1½ miles of "hardwood swamp" (width 300 to 600 feet), and 20 miles of "hardwood fringe" (probably less than 100 feet wide) on one side and five on the other. Thus we have a total hardwood fringe of 25 miles out of 228 miles—the remaining approximate 200 miles of the Satilla was, at that time, bordered with low pinelands.

**Fauna.**

See Appendices III (CP), IV and VI (CP/H) for some aquatic or amphibious fauna of these streams. A rather thorough study of the fauna of a blackwater stream (Satilla) has been conducted by Arthur Benke (pers. comm.). The sands of the Satilla bottom have few species and low biomass, but possess many very tiny individual larvae of midge flies, predaceous ceratopogonid flies, and some oligochaete worms. (Sieve openings of< .1 mm are required to capture these incredibly small animals.) An entirely different fauna is present in the richer river sloughs with caddis and midge flies (such as *Chaoborus*), the isopod *Asellus* sp., and the amphipod *Crangonyx* sp., quite different species from those in either the sand bottom or on submerged snags. It is the community of submerged snags which maintains the detritus-based food chains that feed the river fish. Seemingly devoid of snails and clams and with but few worms or crustacea, these snags, roots, and stems support an incredible insect fauna. The following is a preliminary list of common dominants (courtesy Arthur Benke, Georgia Institute of Technology): **plecoptera** (stone flies) *Acroneuria* sp., *Perlesta* sp.; **ephemeroptera** (may flies) Stenonema (4-5 sp.), *Ephemerella* sp.; **odonata** (dragon flies) *Boyeria vinosa, Neurocordulia molesta;* **coleoptera** (beetles) *Stenelmis* sp., *Ancyronyx* sp.; **megaloptera** (dobson flies) *Corydalus cornutus, Sialis* sp. (largely sloughs); **trichoptera** (caddis flies) *Macronemum carolina, Hydropsyche orris, H. incommoda, Cheumatopsyche* sp, *Cyrnellus* sp., *Chimarra* sp.; **diptera** (midge and black flies) predatory forms: *Ablabesmyia* sp., *Conchapelopia* sp.; Filter-feeders: *Tanytarsus* sp., *Rheotanytarsus* sp., *Polypedilum* sp., *Chironomus* sp., *Simulium* sp.

See **stream fauna** under Alluvial Stream Systems, [10] ALLUVIAL RIVER AND SWAMP COASTAL PLAIN for distribution of invertebrates in Coastal Plain streams.

The following are common fish from the mainstream (not sloughs and swamps) of the Satilla River taken by electrofishing, data courtesy A. Benke and D. Gillespie (pers. comm.): (D) Bluegill, (D) redbreast, (D) spotted sucker, (D) redfin pickerel, (D) taillight shiner (*Notropis maculatus*), (D) shiner (*N. petersoni*). Less numerous but prominent are warmouth, largemouth bass, pirate perch, ironcolor shiner (*N. calybaeus*), silversides, swamp darter (*Etheostoma fusiforme*), and madtom (*Noturus gyrinus*). I suspect that bullheads and perhaps channel catfish are also abundant. In May, 1969 gars were very abundant in certain sections of the Satilla during a 3-day float trip.

Sandow (1971-1972) sampled fish populations on the Satilla and Little Satilla. The most abundant fish were largemouth bass, spotted sucker, and bowfin. The next most common fish were the chain pickerel, black crappie, redbreast, bluegill and spotted sunfishes, warmouth, yellow bullhead, American eel, lake chubsucker, flat bullhead, channel catfish, and madtom catfish. The three Little Satilla sites had standing crops of 313.6, 132.3, and 183.8 pounds per acre.

The aquatic fauna of the gum-cypress swamps of blackwater streams is probably similar to that of the sloughs and ox-bows of alluvial river swamps. The oxygen-poor, acid, shallow water habitats would be inhabited by creatures such as the giant eel salamanders *Amphiuma* and *Siren* and lunged fishes such as the bowfin.

The relatively clear water of the blackwater streams and swamps may assist the feeding of snakes of the genus *Natrix* (especially *N. taxispilota*), cottonmouths, turtles, and alligators. The most numerous and largest water snakes I have ever seen inhabited the Canoochee River, and I once took 15 cottonmouths from a very small section of Chickasawhatchee Creek swamp. On a trip down the Satilla we found both softshell and hardshell turtles common. Predominantly the Florida cooter (*Chrysemys floridana floridana*) and the yellowbelly (*C. scripta scripta*). Alluvial rivers tend to have the river cooter (*C. concinna*) and the yellowbelly.

**Natural and Cultural Values.**

Blackwater streams are fascinating. Both the Satilla and the Alapaha are excellent float streams, offering very white sand bars and a variety of experiences, although not as varied an environment as the great alluvial rivers afford. The Alapaha has some limestone shoal areas as does the Suwannee. It was the first "canoe trail" in the Coastal Plain, and one of the purest of Coastal Plain streams. These streams recharge water tables during high water and, of course, function in degrading pollution although they have limited floodplains. The Satilla and other blackwater streams are productive of fish life in certain sections largely due to a huge assemblage of detritus-feeders on numerous snags and underwater obstructions.

**Man's Impact.**

Pollution, especially by oil, is a recurrent threat to the gleaming white sand bars—lack of large floodplain swamp areas makes oil disposal by the biota difficult. During winter, high-water tannic acids and oil wastes are often flushed into the Satilla by Waycross industry, resulting in a yearly fish kill. In 1965, fish were killed all the way to the coast. Fish from the Satilla are reported to have an oily taste. Public opposition to reservoir construction saved a large segment of the Alapaha from inundation. Channelization and reservoir construction pose the major irreparable threats. Don Scott was one of the first to point out that removing logs and debris (snagging and dragging) was highly damaging to the ecology of southeastern streams. Now, research by A. Benke, D. Gillespie, and others has proven that underwater snags, logs, and limbs provide the habitat for the larval insects that feed game fishes of blackwater streams.

At the Highway 252 bridge (Burnt Fort), the effects of bridge fill on the Satilla floodplain may be seen. The gums adjacent to the river are much healthier than those adjacent to the east edge of the floodplain, where some life parameter has apparently been altered both above and below the bridge fill.

## [8] BLACKWATER BRANCH OR CREEK SWAMPS

### Location and Description.

These are broadleaf tree and shrub communities that occur where drainage is too steep for the development of peat-filled bays and bayheads, but not steep enough so that a head of water carries away the humus and litter annually. They occur as bands of vegetation on moist, organic soils along small streams and are best developed in the Tifton Upland. Harper (1906) indicated that ½ of the woody plants of his branch swamps were evergreen. He indicated that branch swamps frequently dried up, while creek swamps did not. He stated that creek streams rarely got muddy and seldomly had well-defined banks, claiming that the headwaters of the Alapaha and Little rivers near Tifton fell into the creek swamp category. This category corresponds to the stream bank thickets and the woods of Hubbell, Laessle, and Dickinson (1956), and the creek swamps of Clewell (1971). Faircloth (1971) describes them well, and indicates that their vegetation is quite variable. The creek swamps are richer than the acid bays. They do, however, have some of the bay trees. The head of almost every middle and upper Coastal Plain stream, and many branches in the lower Coastal Plain, fall within this category.

### Flora.

The ogeechee lime is a common streamside species as far north as Crisp and Wilcox counties where it is at the northern limit of its range, along with *Gelsemium sempervirens* and *Salix carolinianum,* Bob Lane (pers. comm.). This environment shares species with the bay swamps and the non-alluvial and alluvial floodplains. Two greenbriers (*Smilax walteri* and *S. laurifolia*) are characteristic of river swamps.

Trees: Black gum, sweet bay, tulip poplar, sweet gum, red maple, swamp red bay, loblolly bay, slash pine, loblolly pine, cypress, water oak, ogeechee lime, stiff cornel dogwood.

Shrubs: Rusty blackhaw viburnum, titi, witherrod viburnum, pinckneya, black titi, pinxterflower azalea, alder (*Alnus serrulata*), summersweet clethra, button bush.

Herbs and vines: *Smilax laurifolia, Smilax walteri,* poison ivy, muscadine, climbing hydrangea, trumpet creeper.

### Fauna.

The fauna is similar to that of alluvial and non-alluvial swamp streams. One salamander which occurs in this type of environment is the many-lined (*Stereochilus marginatus*), which also occurs in bay-type streams with sphagnum. The rare spotted turtle (*Clemmys guttata*) has been recorded from this environment by both Gerald Williamson and the author. The Ambystomid salamanders are generally absent from lower Coastal Plain branch swamps, but the southern dusky, two-lined, southern mud and many-lined are present along with a larger fauna in which *Amphiuma, Siren,* rainbow snakes, and cottonmouths occur. See Appendices III (CP), IV, and VI (symbols CP/H).

### Natural and Cultural Values.

These environments are vital wetlands; their vegetation retards excessive run-off. Looking at the satellite composite photographs of the Coastal Plain, we see that the branch swamps control the pattern of agriculture east of the Pelham excarpment. Hundreds of dendritic streams are sharply outlined against the pale shade of agricultural lands. These branches are the first line of defense (in treating wastes) against the nitrates, weedsprays, and pesticides that are run-off pollutants from the agricultural areas.

### Man's Impact.

Channelization poses the single largest threat to the feeder branches and streams. Many branches are ponded into farm ponds.

## (c) ALLUVIAL RIVER SYSTEMS

In contrast to the low mineral transport of the non-alluvial streams, alluvial streams carry considerable silt and clay over long distances (as far as the salt marsh and estuarine systems) and, at the same time (during high water), considerable sand and small gravel by bed load transport. Usually a distinct floodplain is present with the level of the first or major (lowest) terrace at or near mean high water. A sandy, elevated natural levee just inland from the bank is penetrated at intervals by creeks and channels which allow the floodplain to drain.

Flat floodplains are maintained flat by the movement of meander curves thrashing back and forth (if viewed over thousands of years) from one side of the floodplain to the other, sorting and resorting the alluvial materials. This means forest succession is always progressing on the inside of meanders. In stable river systems the rate of growth of the trees should about equal the speed of meander movement. Unlogged floodplains could help us understand much more about stream movement on the floodplain.

As the balanced forest ecosystems clothing the slopes of the Southern Appalachians accomplish their task of soil stabilization and productivity and have developed a protective and flexible steady state system, so also have the floodplain forests. During six months of the year the normal channel carries the entire flow, evenly dissipating the energy in series of meander curves, each guarded by the rootbind of trees on the banks. Meander movement is quite slow. Because the root mat of floodplain trees is near the surface, erosion or scouring is minimized. Man-made disturbances, such as clearcutting, dredging, and channelization, may break rootbind and throw the natural system into disorder and away from the steady state system. In the movement of meanders we really have two processes at work, a continuous lateral and downstream movement of each meander curve, as well as a more abrupt breaking through the natural levee to form a new channel. When a river shortens itself, as in the latter case, the extra energy of the faster drop must be dissipated by increasing the size of the meander curves below the cut, which may mean somewhat faster erosion. We can then appreciate the increased erosion that results when man artificially shortens rivers by dredging cuts as in the Savannah and Mississippi.

If the channel cannot move laterally, an increase in flow volume (such as the diversion of Chattahoochee water plus metropolitan run-off) may cause a river to cut a deeper channel (with increased bank erosion) as has happened on sections of the South River.

Even in the Coastal Plain one finds a number of bedrock rills or "nick points" crossing the stream at intervals, easily observed on the Flint in Macon County and the Ocmulgee between the U.S. 441 and U.S. 23 bridges. These are sandstone outcrops. Although surface shoals or white water are seldom produced; yet the rock bottom, attested often by a change in the molluscan fauna, is nevertheless present.

Geologists consider these nick points or natural dams to be the major geologic control for floodplain or swamp origin. Steeply pitching streams are forced by them to flatten out, slow down, and meander. By doing so they drop their heavier sediments, forming flat floodplains.

The floodplain upstream from the nick point, however, is not flat but is built up from the upper end much as a reservoir is filled in from the upper end. The stream and land surface thus represents a gradual slope. The degree of slope is adjusted by the stream, depending upon the type and amount of sediment supplied by it and by the volume of water supplied by it. Theoretically, the more sediments supplied at the upper end of the system, the steeper the slope and the more meanders necessary to dissipate the additional kinetic energy down to the nick point. Thus, a stream can be driven to aggrade (or raise) both its bed and its floodplain by increased run-off and sediment, both the latter generally occurring through man's faulty management of agriculture, especially row-cropping. If these man-made changes do not take place too quickly, stream-swamp systems can and do accommodate our errors and continue to function as protective and productive environments

Often several elevations or terraces of the floodplain floor may be visible. Their age is problematical. The second terrace may be a product of the 50-or 100-year flood. High terraces have been related to higher stream flow during the last (Wisconsin) glaciation. G. Plummer (pers. comm.) suggests, and evidence seems to concur, that for the past 10,000 years there has been a general drop in river volumes throughout the Southeast. Some authors have recognized several terraces in Georgia streams, although it is not customary to speak of first and second terraces as is done in the Mississippi valley. Farming and erosion, reservoirs, and ditching tend to destroy the evidences of local alluvial terraces. Old terraces on the Flint River floodplain below the 128 (Taylor Co.) bridge, the uppermost of which have been diked and farmed, are examples.

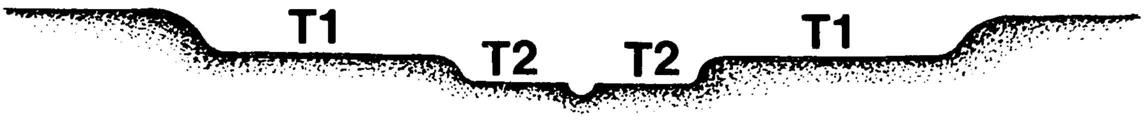


Fig. 4. Cross section of floodplain. Tl=terraces (perhaps "second bottoms"), possibly remnants of Pleistocene floodplains when stream flows were higher.

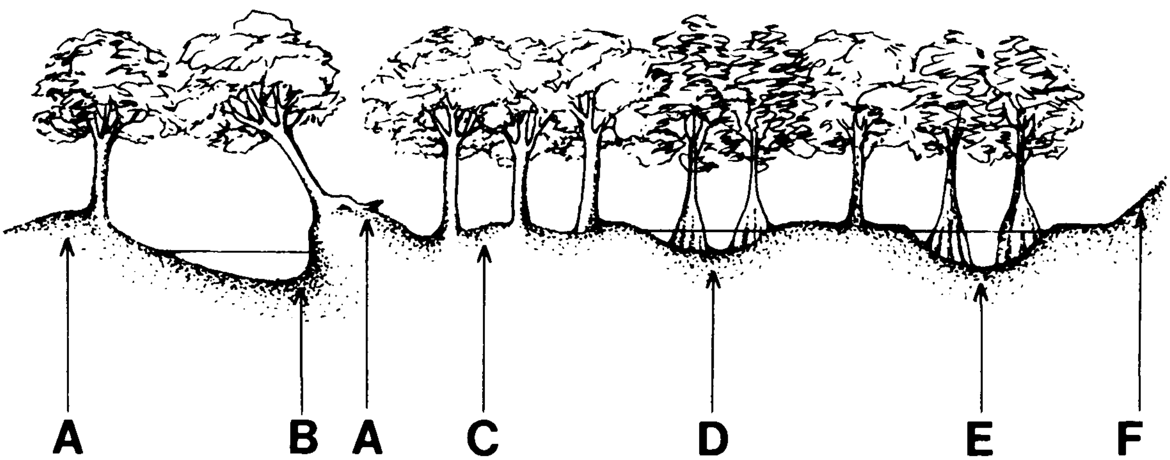


Fig. 5. Profile of a river floodplain. In the Piedmont it may be 30 feet down to bedrock. The floodplain is filled with gravel and sand, with a veneer of clay on the surface. (A) natural levee; (B) outside of meander curve—current cuts deep hole because root bind inhibits lateral movement; trees lean and eventually fall; canopy shades water; (C) floodplain floor (level of mean annual high water with logs and debris—bottomland hardwoods (such as water hickory, overcup oak, sweet gum) grow here; (D) depression pool with tupelo or swamp black gum; (E) oxbow lake (old meander loop) usually with tupelo gum (*Nyssa aquatica*) or cypress; (F) high ground (valley wall), possibly a bluff forest. It supports a mesic forest often with beech and seldom is damaged by fire.

Figure 5 is a cross-section of a typical alluvial stream.

Oxbow lakes form when high-water channels cut across the "neck" of meander loops and a bar builds across the upper end, the lower end usually remaining open. One of the finest examples is in the floodplain opposite the Hatch Nuclear Plant at Baxley. These half-moon lakes can often be reached by vehicle.

Wharton (1970) indicated that the floodplain and the stream that formed it act as a "geo-hydro-biological entity." This becomes clearer if we realize that the entire floodplain of southern rivers is their high-water channel, while the normal bed of the stream acts as a low-water conduit. The floodplains prevent excessive damage (disorder) to the low-water channel (the river), disposing of the excess energy of increased winter water by allowing it to first run through numerous side channels and cut-throughs, and then to overtop the banks and move by sheet flow over the floodplain where the excess energy is drained off by the frictional resistance of vegetation and soil. It is then that temporary "flood" storage, ionic exchange, and silt deposition functions of the floodplain become clearer.

In contrast to mountain streams, the kinetic energy of alluvial streams is moderate. Trophic energy production, however, is considered moderate to high if we include the floodplain. This productivity is the result of the hydrologic regime, as follows.

One of the major characteristics of river swamps is that they are fluctuating water level ecosystems and have annual pulses of fertility and life produced by the alternating high and low water. This fertility is a result of the decomposition of organic material caused by alternate wetting and drying and the action of the biota, and because of an influx of mineral nutrients brought in as silts or clays.

Some food chains involve autotrophic (largely periphyton) primary producers, but most appear to be based principally on detritus decomposers. Following detrital decomposition on floodplain surfaces and in pools and oxbows, winter and spring high water flushes these nutrients into the main stream and into downstream communities along with many of the floodplain organisms.

Thus, particulate matter and organisms flushed into oxbows, pools, and river channels in winter and spring and delivered over the floor of the floodplain forest constitute a nutrient pulse that is undoubtedly important to the various trophic levels of the ecosystem. The binding and use of overbank deposits of silt and clay by the flora and fauna is probably another characteristic feature of these such systems. These nutrient pulses appear to be followed by pulses in living biomass, in such things as macrobenthic invertebrates and fish.

Thus, it is easier to understand why life-forms in both stream and floodplain are dependent upon the annual rise and fall of water levels. As more thoroughly discussed under Altamaha River fauna, the spawning of some species of fishes actually coincides with the rising water and their eggs are deposited on what was formerly (for six months) dry land. The period during which high water stands (or flows) across the floodplain is called the hydroperiod. For most Georgia streams it is a winter and spring phenomenon.

There are usually four major annual inundations in Piedmont streams, Fig. 6, but in the Coastal Plain, streams such as the Altamaha have these smoothed out either by reservoirs or floodplains (or both), so that the curve does not show individual peaks, Fig. 7. Such large streams may keep water over the floodplain for a six-month period, followed by a six-month dry-down.

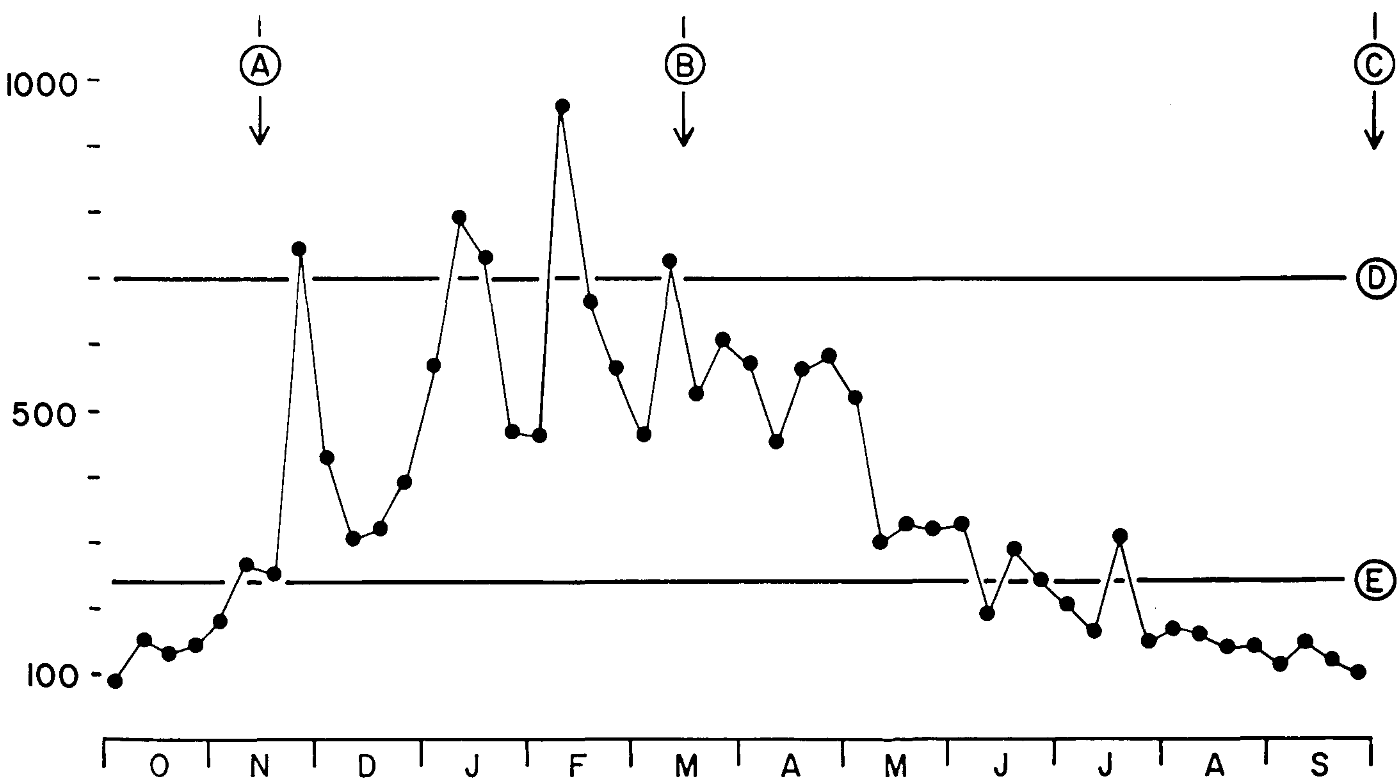


Fig. 6. Hydrograph of the Alcovy River (Wharton, 1970): (A) time of leaf fall; (B) beginning of leaf-out and rapid spring growth; (C) end of growth period; (D) calculated cubic feet per second (CFS) for the east bank at bankfull stage; (E) CFS for the west bank at bankfull stage. The hydroperiod of most of the swamp is about 6 months above (E); 4 annual peaks of complete inundation of the entire floodplain are indicated above line (D), vertical scale in CFS.

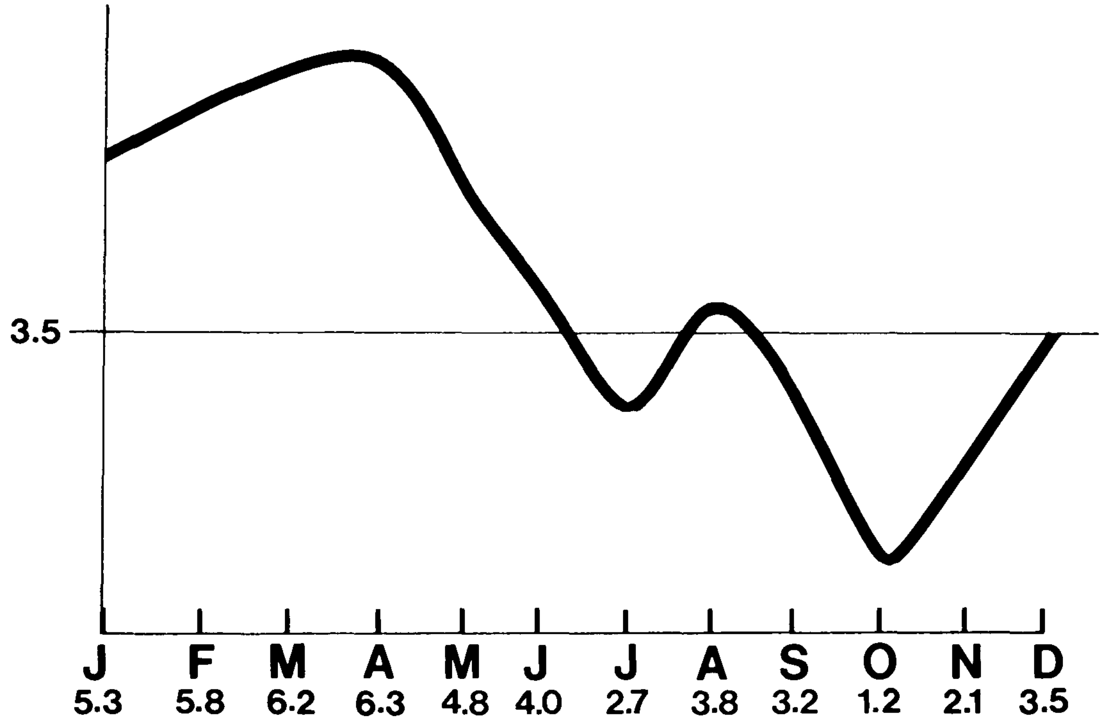


Fig. 7. Water levels in the Altamaha recorded by the U.S.G.S. at Doctortown (Wayne Co.) for the four-year period 1968-1971, relative to 3.5 feet (considered to be the level at which vehicles can be driven on the floodplain). Walking on the floodplain is possible from June to December. The floodplain is under water for the period January - June. Compare with a typical Piedmont floodplain (fig. 6) with its four peak inundations. Coastal Plain streams "smooth out" Piedmont fluctuations. Vertical scale is in feet. Monthly mean water level is given on horizontal scale.

The six-month inundation and higher water tables prevent the establishment of a pronounced herb layer on the floor of the floodplain and favor tree (and a few shrub) species adapted to this environment. In fact some tree species, such as sweet gum, will suffer stress and disease if the water table is lowered (by channelization). On the other hand, artificial flooding through the early part of the growing seasons results in up to 50% increases in tree growth. Water must not inundate the root crown later than July 30, however, lest low oxygen levels kill the trees. Summer rains provide some oxygenation to flooded river swamps in early summer.

When it comes to classification, river swamp ecosystems seem most troublesome to pin down—largely because there are several easily recognizable biotic communities within an alluvial river floodplain system. Braun (1950) lumped three habitats into one she called bottomland forests—these were "swamp forests" (equated with deep swamps, true swamps, sloughs) where water stands the year around; "hardwood bottoms" flooding in winter and spring; and "ridge bottoms." Penfound (1952) recognized two distinct communities in river floodplains, "deep swamps" with surface water throughout most or all of the growing season and "shallow swamps" where the soil is inundated for only short periods during the growing season. These two types are seen in both Piedmont and Coastal Plain swamps (we often use the word "swamp" to include both). In Georgia, we find "flow through" situations where water is more or less coninuously flowing in shallow channels. Here grows tupelo gum on the Alcovy River (Newton Co.), in cuts between oxbow meanders. In one case, Cornish Creek has formed a sheet flow swamp with numerous braided channels, sustaining 20 acres of pure tupelo gum forest. The most dramatic, idealized example of this latter situation is the braided stream system of the Four-Hole Swamp (South Carolina). In the Coastal Plain, cypress grows with tupelo in this situation. Both trees have swollen bases.

The second type of environment is perhaps best called a bottomland hardwood community. Only a foot or so higher in elevation, this area grows hardwoods which are adapted to high water tables but cannot tolerate constant submergence of root systems. Since the river and its floodplain function together as a dynamic unit, in this paper we consider these two facets of a single environment called the **alluvial river and swamp.**

The hydroperiod of these two different environments indicates the turnover rate of the water. Obviously, a cypress pond (still water) with a six-month hydroperiod of standing water has far less opportunity to receive an input of minerals than a river swamp with a six-month hydroperiod and waters being continually brought down and through the system from the mineral-rich Piedmont. Pool *et al* (1972) have summarized this type of approach. The cypress-tupelo flow-through community, called by them "flowing water swamp", has a high water turnover rate (> 6 months), an extremely long hydroperiod, and a low species diversity: the bottomland hardwoods, on the other hand, have a shorter hydroperiod (< 6 months) and a high species diversity.

Photo G. From the air a Piedmont river swamp [9] (Alcovy River, Newton County) appears as a broad band of hardwoods bordered by fields and pine-clad hills on either side. The swamp ecosystem supports a diverse and productive biota adapted to alternating high and low water flows. For society, such a greenbelt has high values in education, recreation, and natural water treatment.

## [9] ALLUVIAL RIVER AND SWAMP SYSTEM-PIEDMONT

**Location and Description.**

Alluvial streams in the Piedmont have three general appearances: shoals, sometimes with white water and falls; the gently meandering slower runs; and the strongly meandering slow water. Narrow floodplains, usually less than ½ mile in width, may border one or both sides of the stream. Shoals which are degrading (wearing down) tend to alternate with floodplains or bottomlands (swamps) which are generally maintained by aggrading. According to Staheli (1976, 1977), the majority of Piedmont swamps are controlled by a hard rock dam (nick point) at the lower end.

Floodplain soils of the Alcovy River (Walton Co.) are classified in the Chewacla-Wehadkee Association, USDA (1961). Both soils are poorly drained and consist of sandy loams and clay loams. Soils on the Oconee (Clarke Co.) floodplain are the Congaree-Chewacla-Alluvial Land Association, USDA (1968c). Congaree soils are better drained. All soils cited above appear to support bottomland hardwoods. Chattahoochee floodplains (Fulton Co.), if unaltered young alluvium, are called Buncombe loamy fine sand-islands in the river are Congaree fine sandy loam, USDA (1958). Murder Creek's (Jasper Co.) floodplain is better drained than those of the Oconee and Alcovy, and is classified as Congaree silty clay loam, USDA (1918). It is less sandy and less acid and supports a somewhat different vegetation. The upland rocks near it contain little sand and are gabbro or hornblende schists, instead of granites and gneisses. There is an unusual glade community in Jasper County which can be classified as a wetland owing to a plastic olive clay subsoil layer which is impermeable. This remarkable "upland swamp" environment covers seven square miles. The soils are Iredell and Mecklenburg loams.

**Floodplain Flora.**

Nelson, Ross, and Walker (1975), analyzing Forest Service data, indicated that 9% of the forest land in the Piedmont was bottomland hardwoods. They recognized a riverfront association, limited to edges of creeks and rivers, having as principal species river birch, sycamore, sugarberry, and green ash, and a green ash association on the lowest bottoms to be the two most common associations of Piedmont floodplains. They indicated that these bottomland oak, boxelder, and sweet gum associations were intermediate in occurrence. According to Nelson *et al*, the bottomland oak association has as principal species water, willow, overcup, cherry bark, and swamp chestnut oaks. They outnumbered pure stands of water oak or willow oak. Their sweet gum (on first bottoms) and boxelder (throughout the bottoms) associations have these trees alone as principal species. I have noted green ash flats on Wolf Creek (Jasper Co.) and on the South River (Dekalb Co.), and small groves of water oaks occur irregularly throughout the floodplains of the Piedmont. Sweet gum stands are likewise frequently encountered, but are generally of small extent.

Floodplains of the Chattahoochee have been highly modified by Caucasians and probably by the Indians to some extent. A Chattahoochee floodplain that has been under Cherokee and Causcasian agriculture now bears a young forest with dominants of pignut hickory, river birch, poplar, and sassafras with water oak, black walnut, boxelder, and loblolly pine as co-dominants, and with black cherry, sweetgum, and mulberry as sub-dominant species. Many normal bottomland hardwoods are conspicuously absent. The aberrant nature of this forest is probably due to several factors other than man's modification through agriculture. Flow regulation by the Buford dam may be a factor, but, also, the Chattahoochee differs from the Ocmulgee, Oconee, and Flint by receiving most of its flow from mountain area; thus the inundation of the Chattahoochee floodplain may have been irregular and the flora less dependent and adapted to flooding. Because of this, the ground cover of the Chattahoochee floodplain is somewhat different from other Piedmont swamps. Honeysuckle (*Lonicera japonica*) and the grass, *Microstegium vimineum,* are abundant. Other common plants are the trumpet creeper (*Campsis radicans*), muscadine, river cane, Christmas fern, and various asters.

The Alcovy floodplain supports disjunct forest of tupelo gum which occupies old oxbows and cut-off channels (floodways), Photo H. The primary bottomland hardwood canopy is composed of red maple, sweet gum, swamp chestnut oak, red ash, hickory, willow oak, and overcup oak, with an understory of dogwood (*Cornus stricta*), possum haw (*Ilex decidua*), and *Lyonia ligustrinus*. The highest Alcovy terrace has water oak and green ash with paw paw and blueberry (*Vaccinium elliottii*). Radford and Martin (1975) described the area below the 278 bridge (Newton Co.) as the best stand of water tupelo for size and dominance seen by Radford in the Southeast in recent years, and stated that this "swamp forest is the northernmost extensive stand of coastal bottomland hardwoods in the Piedmont." The rattan vine (*Berchemia scandens*), poison oak, and muscadine are common vines. The herbs are (D) crossvine, green dragon, (*Arisaema draconteum*), (D) spiderwort (*Tradescantia virginiana*), (D) false nettle (*Boehmeria*), (D) *Sanicula* sp., (D) never-wet (*Impatiens* sp.), (D) *Ranunculus* spp., *Senecio glabellus, Oxalis violacea,* loosestrifes (*Lysimachia* sp.), *Pilea pumila, Galium aparine, Lacineata* sp., (D) *Duchesnia* sp., a mint (*Lycopus* sp.), the (D) chain fern (*Onoclea*), and in wet places (D) lizard tail (*Saururus*). There are a number of Aster species which appear sequentially through summer and fall. The most common lily is the spiderlily in wet places and atamasco lily (*Zepharanthes atamasco*) in ecotones. Other mesophytes, such as mayapple, occur in ecotonal situations.

The Flint Piedmont floodplain has not been intensively studied. Besides the typical species present on the Alcovy, it has some additional Coastal Plain species. Between Woodbury and Pobiddy bridges both the bitternut (*Carya cordiformis*) and the water hickories (*C. aquatica*) are found. As on the Broad River, the Catalpa tree is a common streamside species of the lower Piedmont and the groundnut vine (*Apios*) is abundant. The sweet bay occurs in the Flint floodplain on feeder streams in Pike County and in large stands on Walnut Creek near Woodbury (Meriwether Co.). It seldom occurs elsewhere in the Georgia Piedmont except on the headwaters of the Alcovy River (Walton and Gwinnett counties), although Duncan (pers. comm.) records it for other counties to the east (Oconee?). The distribution of the tupelo gum in the Georgia Piedmont floodplains is even more striking. It is confined to the Alcovy River mostly in Newton County, and its only other Piedmont occurrence appears to be in Upson, Pike and Meriwether counties on the edge of the Flint River. These disjunct areas are also reflected in the fauna and indicate two relict pockets of Coastal Plain species in the Piedmont.

Photo H. Tupelo gum (*Nyssa aquatica*) in an ox-bow lake of the Alcovy River (Newton Co.) [9]. Older trees are frequently hollow and provide nesting sites for wildlife. The seeds and fruits are food for wildlife, and bees make excellent honey from the flowers.

The beautiful floodplain forest of the Murder Creek Natural Area (Jasper-Putnam Co.), distinguished by species such as cottonwood, honey locust, hackberry, and hardy orange, suggests that its flooding regime or soil differs somewhat from the typical Piedmont floodplain forest. The drastic difference between this forest and that of the Alcovy is noted by Radford and Martin (1975) who cited the lack of levees, the better-drained sandy loam soils, and the diverse, extensive herb layer of the Murder Creek floodplain. Dominant trees and shrubs appear to be swamp chestnut oak, water oak, willow oak, oglethorpe oak (?), bitternut hickory, hackberry, southern sugar maple, trifoliate orange (*Poncirus trifoliata*), river cane (localized) and red buckeye.

Unique **upland swamp glades** worthy of being described as separate environments occur on Iredell soils over gabbro in the central Piedmont. In one, three miles south of Monticello (Jasper County) the wetland aspect is maintained by rainwater over a subsurface clay pan, rather than by periodic creek flooding. A remarkable tree association occurs with the following dominants: Oglethorpe oak (*Quercus* oglethorpensis), pin oak (*Q. palustris*), post oak (uniquely), red ash, southern shagbark hickory (*Carya carolinae-septentrionalis*), and loblolly pine. The shrubs are no less unusual. The swamp palm (*Sabal minor*) is a disjunct species here. W. Duncan, who first called attention to this area, noted the unique occurrence of two viburnums (*Viburnum rufidulum* and *V. prunifolium*). Radford and Martin (1975) noted the Coastal Plain parsley haw (*Crataegus marshalli*), spring beauty (*Claytonia*), adderstongue fern (*Ophioglossum vulgatum*) and supplejack (*Berchemia*).

**Stream Fauna**

The shoal areas (6 to 100 feet fall per mile) support a different biota from the slower stretches of Piedmont streams. The shallow, oxygenated water has abundant life. Clams in this niche usually have thicker shells. There are often heavy growths of *Podostemum ceratophyllum* whose dense mats house a great variety of organisms, some possibly unique to this habitat. Snoddy (1971) described a new species of black fly (*Simulium podostemi*) from this plant in Flint River shoals.

The most thorough study of a shoal area was done by Nelson and Scott (1962) on Middle Oconee River (Clarke Co., gradient 70 feet per mile). The rocks supported a growth of the primary producer, *Podostemum ceratophyllum*. The stream, however, was classed as heterotrophic, the primary consumers deriving 66% of their energy from particulate organic matter (leaves and pieces of leaves). The authors classified their invertebrates into the following feeding categories: herbivores, filter feeders, detritus feeders, detritus-herbivores, and carnivores.

Nelson and Scott found that the numbers of taxonomic groups and the numbers of individual bottom-dwelling organisms fluctuated widely with river discharge. River discharges over 1000 CFS reduced the population 43-88%, but apparently recovery between high flows was relatively rapid. The plant *Podostemum* recouped its losses rapidly. The authors found that at low flows the dissolved and colloidal organic load was from 2-10 times greater than the particles of organic material, but during high flows the particulate matter was double the former. An important finding was that the Oconee stream bottom acted as a reservoir which maintained a supply of organic material (200-300g per $m^2$) and silt in the flowing water when there was no surface run-off to bring leaf particles and silt into the stream from the floodplain. Obviously, the many organisms dislodged by high water became part of the drift community and serve to feed downstream areas. Then the bottom community apparently recovers much of its biomass so that community structure is preserved.

The animal species one collects in Piedmont streams vary with factors such as stream size, water quality, time of year, stream bottom, and collecting technique. It is thus difficult to present a list of species common or dominant in Piedmont streams. However, with the help of Fred Parrish and Arthur Benke, a preliminary list of animals from clean streams follows: **oligochaeta** (worms), *Pristina* si,, *Limnodrilus hoffmeisteri;* **gastropoda** (snails),*Goniobasis* (shoals), *Campeloma lima* (pools), *Physa* sp.; **pelecypoda** (clams), *Corbicula manilensis, Sphaerium* sp.; **crustacea** (crayfish and isopod), *Procambarus spiculifer, Asellus* sp.; **plecoptera** (stoneflies), *Peltoperla* sp., *Acroneuria* sp., *Leuctra* sp.; **ephemeroptera** (May flies), *Baetis spinosa, Stenonema annexum, S. pulchellum;* **odonata** (dragonflies), *Boyeria vinosa, Agrion maculata, Progomphus obscura* (burrower); **coleoptera** (bettles), *Macronychus glabratus, Stenelmis* sp., *Helichus* sp., *Ancyronyx variegatus, Dineutus* sp.; **megaloptera** (dobson flies), *Nigronia serricornis, N. fasciatus*; **trichoptera** (caddis flies), *Hydropsyche* sp., *Cheumatopsyche* sp., *Lype* sp.; **diptera** (true flies), *Tipula* sp., (crane fly); *Corynoneura* sp., *Cricotopus* sp., *Rheotanytarsus* sp., *Tanytarsus* sp., *Polypedilum* (3 sp.), (midge flies); **hemiptera** (true bugs), *Gerris* sp., *Corixa* sp. See *Fauna,* Coastal Plain Streams, for other notes on invertebrate distribution.

A thorough study of aquatic insects in a Piedmont creek was done by Caldwell (1973).

By combining data of Ocmulgee drainage headwater streams, such as the Alcovy (Newton Co.) and Big Haynes Creek (Rockdale Co.), the most common fish in our samples appear to be: Spotted sucker (*Minytrema melanops*), creek chub sucker (*Erimyzon oblongus*), brown bullhead (*Ictalurus nebulosis*), red face chub (*Hybopsis rubrifrons*), Altamaha shiner (*Notropis xaenurus*), black crappie (*Pomoxis nigromaculatus*), bluegill sunfish (*Lepomis machrochirus*), long-eared sunfish (*Lepomis megalotis*), flier (*Centrarchus macropterus*), warmouth (*Lepomis gulosus*), blackheaded darter (*Percina nigrofasciata*), cypress darter (*Etheostoma proeliare*), pickerel (*Esox americanus*), and black bass (*Micropterus salmoides*).

McSwain (1971) sampled three shoal areas on the Flint River in Upson County. The standing crops of fish, 56.7, 59.8, and 52.5 pounds per acre (average 56.0), were remarkably uniform for these shallow, swift, and rocky areas. The most abundant fish were gizzard shad, flat head catfish (introduced), channel catfish, snail, and spotted bullheads. The next most common fish were greyfin redhorse, bluegill, and redbreast sunfish.

A number of Alabama drainage streams, particularly tributaries of the Etowah and Tallapoosa, lie within the Piedmont. Their fish fauna is strikingly different, owing to a number of endemic fishes (32) found only in this system, Dahlberg and Scott (1971), only four species of which are shared with the Chattahoochee: *Notropis xaenocephalus, Carpiodes cyprinus, Hypentelium etowanum,* and *Fundulus stellifer.*

We have seven years of rotenone collections from Noonday Creek, a Cobb County tributary of the Etowah. The following is a list of fish from this stream and one of its small tributaries, since Noonday was channelized in 1955 (see comments under **man's impact**): (D) chestnut lamprey (*Ichthyomyzon castaneus*), southern brook lamprey (*L. gagei* 1), blacktail redhorse (*Moxostoma poecilurum* 2), spotted sucker (*Minytrema melanops*), Alabama hogsucker (*Hypentelium etowanum*), (D) bandfin shiner (*Notropis zonistius* 3), striped jumprock (*Moxostoma rupiscartes* 1) stoneroller (*Campostoma anomalum*), (D) chub (*Hybopsis storeriana* 1), chub (*Nocomis leptocephalus*), (D) bluntnose minnow (*Pimephales notatus*), (D) creek chub (*Semotilus atromaculatus*), brown bullhead (*Ictalurus nebulosus*), yellow bullhead (*Ictalurus natalis*), (D) speckled madtom (*Noturus leptacanthus*), madtom (*N. nocturnus* 1), northern studfish (*Fundulus stellifer*), threadfin shad (*Dorosoma petenense* 3), (D) bluegill (*Lepomis machrochirus*), (D) redbreast sunfish (*L. auritus*), white crappie (*Pomoxis annularis*), black crappie (*P. nigromaculatus*), green sunfish (*Lepomis cyanellus*), spotted bass (*Micropterus punctulatus*), (D) redeye bass (*M. coosae*), logperch (*Percina caprodes*), blackbanded darter (*P. nigrofasciata*), bronze darter (*P. palmaris* 2), and banded sculpin (*Cottus carolinae*).

1. Tentatively identified as new record, needs verification.
2. Endemic to Alabama drainage.
3. Probably or definitely introduced.

Owing to our being able to seine some Flint River beaver ponds and set traps at the draining of one, we have a good record of fishes of a Piedmont swamp, although there are indications that the swamps of the upper Flint support, like the Alcovy, a rather unique fauna. (See [39] BEAVER DAM TYPE for fishes of the Flint floodplain.)

Evidence is now mounting that both upstream and downstream reaches of a Piedmont stream are important in the overall biotic function of the streams. Holder's (1970) and Gasaway's (1973) work on Coastal Plain streams support this conclusion. Hall (1971) studied fish movement in New Hope Creek in the North Carolina Piedmont which probably is indicative of most of our unpolluted Piedmont streams. He trapped 27 species of fish. The most common species were (in descending order of total number): whitemouth shiner (*Hybopsis leptocephalus*), redbreast sunfish (*Lepomis auritus*), redhorses (*Moxostoma robustum, M. collapsum*), bluegill (*Lepomis machrochirus*), pickerels (*Esox niger, E. americanus*), bullheads (*Ictalurus platycephalus, I. brunneus*), and chubsucker (*Erimyzon oblongus*).

Hall's fish showed a consistent pattern, with the larger fish moving upstream and the smaller downstream, resulting in a movement of biomass upstream. Hall postulated that the native fish, by migrating upstream, were able to place their young in the more productive (and less exposed to predation) headwaters of Piedmont streams. He also found, quite remarkably, that a much larger biomass of frogs moved upstream (73.5) rather than down (4.6). Even more crayfish biomass moved upstream (12.8) instead of down (10.9), whereas more turtle biomass moved down stream (634.8) instead of up (459.7). Obviously, even a small dam or weir would interfere with this natural migration. While upstream areas have more extreme diurnal pulses of oxygen, they also have in the spring a larger pulse of productivity. Juvenile fishes, owing to population pressure, oxygen demand, etc., must move downstream to the security of larger pools and do so in great numbers. Hall found his Piedmont stream dependent upon detritus from leaf fall and organic run-off. He showed that mayfly and stonefly larvae quickly skeletonize dead leaves, thus playing a significant role in the food chain. New Hope Creek flows through a mature Piedmont oak-hickory forest. Hall points out the value of a natural streamside ecosystem in retaining vital nutrients. He suggests two important reasons for preserving the original watershed: (1) "for maintaining stocks of nutrients in valuable locations such as forests" and (2) "keeping the same nutrients out of oligotrophic streams where they might cause undesirable eutrophication if they should be released." It has been demonstrated at Hubbard Brook that clearcutting causes this type of stream pollution.

Photo I. Piedmont bottomland hardwoods [9] seldom are allowed to reach the size of this water oak on the Alcovy floodplain at Flat Branch (Walton Co.). Although cypress is not found in these swamps, such Coastal Plain trees as tupelo gum and sweet bay do occur along with some Coastal Plain animals such as bird-voiced tree frogs and mole salamanders.

### Floodplain Fauna

Enormous hatches of mayflies (largely *Leptophlebia* sp.) occur in early spring on the Alcovy River floodplain, followed (in the pools) by the dominance of minute isopod crustacea (*Asellus* sp.) (with some amphipods, *Hyalella azteca*), whose population declines as water levels fall and mud-loving oligochaete worms proliferate. Up to 100 mayfly nymphs and 1,500 fingernail clams (*Musculium*) have been recorded, Parsons and Wharton (1976).

A complete tabulation of invertebrate life on the Alcovy floodplain has not been completed. The two dominant crayfish are *Cambarus latimanus* and *Procambaus spiculifer.*

The Chattahoochee floodplain supports a vertebrate fauna essentially similar to that of other Piedmont floodplains. Some deciduous forest bluff species, such as the slimy and red-backed salamanders (*Plethodon glutinosus* and *P. cinereus*), sometimes occur on higher parts. The Chattahoochee fauna differs from that of the Alcovy in that it has, in addition, the following amphibians: the newt (*Notophthalmus viridescens*), the spade foot toad (*Scaphiopus holbrooki*), and Fowler's toad (*Bufo fowleri*). The green anole (*Anolis carolinensis*) and the 5-lined skink (*Eumeces fasciatus*) inhabit the Chattahoochee floodplain, whereas the other skink species (*E. inexpectatus*) is confined to the bluff forests, seemingly a common Piedmont phenomenon. The spadefoot toad and the 6-lined racerunner are probably present owing to the cessation of flooding and the very sandy nature of the Chattahoochee floodplain which favors burrowing. The small mammal fauna of the Chattahoochee floodplain is essentially similar to that of the Alcovy except that owing to the more sandy conditions noted above, the semifossorial pine vole (*Pitimys pinetorum*) and the fossorial mole (*Scalopus aquaticus*) are additional elements.

Thorough collecting of the Alcovy floodplain reveals that among the salamanders, the two-lined is by far more common than the three-lined (*Eurycea* spp.). The marbled salamander (*Ambystoma opacum*) is spotty in distribution, but not nearly so much as the showy spotted salamander (*Ambystoma maculatum*), which is confined to the higher terraces. The rarer salamanders are the two reds (*Pseudotriton ruber* and *P. montanus*) and the four-toed salamander (*Hemidactilium scutatum*). The southern dusky salamander is locally abundant in very moist places. The mole salamander (*Ambystoma talpoideum*) has apparently a disjunct population on the Alcovy—it is a Coastal Plain form.

Of the frogs, the bull, green and cricket frogs are most common. The spring peeper becomes locally abundant at breeding time. The leopard frog, American toad, and narrow-mouthed toad are sometimes encountered. There is a remarkable disjunct population of the bird-voiced tree frog in the Alcovy swamps. although they also occur (along with green tree frogs) on Wolf Creek, an Oconee tributary in Jasper County.

The most common reptile on the floodplain is the box turtle—snakes are rare. Painted turtles are confined to quiet oxbows; the mud and musk turtles (including the loggerhead musk) inhabit channels as well. The primary slider is the river turtle (*Pseudemys concinna*). Often schools of these turtles can be seen in pools in shoal areas. Spiny soft shells were once common in pre-pollution days. The brown water snake (*Natrix taxispilota*) appears to be dominant on the Alcovy where, remarkably, it shares the shoal areas with the common banded water snake and queen snake.

Among the mammals using the river resources directly are the otter, mink, raccoon, and muskrat. The dominant small mammals on the floodplain are the short-tail (*Blarina*) and long-nosed (*Sorex longirostris*) shrews which scamper over the often bare forest floor winter and summer, seeking the rich insect and worm fauna. Three rodents are at home on the floodplain of the Alcovy: the deer mouse (*Peromyscus leucopus*), the golden mouse (*P. nuttali*), and the meadow jumping mouse (*Zapus*). Interestingly, some of Georgia's largest deer come from the river swamp areas of Newton and Walton counties. The swamp rabbit (*Sylvilagus aquaticus*) and the beaver are conspicuous herbivores of Piedmont floodplains. (See [39] BEAVER POND environment.)

The bowfin (*Amia calva*) is common in beaver ponds of the Upper Flint. This fish, like the cottonmouth, mud snake, green tree frog, and Barbour's map turtle recorded from the upper Flint, is a member of the Coastal Plain fauna, suggesting disjunct populations and, like the Alcovy, evidence of a swamp habitat that existed there long before the coming of Caucasian man.

The most common birds of Georgia river swamps are the Prothonotary, Parula and Magnolia Warblers, Alder and Acadian Flycatchers, Grey Kingbird, Chuck Wills Widow, and the Red-breasted and Pileated Woodpeckers. Flocks of Robins, Waxwings, and blackbirds pass through in migration. They are agents for the tupelo trees on the Alcovy River, and probably also have contributed to the establishment of some introduced species which have done well in Piedmont swamps, such as the privet (*Ligustrum sinense*). The Black Duck and Mallard habitually winter in Georgia river swamps. The Wood Duck nests there, and the Red-shouldered Hawk and Barred Owl are nearly confined to river swamps, the latter feeding heavily on crayfish which emerge at night to walk the floodplain floor.

**Natural and Cultural Values.**

The slow-moving floodplain sections of Piedmont streams have important value in maintaining water quality and quantity, producing animal products, and in the stabilization and use of silts and clays accumulated from the row-crop monoculture and urban activity on the Piedmont uplands. The contributions and value of a Piedmont swamp system were detailed by Wharton (1970). Further data on purification of the Flint River between Highway 138 and 54 is detailed by WQCS (1971) and DNR 1976. In brief, the swamp acts as a natural regulator of water quantity, as a filter for pollutants and toxins, as a remarkable linear wilderness or green belt, as an outdoor laboratory for the eductional system, and as a diverse, productive, and balanced environment that provides life support for the tremendous acreage in agriculture, tree farms, and urban development.

The shoal sections of Piedmont streams are picturesque, have a distinctive fauna, aereate the river, and provide exciting white water during float trips. The Piedmont floodplains, such as the Alcovy and Flint possess, provide pockets of unique flora and fauna and pose (and may answer) many questions of value to science. Many Piedmont archaeological sites are on or at the edge of the floodplain or near shoal areas where shellfish were plentiful.

**Man's Impact.**

The inpact of channelization in modifying the Piedmont floodplain ecosystem has been detailed by Wharton (1970), Figure 8.

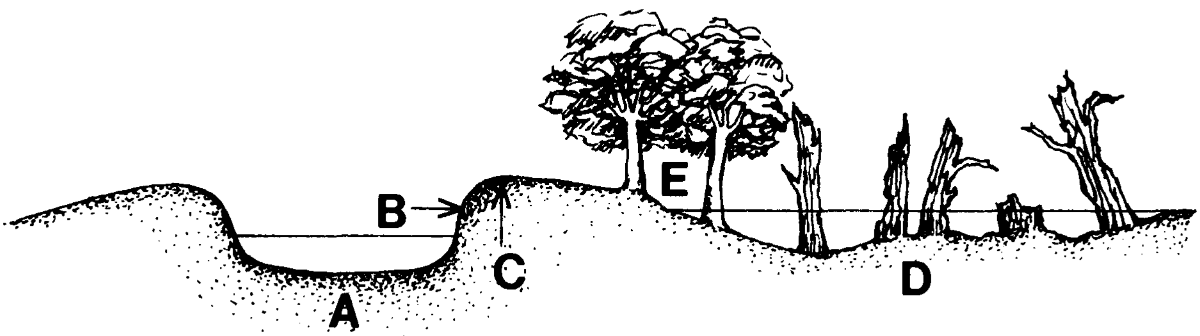


Fig. 8. Profile of Piedmont floodplain following modification by channelization. (A) streambed; (B) steep slope on both sides of stream; (C) artificial levee; (D) water ponded behind artificial levee - bottomland hardwoods are destroyed by water which is unable to move off the floodplain; (E) Successional and riverbank species (such as river birch) are found here.

There have been suggestions, Trimble (1970), that Piedmont swamps are man-made. Staheli, Ogren, and Wharton (1974) indicate that while there may be several feet of recent clay sediment in Piedmont swamps, such as the Alcovy, these swamps originated long before the arrival of Caucasian man. The presence of ox-bows and animals which breed in them (bird-voiced tree frog) and the occurrence of disjunct wetland burrowers, such as the mole salamander, provide additional evidence for the antiquity of Piedmont swamps. Regardless of their origin, these floodplain systems support a stable, unique, and diverse biota which stabilizes and uses sediments and pollutants resulting from man's use and abuse of the more readily available resources of the Piedmont uplands. The floodplain systems thus have the capacity for the absorption of human error on the uplands. It is seldom appreciated that Georgia floodplains have been purifying our water for hundreds of years. The cost of replacement of such natural life-support systems is beyond our means. Reservoirs have eliminated most of the shoal and swamp areas that channelization has not modified. Some rivers have been either drowned by a continuous series of dams (Hartwell, the projected Trotter's shoals, Clark Hill on the Savannah) which, by releasing cold water from the depths, have completely changed the biota of the streams (Chattahoochee below Buford Dam) or by the drastic, unnatural rise and fall (up to 12 feet) have caused tremendous bank erosion and limited the capacity of vegetation (by root bind) to protect the banks (Etowah below Allatoona Dam). Dams allow silt to settle in the reservoir and enable rivers below the dams to pick up their original load of suspended sediment—this is an additional source of bank and bed scour. A river on a certain gradient will transport, if available, a certain minimum load of suspended sediment—if the water is slowed, the sediments will be deposited; if the water is speeded up, as in straightening streams by channelization, the water will automatically acquire a heavier load of sediment and thus increase its erosive power.

Photo J. Channelization is one of man's most drastic techniques for modifying hydric systems. These bottomland hardwoods [9] along Marbury Creek (an Oconee tributary) are either dead or dying due to the ponding of water by the dredging spoil. Beavers often take advantage of these artificial water-retaining ridges and augment the damage.

Floodplains of some Piedmont streams have been used for agriculture by Caucasian inhabitants, perhaps some by the Indians. Agriculture was more feasible on the floodplains of streams which flooded irregularly (as the Chattahoochee, Etowah, Coosawattee, etc.) and headed in the mountains. The heavy vegetation cover and deep humus of the mountains probably reduced the magnitude of prehistoric flooding. A sandy elevation in the Chattahoochee floodplain near Long Island Creek (Fulton Co.) had been used by Indians until 1800.

Human pollution has damaged the biota of Piedmont streams to varying degrees. Biologists of the Georgia Environmental Protection Division have assembled a huge amount of data concerning the macroinvertebrate life and degree of eutrophication of the major Georgia streams and reservoirs. Other aquatic species, such as freshwater clams and fishes, are less well sampled in many areas. Silt and other erosion products are important pollutants. Siltation from intensive cotton monoculture has had a drastic effect on the life of many Piedmont streams; so has channelization, practiced widely in the 1930's and currently, changing streams from diverse to limited habitats. Some life-forms were perhaps able to survive only in small tributaries with non-agricultural watersheds. An example (before the lake drowned most of the stream) was Lake Creek, an Altamaha tributary in Stone Mountain Park. Owned for years by the Venable family, its rocky headwaters were never farmed, and a small headwater lake acted as a sediment trap. Until 1962, Lake Creek supported a large population of large clams, (*Elliptio complanata*), a formerly widespread species in the Piedmont studied by Raulerson and Burbanck (1962).

Of the finest existing shoal areas in the Georgia Piedmont, most are threatened with reservoir construction. Two dams are planned for the picturesque Broad River and three for the scenic Flint (including Spewrell Bluff). The loss of these major shoal areas would leave only smaller isolated shoal areas on the Oconee, Alcovy (Factory Bridge Shoals), Potato Creek and Sweetwater (both polluted), Dog River (scheduled for development), Chattahoochee (a small segment protected by a state park), and other scattered areas, such as occasional shoals on the Ocmulgee in Jones County and on Mulberry and Standing Boy Creek (Harris and Muscogee counties).

An abundant mollusc fauna, such as is found in the Alcovy (Factory Bridge Shoals) and Flint (Dripping Rock), often attests the ability of the upstream swamps to regulate the silt and other pollutant load of these Piedmont rivers within limits tolerable to aquatic life and verifies their function as pollutant sinks.

## [10] ALLUVIAL RIVER AND SWAMP SYSTEM-COASTAL PLAIN

**Location and Description.**

Most alluvial streams crossing the Coastal Plain originate in the Piedmont, and their headwaters have already been described under Piedmont types. Few streams originating on the Coastal Plain can be considered alluvial. Wayne Faircloth says that the Ochlockonee has a substantial alluvial floodplain and is therefore unlike the non-alluvial streams. The Ochlockonee flows through the Tallahassee Hills where it picks up erosion products of sand, silt, and clay. Most alluvial streams, heading as they do in the Piedmont, have a heavy run-off brought down from higher relief and run-off from clay substrates (which absorb slowly), thus building a head of water faster than sandy terrain. They have the capacity to form extensive floodplains.

General descriptions of Coastal Plain streams are rare. The U.S.A. Corps of Engineers (1935) briefly describes features of the Altamaha, Oconee, and Ocmulgee. Information relative to rock shoals and slope (fall) are pertinent.

From the coast inland, the Altamaha is bordered by abandoned rice fields (to mile 13) which have a general elevation of seven feet above low water. The Seaboard Railroad crosses at mile 23.5; here the tidal effect is limited to several inches. The general slope of the Altamaha is 0.7 feet per mile, but there are short segments less than one mile long where slopes reach three and four feet per mile. The sharpest curve has a radius of 200 feet and there are 50 curves with radii of less than 500 feet.

The Oconee floodplain is similar to that of the Ocmulgee, being up to 4.5 miles wide just below the Fall Line. However, water slopes are steeper than the Ocmulgee and range from 0.7 to 1.8 feet per mile. In short reaches slopes may reach four feet per mile; at mile 83 the slope is several times greater. A few rock outcrops are found below mile 65, but rock shoals are frequent between miles 73-105. In 145 miles, there are 22 curves with a radius of 200 feet and 205 with radii less than 500 feet.

Monk (1968) calls the fringing rivers and sloughs "cypress swamps" and refers to bottomland hardwoods as "mixed hardwood swamps" or simply "mixed swamps." To understand how mineral-rich the bottomland hardwoods are (not the cypress-tupelo community), refer to Table 2.

TABLE 2. Mineral (ppm) Levels in Major Wetland Environments of Northern Florida. Standard Errors Omitted, after Monk (1968).

| | CA | Mg | K | P |
|---|---|---|---|---|
| Mixed Swamps | 8131 | 2958 | 174 | 75 |
| Bayheads | 575 | 1136 | 122 | 68 |
| Cypress Heads | 185 | 35 | 16 | 1 |
| So. Mixed Hardwoods | 367 | 76 | 11 | 6 |
| Flatwoods | 69 | 16 | 4 | 1 |
| Sandhills | 28 | 9 | 7 | 4 |

It may be seen at once that the only other environment that approaches the river swamp is the bayhead category (see **bay swamps**). It is interesting to note the comparative mineral poverty of the dry upland forest (southern mixed hardwoods). This has led

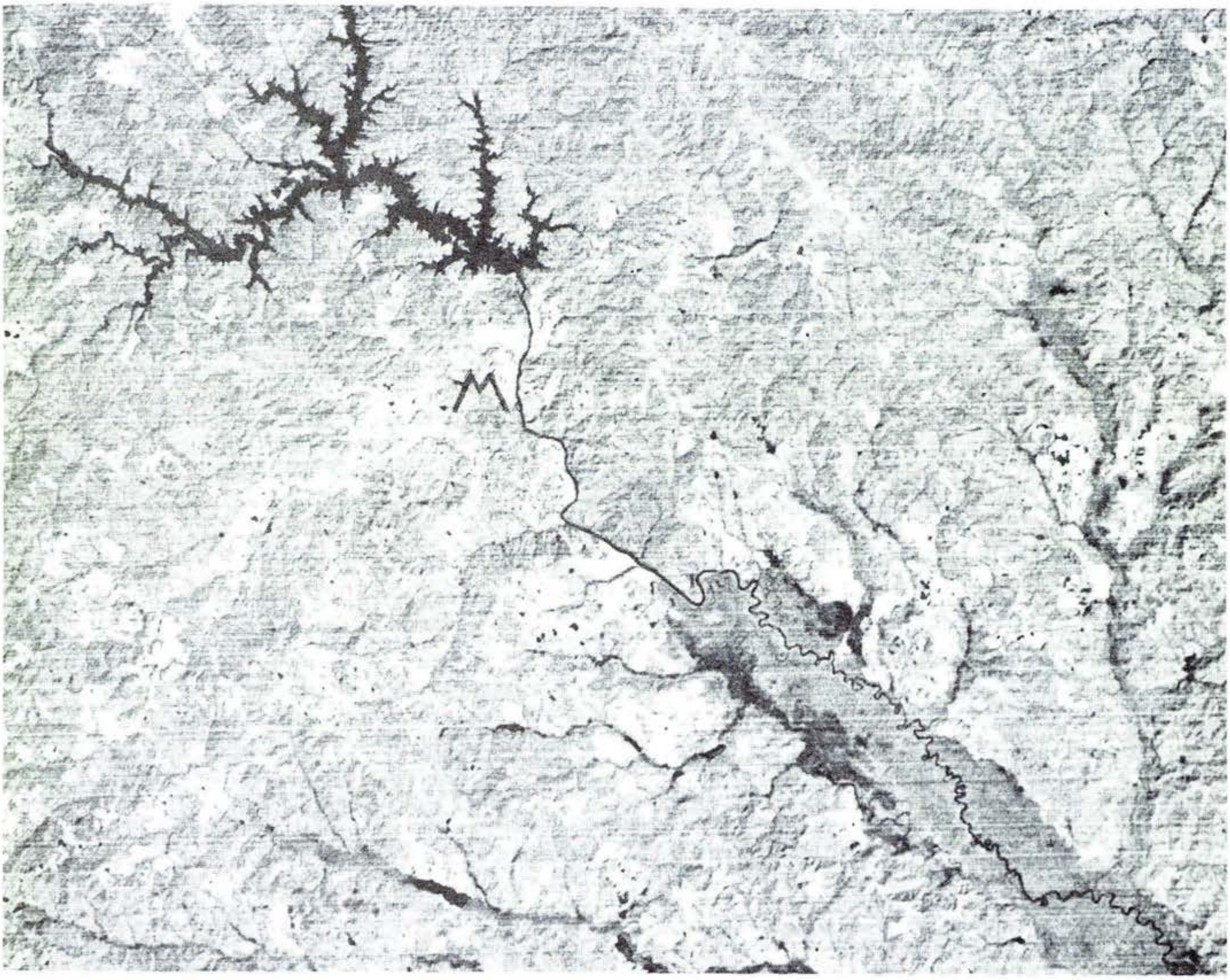


Photo K. This remarkable satellite image clearly shows how the alluvial rivers draining the Piedmont form extensive Fall Line swamps at the juncture of Piedmont with Coastal Plain. Here the Oconee River forms the great Oconee swamp several miles in width, a magnificent natural area of natural values. The Fall Line diagonals across from SW to NE. Lake Sinclair is visible, Milledgeville is marked "M" and Commissioner's Creek runs along the bottom of the image. Courtesy S.M. Pickering, Geologic and Water Resources Division, Georgia Department of Natural Resources.

Eugene Odum to comment that the river swamps appear to have an energy subsidy (in the form of free mineral and organic transport), which could supporo a "life pulse" in these wetlands.

Diversity or number of species, is another important factor in considering natural environments. The river swamps, while they have more nutrients available, are restricted to fewer species than are drier upland sites. Stevenson (1972) has compared plant species' richness in various ecosystems: tropical sea 90, rain forest 75, stable spring creek 35, mesic southern mixed hardwoods (calcareous soil) 34, same but non-calcareous 25, mixed swamps 17 pine flatwoods 15, cypress head 13, hypersaline marsh 12.

Another way to look at diversity is in terms, not of total number of species, but of the number of diagnostic species, those which occur frequently and are reasonably abundant. In comparing Floridian environments, Lugo and Carr (1970) found the following numbers of common species: long-leaf pine-turkey oak (2), pine flatwoods (3), mesic upland hardwoods (10), swamp hardwoods (12).

Regarding general soil conditions for bottomland species growth, Broadfoot *et al* (1971) indicate that the following species prefer a surface soil pH range of 5.1 to 6.5: cherrybark oak, laurel oak, shumard oak, swamp chestnut oak, redbay sweet bay and black, swamp and water tupelos (also beech, sou. magnolia, yellow poplar and white oak). The following species that are important to the southern river swamp prefer a surface soil range of 5.1 to 7.3 (av 6.5): green, pumpkin and white ash, bald cypress, American elm, water hickory, red maple, overcup oak, water oak, willow oak, and sweet gum. Others, such as cottonwood, slippery elm, hackberry honeylocust, silver maple, swamp privet, and willows, grow in a pH range spanning from 5.1 to well into the alkaline side. Osage orange and boxelder occur most often with a pH that averages 7.3.

Water depth and rate of movement of water over the root crown of floodplain forest trees are important in the trees' survival because they affect the amount of dissolved oxygen. During studies of the Oklawaha floodplain, Gardner *et al* (1972) found wet swamp soil surfaces to have 8.6 ppm DO, water from 8 to 18 inches to have 3.5 ppm DO (6 inches below soil surface 0.7), and depths of 30 to 45 inches, 2.5 ppm DO (6 inches below surface 0.5).

Broadfoot (1967) found that artificial flooding of bottomland hardwoods resulted in a "growth pulse," an increase in radial growth of 50% in sweet gum, green ash, and cottonwood, and to 10% in willow oak.

The Savannah has been more intensively studied than any other large Coastal Plain river, and figures on flow measured in CFS (cubic feet per second) generally represent flow variation in this type stream. The Savannah has an average discharge at Augusta of 10,660 CFS—the average maximum yearly flow is 16,970 CFS, the minimum 5,520 CFS. The maximum recorded flood at Augusta was 360,000 CFS in 1796. The mean annual flood is 105,000 CFS, the 10-year flood 180,000 CFS. Patrick *et al* (1967) cite records indicating that Clark Hill Dam lowered the maximum flow and raised the minimum flow; it also appeared to cut the average annual flow volume, or the river flow was slackening during the study period. Between 1942 and 1960 the lowest flow for the Savannah was 1,390 CFS, compared to 1,710 CFS following construction of Clark Hill Dam.

The temperatures (at Burton's Ferry Bridge) between January 1960 and September 1970 ranged from a minimum of 41°F to a maximum of 84°F. The minimum and maximum temperatures of record are 39.2°F and 86°F, Gold *et al* (1975).

Georgia Power Company (GPC) made a detailed analysis of water quality in 1971 and 72 (average in ppm): iron 0.3, calcium 6.5, magnesium 3.5, sodium 7.3, potassium 1.9, bicarbonates 28.8, sulfates 7.3, chlorides 4.8, nitrates 0.28, phosphates 0.09, total dissolved solids 59.9, total hardness 30.8, pH 6.8.

**Stream Flora**

We have far more data on the aquatic communities of the Coastal Plain section of the Savannah River than for any other river. The types of substrates (or micro-environments) in the Savannah River Coastal Plain stream environment have been listed by Gold *et al* (1954), who afford the best and one of the few thorough descriptions of a Georgia river. The benthic substrates listed by them are (A.) masses of attached algae, (B.) compact clay, (C.) sand, (D.) mud, (E.) fixed organic debris (brush, logs, roots), and (F.) rock and gravel. The free-swimming aquatic organisms are classified into plankton (respectively) and nekton (macroscopic motile organisms, such as fish).

The Gold (1954) group found phytoplankton to be low in the river, varying from 3,200 to 6,200 organisms per liter and showing no significant changes between Clark Hill Dam and Savannah. Some of these river plankton may have been supplied by the Clark Hill reservoir, but others "apparently entered the river from other sources, such as sloughs, oxbows, and tributaries draining the floodplain." In one oxbow (at mile 146.4) sampled, the net phytoplankton count was more than seven times the number found anywhere else in the river. Eleven genera of diatoms were identified from the river, six being unique to the river (in contrast to Clark Hill Reservoir). "Diatoms, in particular, appeared to be multiplying in the river, or entering it from some source other than Clark Hill Reservoir." Enrichment from sewage did not seem to increase total phytoplankton count below the outfalls at miles 215 and 202.6.

Patrick *et al* (1967), summarizing data from 1954-1960, and the Academy of Natural Sciences of Philadelphia (1970) record plankton as insignificant. They found 100 organisms per liter in pre-dam years.

Williams (1962, 1966) sampled the Savannah for plankton in 1959-1962. At North Augusta (river mile 201) he found the most abundant diatoms to be *Melosira distans apigena, M. ambigua*, and *Navicula* sp. Abundant rotifers were *Keratella, Polyarthra,* and *Trichocerca*, averaging 3.0 organisms per liter. Copepods averaged 0.2 counts per liter and cladocerans 0.1.

Because the water of the larger Georgia rivers is not transparent, floating debris, willow branches, and roots support algae for longer periods than fixed substrates. Algae were found to persist for several weeks in winter, spring, and summer, when there were extended periods of stable water levels. Gold *et al* found that algae in our rivers are adapted to rather rapid growth if given only a week of relatively stable water level. Natural river fluctuations are not that rapid, except during peak inundations or "freshets" (as they were called historically). One wonders, with the reservoirs raising and dropping water levels over 24-hour periods, how algae are now able to grow at all.

ALGAE. Most algae are common in the summer and fall, others in the spring, and a few species are most abundant in the winter. Many are habitat-specific. Some algae form long filaments in swift water: *Stigeoclonium lubricum, Oedogonium* sp. (green algae), red algae *Compsopogon* and *Batrachospermum,* and the filamentous diatoms *Melosira* sp. and *Acnanthes* sp. Others form streamers in quieter water, such as *Lyngbya* (blue-green).

Some green algae form mats on sand or mud in shallow water, such as *Vaucheria* and *Oedogonium,* while *Spirogyra* inhabit deeper areas (8-12"). The blue-green *Phormidium* sp. also forms periphyton mats on debris and sand bars. One diatom, *Biddulphia*, prefers the roots of willows. Patrick *et al* (1966) and ANSP (1970) found the most common algae species to be: green algae, *Stigeoclonium lubricum* and *Tetraspora gelatinosa;* bluegreens, *Microcoleus vaginatus, M. lyngbyaceous, Schizothrix calcicola,* and *Oscillatoria retzii;* red algae, *Compsopogon coeruleus;* diatoms, *Navicula mutica N. lateropunctata, N. germainii, N. confervacea, Nitzschia palea, Euonotia mondon, Achanthes biporoma, A. lanceolata, Melosira varians,* and *Bacillaria paradoxa.* According to Gold *et al*, the predominant algae that formed mats in the Savannah River were *Stigeoclonium lubricum, Melosira italica, Fragilaria* sp., *Vaucheria polysperma,* and *Oedogonium* sp.

Although the aquatic biota of the Altamaha has not been studied as intensely as that of the Savannah, environmental studies for the Hatch Nuclear Plant at Baxley have yielded valuable information, summarized by Robert Woodall and John Adams.

Between October 1973 and September 1974, periphyton algae were collected on artificial substrates in the Altamaha at four localities within two miles of the Hatch Nuclear Plant. The green mat-forming algae *Vaucheria, Oedigonium,* and *Lyngbya* were either not as prevalent on the Altamaha or were not taken by the techniques used. There is some difference among the diatom flora. More blue-green algae are recorded from the Savannah and may reflect its heavier pollution.

From December through February there is a marked decrease in species diversity of algae as well as a diminished density of those species present. A few species, such as *Cymbella tumida, Gomphonema sphaerophorum, Melosira varians, Navicula* (sp.A,C), *Nitzschia palea, Cosmarium* sp., *Closterium* sp., and *Mougeotia* sp., seem to be abundant the year round. A few (*Nitzschia acicularis, Synedra ulna*) are recorded only from the cold high water of winter. I could find few studies of submerged, floating, or emergent higher plants in Georgia rivers. CPECL (1972) identified aquatic plants on the Savannah River between river miles 128 and

162. They found water milfoil (*Myriophyllum* sp.) and hornwort (*Ceratophyllum* sp.) to be most abundant; alligator weed (*Alternanthera* sp.) very abundant; the water weed (*Anacharis* sp.) abundant; the duck potato (*Sagittaria* sp.) present but not abundant; and the pickerel weeds (*Pontederia* sp.) and cattails (*Typha* sp.) scarce.

In Coastal Plain rivers, especially the Altamaha system, dense mats of the tiny-leaved flowering plant *Micranthemum umbrosum* (*Scrophulariaceae*) are sometimes encountered festooning underwater logs and snags.

### Stream Fauna

Patrick *et al* (1967) indicated that in the Savannah River the ciliates, flagellates, and sarcodinids of the animal phylum protozoa were well-represented. Ciliates had the greatest species diversity (97 species, 57 genera). Although the bulk of protozoa occupied protected areas with slowly moving water, algae tufts maintained diverse protozoan communities. Mats of the algae *Vaucheria* growing in the riverbed often proved the best habitats for protozoa, although sand surfaces, mats of debris, and submerged logs and branches were also good habitats. The most favorable habitat appeared to be backwater conditions with slow currents, quiet pools, and a variety of substrates. Table 3 compares organisms at high and low flow levels.

TABLE 3. Numbers of Species of Plants and Animals of Savannah River at Low and High Flows (data summaried from Patrick *et al* (1967); four stations averaged).

| | | Fall Low flow | Spring High flow |
|---|---|---|---|
| algae | 1951-52 | 100 | 62 |
| | 55-56 | 102 | 94 |
| | 1960 | 91 | 84 |
| Protozoa | 1951-52 | 32 | 30 |
| | 55-56 | 50 | 41 |
| | 1960 | 61 | 58 |
| invertebrates (non-insect) | 1951-52 | 18 | 18 |
| | 55-56 | 18 | 11 |
| | 1960 | 17 | 18 |
| invertebrates (insect larvae) | 1951-52 | 38 | 59 |
| | 55-56 | 49 | 48 |
| | 1960 | 30 | 30 |
| fish | 1951-52 | 11 | 25 |
| | 55-56 | 28 | 28 |
| | 1960 | 38 | 32 |

Even though there is considerably more water in spring, the number of kinds of organisms remains surprisingly similar.

In the following section the macroinvertebrate fauna of the Savannah is treated by *habitat.*

**Algal Mats.** Algae masses growing in fast water have largely insect larvae or nymphs, while algae in quiet water have a more diverse fauna of protozoans, rotifers, nematode worms, and oligochaete worms. Fast water algae mats have larval mayflies (*Ephemerella* sp.); midges (*Spaniotoma* sp.); and caddis flies (*Leptocella* sp.) as dominant fauna but also house stone flies (***Hydroperla harti***), caddis flies (*Macronemum carolina, Hydroptila* sp.), midges (*Polypedilum* sp. and *Tantarsus dissimilis*), snipe flies (***Atherix variegatus***), and beetles of the family Elmidae.

According to Gold *et al,* the most abundant organisms in Savannah algae mats appeared to be: oligochaete worms (*Nais* sp., *Pristina aequiseta*); copepods (*Cyclops* sp., *Diaptomus* sp.); water fleas (*Pleuroxsus denticulatus*); caddis flies (*Hydropsyche* sp.); flies (*Ablabesmyia monilis, Spaniotoma* spp., *Polypedilum illinoiense, Limnochironomus modestus, Coryoneura scutellata Modestus, Coryoneura scvtellata*).

**Clay Substrate.** One of the remarkable findings of the Gold *et al* group, and reported by Scott, Berner, and Hirsch (1959), was that compact clay and marl strata on the outside of meander bends and between meanders, if exposed to the current, were occupied by a community of organisms based in the burrows of a mayfly (*Tortopus,* sp.), which formed an underground interconnecting labyrinth of tubes. The faunal community moves up and down with the rise and fall of the river. While 54% of the total number of organisms were *Tortopus* nymphs, other mayflies, such as *Stenonema* spp. and *Isonychia* spp., were abundant. Caddis flies were chiefly *Macronema carolina* and *Hydropsyche orris; Stenelmis decorata* was an abundant bettle, and a snail (*Pleurocera* sp.) was common. Nematode worms also appeared abundant.

**Sand and Mud Substrate.** Here the number of macroinvertebrates was small, but the area large. Areas of shifting sand (largely in swift current) appeared nearly devoid of life. Bottoms of sand, mud, and organic debris in backwaters and quiet places, however, supported a diverse and abundant fauna. The most common organisms were midge fly larvae, (largely *Coelotanypus* sp., *Limnochironomus modestus, Parachironomus tenuicaudatus*), undetermined flies of the family Ceratopogonidae, burrowing mayflies (such as *Hexagenia bilineata* observed in huge swarms), leeches (*Helobdella* sp.) and a beetle (*Stenelmis* sp.).

**Brush, Logs, Rocks, and Gravel Substrate.** These substrates support large and diverse populations of invertebrate animals. (Gold *et al* used boxes containing brush and rocks to sample benthic organisms). The dominant animals taken are presented below in their respective phyla, classes, or orders: **porifera** (sponges)—*Spongilla fragilis* is common in the river, and extensive colonies of the sponge *Trochospongilla horrida* were found. **turbellaria** (flatworms)—*Dugesia tigrina* occurred at widespread locations. **rotatoria**—In summer, rotifers were found at all stations. **bryozoa** (moss animals)—*Plumatella repens* is widely distributed and most abundant at polluted water stations. *Pottsiella erecta* was associated with sponges, while large colonies of *Federicella sultanta* were sometimes encountered. **annelida**—the tubificid worm (*Limnodrilus hoffmeisterii*) was the common oligochaete, and leeches were most abundant in polluted areas. **crustacea**—The small glass shrimps, *Palaemonetes paludosus* and *Macrobrachium ohione*, were widespread in the river. The amphipod *Hyalella azteca* was locally abundant. **insecta**—Insect species were (approximately) 25% phytophagous, 36% predaceous, 7% saprophagous, and 32% omnivorous. **plecoptera** (stone flies) Abundant throughout, although thought to have been severely reduced by dredging. **ephemeroptera** (mayflies)—Present everywhere, the most abundant genera were *Stenonema, Caenis,* and *Tricorythodes*. **odonata** (dragonflies, damselflies)—Generally present throughout. The most frequently encountered genera were *Argia, Macromia,* and *Neurocordulia*. **neuroptera**—The dobson fly (*Corydalis cornutus*) was common in fast water areas. **trichoptera** (Caddis flies)—*Macronemum carolina, Hydropsyche* spp., and *Neureclipsis* sp. were extremely abundant in swift water areas. The best description of common Georgia caddis flies was given by Gordon and Wallace (1975), who found seven of the eight North American genera of Hydropsychid caddis flies in the Savannah and tributaries. Stream size and minimum oxygen content, interacting with altitude and temperature, strongly affect their distribution in Georgia. *Hydropsyche* and *Cheumatopsyche* were the dominant genera in individuals and numbers of species. Caddis flies fall into three groups: (1) Species not extending into the Piedmont: *Parapsyche cardis* in springs, *Arctopsyche irrorata* in brooks, and *Cheumatopsyche minuscula* and *C. etrona* in large streams, (2) Species that do not extend into the Coastal Plain: *Hydropsyche sparna* and *H. betteni* in large streams (600-1,067 meters elevation); *Diplectrona modesta* at high elevations or small streams at low elevations, and *Hydropsyche venularis* in the lower headwaters (400-200 meters elevation), (3) Species that extend into the Coastal Plain (<37 meters elevation): *Cheumatopsyche pinacea* in the smaller streams, *C. pasella* in larger ones, one primarily Piedmont species, *C. analis* (244-37 meters elevation), and three species in large rivers at low elevations, *Hydropsyche incommoda, H. orris* (dominant), and *Macronema carolina,* these last three inhabiting snags. Wallace *et al* (1976) indicate that filter feeders, such as caddis fly larvae, perform a vital function for river ecosystems—the many species feed on different particle sizes, reducing loss of detritus from flowing waters. coleoptera (beetles)—Three genera were widespread: *Ancyronyx, Macronychus,* and *Stenelmis*. **diptera** (true flies)—The midges, *Endochironomus nigricans, Ablabesmyia monilis, Limnochironomus modestus,* and *Chironomus riparius* were abundant in polluted waters. In swift polluted waters *Polypedilum* spp. were common; *Tanytarsus* spp. are found in clean waters. Snipe flies (*Atherix variegata*) and black flies (*Simulium* sp.) inhabit swift water areas. **gastropoda** (snails)—*Physa heterostropha* was abundant and *Pseudosuccinia columella* was also taken. Both species sometimes were the dominant invertebrates. The ctenobranch snail *Pomatiopsis lapidaria* was common in a slack water slough. **pelecypoda** (clams)—Fingernail clams (*Musculium* sp., *Pisidium* sp., and *Sphaerium*) are present in the river and locally abundant. Six species of Unionid clams appeared dominant to the Patrick *et al* group. The most abundant were *Elliptio hopetonensis* (apparently misidentified, since it is an Altamaha endemic) and *Lampsilis dolabraeformis*. The largest fresh water clam populations were formed by four species, *Elliptio hopetonensis, E. incrassatus, E. fisherianus,* and *Lampsilis cariosa*. The Patrick group found a slough to be inhabited by the clams, *Anadonta hallenbeckii, A. couperiana,* and *A. imbecilis*. One study area yielded nine species of unionid clams including *Lampsilis splendida* and *Micromya ogeecheensis*.

In another study benthic macroinvertebrates of the Altamaha were collected by the GPCEL (1974) group at U.S. 1 bridge by three techniques: 1) rock-filled baskets, 2) Dendy multiplate, and 3) Peterson dredge. This study found the most abundant insects to be the following genera (those with an asterisk occur at almost all stations): **mayflies**—*Isonychia** sp., *Tricorythodes, Caenis, Haptagenia** *Stenonema*, Baetis*;* **dragonflies**—*Argia,* and **damselflies**—*Gomphus, Neurocordulia*;* **stoneflies**—*Neoperla*, Perlesta, Acroneuria*, Paragnetina, Isoperla;* **dobsonflies**—*Corydalus*;* **beetles**—*Dineutes, Stenelmis*, Macronychus glabratus*;* **caddisflies**—*Chimarra*, Neureclipsis, Macronemum, Hydropsyche incommoda*, H. orris*, Cheumatopsyche*,* Hydroptilidae*; **true flies**—Ceratopogonidae*, Chironomidae*, and *Simulium** sp.

It has long been known that fish (such as trout) feed by lying motionless and ambushing invertebrates (and incautious vertebrates) carried down by the current. The word which characterizes this assemblage of water-borne life is "drift." One of the most important discoveries of the Woodall-Adams GPCEL team was in the study of drift in the Altamaha, Table 4. Some genera were present in the drift sample that were not taken with artificial substrates.

TABLE 4. Taxonomic Invertebrate Groups Contributing Over 1% of the Total Drift, of Samples from the Altamaha at U.S. 1 Bridge (unpub. data, courtesy Ga. Power Co. Environmental Laboratory).

| organism | numbers | percent total drift |
|---|---|---|
| mayflies (Ephemeroptera) | 42,486 | 29.5 |
| beetles (Coleoptera) | 42, 237 | 29.3 |
| waterfleas (Cladocera) | 24,812 | 17.3 |
| stoneflies (Plecoptera) | 11,536 | 8.0 |
| caddisflies (Trichoptera) | 9,421 | 6.4 |
| true flies (Diptera) | 6,721 | 4.7 |
| worms (Oligochaeta) | 2,167 | 1.0 |
| isopods (Isopoda) | 1,508 | 1.0 |

The data seem to indicate that the abundance of drift organisms coincides with high discharge levels after the temperature begins to climb in late February. Nearly three times as many species and 10 times as many individuals were taken in night samples, Gardner *et al* (1975).

With the present state of our knowledge, it is impossible to draw any conclusions about the distribution of the wetland and aquatic insects and annelid worms. If one collates all known sources, the list represents more where the collectors have been than the actual distribution of the organisms. The Georgia Environmental Protection Division has collected numerous streams in the state but has largely avoided the pure mountain streams, and by using alkaline limestone substrate in acid blackwater streams has probably biased the faunal descriptions from these streams. Another reason for omitting lists of insects is the incredible species diversity, and the species yet undescribed. Years ago it was thought that there might be as many as 100 species of midge flies (Chironomidae) in Florida; now William Beck estimates in excess of 400 species—the situation is similar in Georgia. I conclude that the studies cited above on the Savannah provide our best data on Georgia stream invertebrates.

In the following summary statements on statewide invertebrate distribution the larger and more easily identified organisms, such as snails, and clams are emphasized.

**Annelida** (segmented worms)— River annelids are oligochaetes. One species, *Limnodrilus udekemianus,* occurs statewide. *Aulodrilus pluriseta* and *Limnodrilus profundicola* are common in the Piedmont, and *L. hoffmeisteri* is common everywhere, F. K. Parrish (pers. comm.). Among the leeches, Patrick *et al* (1976) found eight species in the lower Savannah.

**Gastropoda** (snails)—The genus *Goniobasis* appears to have statewide distribution. Three species are found in the Coastal Plain and Piedmont: *Goniobasis albanyensis* (Harris Co.), *Physa crocata* (north to Meriwether County), and *Pseudosuccinia columella* (Troup Co.), and, except for the latter, these species are either in the Flint or Chattahoochee only. Two snails, *Goniabasis boykiniana* and *G. catenoides,* are reported by Clench and Turner (1956) to have formerly lived in the Chattahoochee at and above Columbus, but are now probably extinct due to upstream pollution. *Ferrissia fragilis* and *Somatogyrus substriatus* are reported by the EPD from the Piedmont only. The remainder of the species appear to be Coastal Plain forms.

A number of snails have a preference for springs, *Vivipara georgianus* being common there. Large individuals occur at the lime-rich Brinson Springs (Decatur Co.). This is the principal food of the Limpkin or "crying bird." Shell piles of this species found in the Altamaha swamp above the Seaboard RR Bridge (McIntosh Co.) are associated with the Limpkin.

The great bulk of aquatic snails have been recorded from the Chattahoochee-Flint system. *Pomacea paludosa,* the typical Limpkin food in Florida, is recorded in Georgia only at Sealey Springs in Seminole County, in extreme SW Georgia. This is the snail that lays the conspicuous pink egg mass on trees at or above the water line. *Goniabasis floridensis* prefers springs in the Decatur County area. Other species of pulmonate snails, such as *Physa* sp., *Pseudosuccinea columella,* and *Ferrissia dalli,* inhabit springs and spring runs. The latter species is known only from Blue Springs in Decatur County.

**Pelycypoda** (clams)—No native species are restricted to either mountains, Piedmont, or Coastal Plain. The mountain streams are species poor. The introduced Asiatic clam (*Corbicula manilensis*) is probably the only statewide species and is becoming increasingly common in Georgia streams. Asiatic clams provide food for certain fish, such as catfish and shell-cracker bream, and a few turtle species. They are extremely abundant in Spring Creek (Decatur Co.)—the stomach of a captured Barbour's map turtle (*Graptemys barbouri*) contained by weight 90% *Corbicula*. However, damage may far outweigh benefits. Larvae entering the cooling system of atomic power plants necessitates water treatment by heat or chemicals, R.W. Woodall (pers. comm.). This clam has entered the intake of Cartersville's water supply and caused reduction of volume, F.K. Parrish (pers. comm.). Gardner *et al* (1976) determined that the Asiatic clam has had a very serious impact on native species in the Altamaha River. From October 1971 *Corbicula* increased from zero to a maximum average density of 10,000/$m^2$, reaching a peak in July, 1974, then dropped to an average density of 200-300/$m^2$ in 1975. Native clams dropped from a density of 200/$m^2$ in 1971 to zero in 1974. Young native clams (including spheriids) reappeared in small numbers in 1975, following the drop in numbers of Asiatic clams, R.W. Woodall (pers. comm.).

A few clam species, such as *Anodonta imbecilis, Elliptio lanceolata, E. icterina,* and *Villosa vibex,* appear to be found in both the Piedmont and Coastal Plain. Ten species (of 10 genera) occur in the Coastal Plain but have been recorded in the Piedmont north of the Fall Line, in either the Chattahoochee or Flint rivers. These are: *Quincuncina infuscata* (Harris, Troup); *Prenodonta boykiniana* (Muscogee, Troup); *Pleurobena pyriforme* (Muscogee); *Elliptio strigosus* (Cobb); *E. sloatianus* (Muscogee); *Uniomerus obesus* (Muscogee, Morgan); *Alasmidonta triangulata* (Muscogee, Harris); *Anodontoides elliotti* (Troup); *Medionidas penicillatus* (Harris, Muscogee); *Carunculina parva* (Muscogee); and *Pisidium dubium* (Troup).

No clam species have been recorded from Georgia that are restricted to the mountains. Two species, *Lasmigona subviridis* and *Alasmidonta varicosa,* are known only from sub-mountain Savannah tributaries in South Carolina. One species, *Anodonta hallenbecki,* appears to be restricted to NW Georgia, but has been recorded from the Savannah. Twelve species have been reported only from the Piedmont as opposed to 30 species reported exclusively from the Coastal Plain. The rarest Piedmont species appears to be *Anodontoides elliotti* from Westpoint (Troup Co.), perhaps now extinct due to reservoir construction.

*Elliptio complanata* is a widespread large clam in the Piedmont and Coastal Plain. It was misidentified for Raulerson and Burbanck (1962) by Johnson as *hopetonensis*. This large clam was common in small Piedmont creeks.

Study of clam distribution reveals that a number of species appear to be confined to streams in the Gulf drainage (Little River west to Chattahoochee), while others appear to be confined to the Atlantic drainage. Although Clench and Turner (1956) concentrated on the Gulf, and Johnson (1970) on the Atlantic drainage, there may be a marked faunal division between the two drainages. The Alapaha, Suwannee, St. Marys, and Satilla have a depauperate fauna, partly because of their non-alluvial nature and partly because of their geologic youth.

One species, *Carunculina pulla,* only occurs as far west as the Savannah River and thus is confined to this stream in Georgia. There are six species that are endemic to the Altamaha river system and found nowhere else. These are: *Elliptio spinosa* (the famed spiny clam), *E. hopetonensis, E. shepardiana, Alasmidonta arcula, Anodonta gibbosa,* and *Lampsilis dolabraeformis.* I have specimens of *Alasmidonta arcula* as far north in the Piedmont as the Alcovy River (Newton Co.). Johnson (1970) suggests that this large number of endemic unionid clams in the Altamaha indicates that "this system is particularly old and that it was sufficiently isolated during some of the Pleistocene to have facilitated speciation."

Johnson also indicates that species endemic to the larger Apalachicolan river system (in Alabama and Georgia) indicate that refugia were available above the maximum Pliocene and Pleistocene marine shore. From clam distribution Johnson deduces that there was once a confluence of the headwaters of the Alabama-Coosa and Apalachicola river systems; a confluence between the Savannah and Chattahoochee in pre-Pleistocene times, and that the first-cited confluence took place first. These is also evidence from clam distribution of a confluence between the Alabama and Tennessee rivers. The subspecies *Elliptio crassidens downiei* from the Satilla (Buck Lake) is considered an endemic type.

Species considered rare by Clench and Turner (1956) and Johnson (1970) are: *Alasmidonta arcula* (Altamaha endemic), *Pisidium dubium, Crenodonta nelsleri, Elliptio crassidens incrassatus* (Flint-Chattahoochee system), the extremely rare *Anodontoides elliotti* from the Chattahoochee, and *Anodonta couperiana* from the Ochlockonee, St. Marys, and Savannah.

We have much to learn about the ecology of fresh-water clams. Some species favor non-fluctuating springs and spring-fed creeks: *Lampsilis subangulata, Villosa villosa,* and *Sphaerium stamineum*. Others, such as *Lampsilis splendida, Elliptio icterina, Pleurobema masoni, Elliptio spinosa,* and *E. fraterna,* prefer swift waters with sandy bottoms. Some species, notably *Elliptio arctata* and *Alasmidonta triangulata,* inhabit rocky shoals. Others, such as *Uniomerus tetralasmus* and *Villosa lienosa,* inhabit mud bottoms. Some, such as *Anodonta couperiana,* are partial to ponds and abandoned rice plantations. A number of species, such as *Anodonta gibbosa, Carunculina pulla, Anodonta cataracta,* and *Lampsilis ochracea,* live in quiet, sluggish water, or ponds. One very small (¼ inch) clam, *Byssanodonta singleyi,* occurs only on tree roots in certain clear streams (Spring Creek). Among the outstanding collecting localities in Georgia (because of clear water or shoals), Spring Creek (Decatur Co.) and Mulberry Creek (Harris Co.) stand out as most frequently mentioned in the literature.

**Isopod Crustacea**—The isopod and amphipod crustacea in Georgia have been seldom collected. Four species of isopods have been collected from the Savannah. Two of the most common Georgia species are *Lirceus lineatus* and *L. fontinalis.*

**Amphipod Crustacea** (sand "fleas")—*Hyalella azteca* seems widely distributed in Piedmont and Coastal Plain streams. *Cragonyx gracilis* is recorded from the Savannah and *Gammarus fasciatus* from the Savannah and Altamaha—all in the Coastal Plain.

**Decapod Crustacea** (shrimp, crayfish, etc.)—Four species appear restricted to the Coastal Plain. The well-known genus *Palaemonetes* has a widespread species (*kadiakensis*) in the Coastal Plain, and two species of *Macrobranchium* are known from the Savannah. Only one crayfish has nearly statewide distribution, *Procambarus spiculifer.* Two common species, *Cambarus bartonii* and *C. latimanus,* are rather widespread in both mountains and Piedmont. Another, *P. howardi,* has a similar range, but is endemic to the Chattahoochee basin. Seven species are endemic to Tennessee watersheds in the mountains. Four of these are *Cambarus,* one *Procambarus,* and two *Orconectes.* Eight species appear confined to the Alabama system—three, however, are in the Ridge and Valley province, and two, *Cambarus englishi* and *C. halli,* are endemic to the Tallapoosa basin, which is more Piedmont than mountain. One group of species (*Procambaris fallax, P. seminolae, P. paeninsulanus, P. enoplosternum*) appears confined to the lower middle Coastal Plain. Other species occur in the Flint and the Altamaha system, appearing to skip entirely the non-alluvial stream systems occupied by some of the above-named species. *P. epicyrtus* is confined to the Ogeechee-Savannah basin and *P. litosternum* is confined to the Ogeechee-Canoochee drainage. They are among a number of species (9) which occur chiefly from the Ocmulgee eastward. *P. barbatus* appears known only from the Ohoopee River. The large red *Procambarus, troglodytes* is one of the most striking animals of unpolluted river swamps. I found it most abundant in the constantly wet, sandy, braided stream system of the virgin Four-Hole Swamp of South Carolina. The Georgia Piedmont appears to have two species confined to it, a *Cambarus* sp. and *Procambarus raneyi,* the latter from the Broad and Little rivers (Savannah River system).

**Fish**—No strictly endemic fishes occur in the lower Savannah. One darter, *Etheostoma serriferum,* is shared with the Ogeechee and drainages to the north, and several species of *Carpiodes* are shared with the Altamaha. In 1952 the most common fishes in rotenone sampling from five stations on the Savannah were: the eel (*Anguilla rostrata*), the silvery chub (*Hybognathus nuchalis*), five shiners (*Notropis leedsi, N. hudsonius, N. maculatus, N. petersoni, N. emiliae*), the channel catfish (*Ictalurus punctatus*), the flat bullhead (*Ictalurus platycephalus*), pirate perch (*Aphredoderus sayanus*), blackbass, warmouth, bluegill, redbreast, and two crappies (*Pomoxis annularis* and *P. nigromaculatus*).

In 1954 the gizzard shad (*Dorosoma cepedianum*) was common in the river and backwaters. On all surveys by Patrick *et al* (1952) the most common fish were young silvery chubs (*Hybognathus*), which swarmed by the thousands at all stations.

The sloughs contained more long-nosed gar, carp, chain and redfin pickerel. Catfish were most common in flowing water. Some fish, a madtom (*Noturus gyrinus*), darter (*Etheostoma nigrum*), and spottail shiner (*Notropis hudsonius*) preferred flowing water, while others (often a different species of the same genus), madtom (*Noturus leptacanthus*), darter (*Etheostoma fusiforme*), eel, golden shiner (*Notemigonus chrysoleucas*), and shiner (*Notropis maculatus*), preferred the quiet water of the sloughs. Other still-water species noted were bowfin, lake chub-sucker, shiners (*Notropis leedsi, N. callisema, N. nivens*), white catfish (*Ictalurus catus*), brown bullhead (*Ictalurus nebulosus*), rice field fish (*Chologaster cornutus*), starhead topminnow *Fundulus dispar,* mosquito fish (*Gambusia affinis*), and a number of the sunfish, including the blue-spotted (*Enneacanthus gloriosus*), banded (*E. obesus*), flier (*Centrarchus macropterus*), black crappie, and white crappie.

Gold *et al* recorded two marine fish, the needlefish (*Strongylura marina*) at mile 165 and the hogchoker (*Trinectes maculatus*) at mile 170.

In the Georgia Power Company (GPCEL 1972) study of the Altamaha River, Adams and Woodall compared the fish fauna of an oxbow lake with that of the river (at Beaverdam Creek). In May, 1972 they found 19 species in both localities but 2,507 individuals in the oxbow and 185 in the river. In September the oxbow had lost nine species and the river five, but the oxbow still exceeded the river in number of individuals (191 vs 161). The red-ear sunfish, highfin carpsucker, and striped bass were about the only fish found in the oxbow that were not found in the river. The species with the most individuals in the oxbow were gizzard shad (208), channel catfish (33), and spotted sucker (22).

Examination of the list of fish gill-netted in the Altamaha River above and below U.S. 1 Bridge at river miles 113 and 117 by GPCEL (1974) reveals two brackish-water fish, the striped mullet (*Mugil cephalus*) and southern flounder (*Paralichthys lethostigma*) and two euryhaline species, the Atlantic needlefish and the hogchoker (a small flatfish similar to the flounder). The latter two, as well as gizzard shad and threadfin shad (*Dorosoma petenense*), were collected as juveniles (by seine), hence hatched upstream or in the vicinity of the U.S. 1 bridge at Baxley.

If gill net figures can be relied upon, the dominant fishes (as adults) in the Altamaha at mile 117 are (in order of abundance) gizzard shad, carpsuckers (*Carpiodes carpio*), spotted suckers (*Minytrema melanops*), long-nose gar (*Lepisosteus osseus*), channel catfish, black crappie (*Pomoxis nigromaculatus*), and brown bullhead.

Fishes of the lower Chattahoochee are similar to those of the other large rivers, with several exceptions. EPA (1972) sampled fishes at Neal's landing near Highway 91, Seminole County, just above Lake Seminole. They found, besides the common game fish, one euryhaline species, the needlefish, the skipjack shad (*Alosa chrysochloris*) indigenous to the Alabama and Apalachicola systems, the small mouth buffalo, *Ictiobus bubalis* and Alabama shiner (*Notropis callistius*) formerly known only from the Alabama, and the blacktail shiner (*Notropis venustus*).

McSwain (1971) sampled fish populations of the lower Flint near Putney (Dougherty Co.). Carp and gizzard shad were abundant; the most common fish were bluegill, redbreast, snail and spotted bullheads (*Ictalurus brunneus* and *I.* sp.), greyfin redhorse (*Moxostoma* sp. cf *poecilurum*), spotted suckers, white and channel catfish, and long-nose gar. McSwain found a standing crop of 259.7 pounds per acre in one sample and 90.9 pounds per acre in a second.

Regarding endemic fishes, the Chattahoochee apears to have only one, *Notropis eryzonus.* The Flint-Chattahoochee (Apalachicola) system is characterized by six: spotted gar (*Lepisosteus oculatus*), silverjaw minnow (*Ericymba buccata*); a Piedmont form, the widespread bluestripe shiner (*Notropis callitaenia*); grayfin redhorse (*Moxostoma* sp. cf *Poecilurum*), and two species of darters shared with the Ochlockonee (*Etheostoma edwini, E. swaini*). Some 12 species have not been recorded from the Ochlockonee but do occur in the Flint, Alapaha, or other streams. Moving eastward, a number of species have not been recorded from the Suwannee but occur in adjacent rivers. The Ogeechee and Savannah share the range of *Etheostoma serriferum.* The Altamaha system seems to have one species, the Ocmulgee shiner (*Notropis callisema*), and the only Georgia record of the sea lamprey (*Petromyzon marinus*). The Altamaha and Ogeechee share *Lucanea goodei* along the coastal strip.

In Georgia there is a greater fish diversity above the Fall Line (156 species) than below (105 species), owing to the wealth of Alabama and Tennessee drainage forms, Dahlberg and Scott (1971). When the Atlantic coast drainages are examined, there are only 70 species above the Fall Line and 81 below. These authors indicate that about 21-38 species of fish are restricted to the Coastal Plain, some 34 species range widely from Coastal Plain to mountains. There are 68 known or probable fish species that have been introduced into Georgia streams.

### The Floodplain

The river and its floodplain act together as a geohydrobiological system. Yet, for purposes of clarity, the floodplain is described separately, proceeding through soils, flora, and fauna. Here, we deal with plants and animals that must have dry land at least during part of their life cycle (even cypress trees). Many floodplain organisms need an annual cycle of alternating wet and dry conditions to insure their survival.

**Floodplain soils**—The Penholoway Swamp of the Altamaha at Jesup has soils described as "Swamp-Wet Alluvial," USDA (1965). Ocmulgee floodplain soils are classified as Chewacla-Wehadkee Association (USDA, 1963), being silt or clay loams over mottled silty clay subsoils, similar to some Piedmont floodplains. Boyd's (1976) laurel oak study sites were apparently in bottomland hardwoods on Coxville and Duplin soils on the Oconee (Wheeler Co.). Flint River floodplain soils are classified as Dunbar-Izadora-Bladen Association (USDA, 1968 a), have clay loams over clay or sandy-clay subsoils and are somewhat drier than the Oconee-Ocmulgee soils. They are comparable to soils from higher elevations in the Ogeechee floodplain rather than with the soils of the Ocmulgee-Oconee system. The Ogeechee, with soils more related to the Flint, appears intermediate between alluvial and blackwater rivers—indeed, it heads slightly on the Piedmont. The lowest floodplain of the Ogeechee is occupied by the Bladen-Rains Swamp Association, with Dunbar-Izagora soils on slightly higher elevations (USDA, 1968 b).

Boyd (1976) found that the biomass of cotton mice (*Peromyscus gossypinus*) and the growth of laurel oak were considerably greater on the alluvial Oconee floodplain than on the non-alluvial Canoochee floodplain. He found that the soils of the Oconee floodplain were significantly higher in calcium, magnesium, nitrate, and sodium than those of the Canoochee, and that Oconee river water apparently carries more calcium, sulfate, iron, magnesium, potassium, phosphorus and manganese ions than does the Canoochee. The mean sediment load of the Oconee is 40 ppm. versus 20 ppm for the Canoochee, but the Canoochee carries less than ten percent 50% of the time. The Oconee derives 68% of its flow from the mineral-rich Piedmont.

**Floodplain Flora.** As in the Piedmont, the Coastal Plain floodplain communities can be divided into two types, those inundated more than six months per year and those inundated about or less than six months. Penfound (1952) calls the former "deep fresh water swamps" and the latter "shallow fresh water swamps." The first category supports bald cypress (*Taxodium distichum*) and tupelo gum (*Nyssa aquatica*) and some swamp black gum (*Nyssa biflora*). These trees occupy the lowest areas of the floodplain including all waterways—many with more or less permanent standing or flowing water. Buttress tops generally indicate the height of inundation, and roots to anchor these trees in soft sediments often have aerial, respiratory counter-growths (knees) at the point where they turn downward again. Those swamps having the deepest and most prolonged winter inundation usually have the tallest knees. Generally speaking, tupelo gum is confined to the floodplains of the larger rivers; the swamp black gum is mainly in the Coastal Plain uplands, Penfound (1952), and in the acid backswamps along the edge of the floodplain.

Klawitter (1962) summarized the relation of the hydroperiod to gum species. Short hydroperiods and shallower waters favor swamp black gum, which grows in highly organic soils (silt-clay content averages 42-56%) with a low pH (3.6-4.1) with best growth reported under flooded or near-flooded conditions. Tupelo gum grows where the silt clay fraction of the soil is somewhat higher (56% for swamps, 80% for river bottoms) and the organic matter less (40% for swamps and 26% for river bottoms)—the pH for tupelo gum sites averaged 4.4.

Photo L. Bottomland hardwood forest [10] on the Altamaha floodplain (McIntosh Co.) during spring high water The men are following an inundated logging road. The major tree species are water and willow oaks. The rare "crying bird" or limpkin (*Aramus guarauna* occurs here along the sloughs and ox-bow lakes. Two graceful and rare hawk species occur over the floodplains, the Mississippi and Swallowtail Kites.

Klawitter (1962) gives the principal tree species associated with the cypress-tupelo environment as red maple, carolina ash, and swamp black gum, roughly the same species recorded by Applequist (1959). Klawitter found that the water table was at about the same depth on swamp black gum and tupelo gum sites when the Santee was below flood stage, but the latter trees were more deeply inundated at highwater The height of tupelo was correlated with abundant soil moisture and long hydroperiods, and annual radial growth was directly related to the number of days the Santee River flooded. Klawitter (pers. comm.) also apparently observed evidence of diminished growth in gum trees correlated with the diversion of the main flow of the Santee down the Cooper River

Applequist (1959) studied soil-site relationships of swamp black gum and tupelo gum on 90 plots in eight counties in the lower Coastal Plain of Georgia. He found that time and duration of highwater during the growing season was of critical importance and that these trees do not make their best growth under well-drained conditions but "literally thrive under flooded or near-flooded conditions." Tupelo seedlings grow up to 50% faster in alluvial river swamp soils than in non-alluvial headwater swamp soil, Harms (1973).

The remainder of the floodplain (flooding less than six months per year) supports bottomland hardwood forest.

Elevations of floodplain surface vary but a few inches or feet, yet such minor changes profoundly affect the biotic community The most complete discussion of floodplain vegetation is by Putnam *et al* (1960). They define the first bottoms as the present or relatively recent floodplain and second bottoms (or terraces) as remnants of former floodplains left when general uplift, tilting, or reduced flow formed a new floodplain at a slightly lower level. A mature soil profile tends to form on second bottoms. Figure 9 is an effort to clarify the topography of the floodplain.

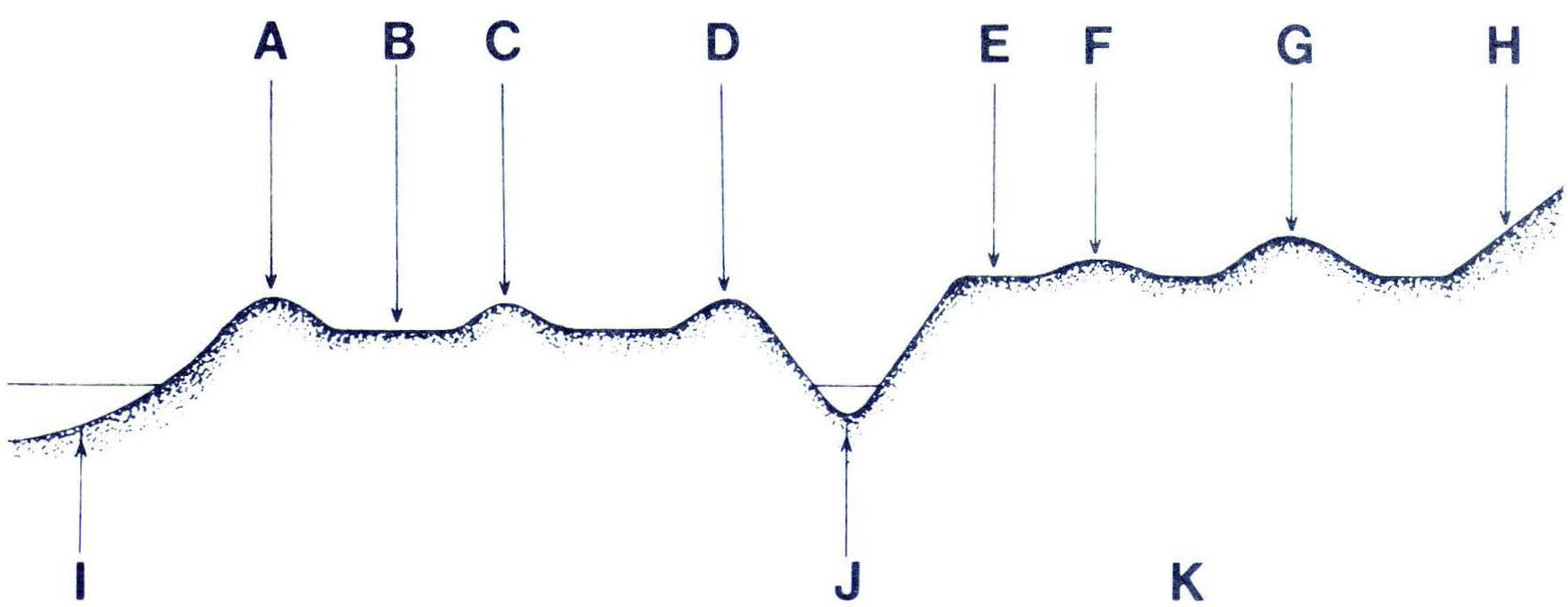


Fig. 9. Cross section of one-half of a floodplain indicating the topographic features referred to by numerous authors. Vertical scale highly exaggerated. See text for explanantion of symbols.

The terminology in use is: (A) **Natural levee or "front,"** occupied by pioneer species, such as willow (at waterline), cottonwood (*Populus heterophylla*), silver maple (especially along the Flint), river birch, etc. (B) **Flats or back swamp,** with longer hydroperiod or higher water tables. These areas are occupied by an overcup oak-water hickory community. With less hydroperiod and a lower water table, there may be sugarberry, laurel oak, overcup oak, red maple, American elm, and green ash. Green ash and hackberry tend to form pure "stands" on Georgia floodplains, particularly after catastrophism, such as too intensive logging. (C) **Low ridge,** occupied by sweet gum, willow oak, and green ash. This association is similar to that occupying the flats (E) of the second terrace. (D) **High ridge**, or old natural levee or ancient front-vegetation has evolved similar to that of the high ridge of the second bottoms, a mixed hardwood climax forest resembling upland forest with white oak, blackgum, winged elm, white ash, various hickories, and loblolly pine. (E) **Flats** (of second bottom), occupied by sweet gum, willow oak, laurel oak, green ash, and red maple. (F) **Low ridge** (of second bottoms), usually occupied by swamp chestnut oak, cherrybark oak, water oak, blackgum, winged elm, etc. (G) **High ridge,** or old natural levee (of second bottoms) (see D above), (H) **High ground**, ( I ) **River Channel,** (J ) **Oxbow lake.**

Figure 10 is a cross-section of one-half of the Altamaha floodplain in Wayne County, indicating the approximate water elevation when each floodplain level is inundated. Rayonier foresters state that at 3.5 feet the floodplain is dry enough for normal vehicular traffic (jeeps, logging trucks). The vegetation for each level, as determined by Rayonier foresters, is as follows for an approximately 6,000-acre of floodplain (Boyle's Island) (A) Two small stands of ash with scattered silver maple, probably successional on sand bars; (OC) poorly-drained flats characterized by overcup oak and cypress, with water oak and water hickory important sub-dominants; (TC) nearly pure tupelo with scattered cypress; (WS) the most extensive floodplain type on Boyle's Island, the dominant trees being water oak and sweet gum, with overcup oak, water hickory, elm, ash, and red maple as common sub-dominants; (SE) low ridges (such as natural levee remnants) also dominated by water oak and sweet gum, with elm and hackberry as co-dominants—the swamp palm (*Sabal minor*) can grow here, (L) these high ridges are sand hills that are almost never inundated. Live oak is the dominant tree. Swamp chestnut oak and mockernut hickory, may occur; (R) river channel; (H) highground or valley wall.

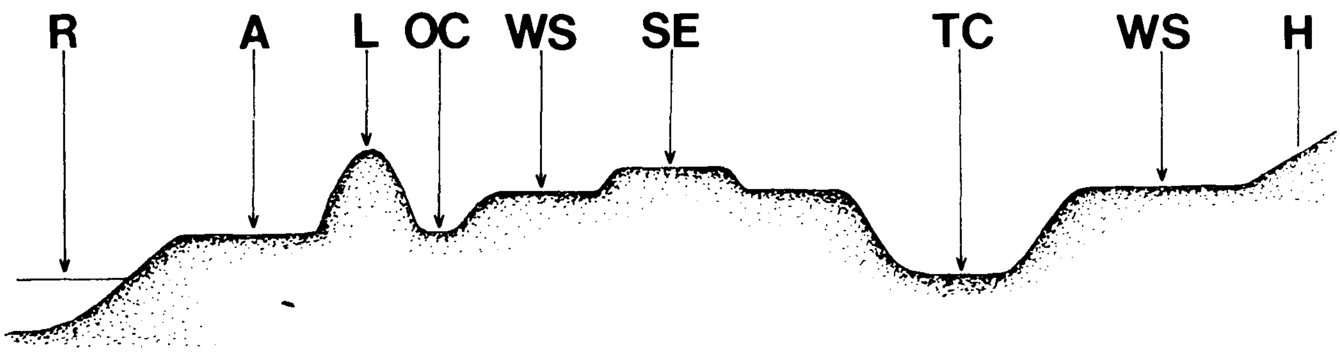


Fig. 10. Cross section of one-half of the Altamaha River floodplain at Boyle's Island (Wayne Co.), with approximate elevations relative to and based on U.S.G.S. Doctortown guage readings: R (0 ft.); A (3 ft.); OC (3 ft.); TC (0 ft.); WS (6 ft.); SE (8 ft.); L (above annual inundation). All except "L" are annually inundated. The natural levee is omitted. See text for symbol explanation. Adapted from Rayonier Altamaha River Bottomland Hardwood Management Plan, Appendix 1. Vertical scale is greatly exaggerated.

McKnight (1968) indicates that the floodplain association with poor drainage (overcup oak-water hickory) in Mississippi delta forests, after heavy cutting and fire, consists of a good deal of hackberry, elm (*Ulmus americana*), and green ash (*Fraxinus pennsylvanica*)—giant cane follows the logging of sweet gum. Dennis (1973) recognized three environments within the Santee swamp floodplain (Sumter Co. S.C.).

Sharitz *et al* (1974) described the vegetation of some of a 7,460-acre Savannah floodplain in the upper Coastal Plain of South Carolina. The floodplain, 3 to 4 kilometers wide behind the natural levee, supported mixed bottomland hardwoods. Swails *et al* (1975 a) recorded vegetation in the Savannah swamps on the South Carolina side but did not clearly define the quadrat area. Bozeman and Darrell (1975) listed indicator species for Coastal Plain alluvial (Class I) river swamps, citing canopy dominants and co-dominants (50% or more of canopy). Cypress-gum dominants: bald cypress, tupelo, overcup oak, green ash, swamp black gum. Understory: swamp privet, swamp dogwood. Typical bottomland hardwoods: overcup oak, water hickory, green ash, American elm. Understory species: water elm, (*Planera*) ironwood persimmon, swamp holly (*Ilex decidua*), button bush, sebastian bush, Virginia willow, swamp palm.

One of the values of an undisturbed natural area is that it gives us baseline information as to the ultimate climax vegetation of that environment. Such an area is the great Congaree Swamp of 10,000 acres lying within 20 miles of Columbia, S.C. National Park Service (1963), Dennis (1967), and Sierra Club (1974) describe the area. On the wetter portions which I visited, the dominant trees were water hickory, overcup oak, sweet gum, and elm, with some sycamore. Slightly higher flats were oak-dominated, the canopy consisting of overcup, swamp chestnut and cherrybark oaks, with sweet gum, American ash, and a few American holly. A very common shrub was *Ilex decidua,* and common floor herbs were *Polygonum virginicum,* cross vine, *Justicia ovata,* and *Carex* sp. In the center of the floodplain near Hammond's Gut we found a still higher but remarkably small knoll (perhaps 200 feet in diameter) supporting a stand of beech, spice bush (*Lindera*), and some remarkable herbs such as the northern ginger (*Asarum canadense*). Gaddy *et al* (1975) found that a 4,000-acre area of virgin Congaree swamp might contain 11 plant community types, plus numerous canopy (age) types. The most common type was sweet gum-dominated, with swamp chestnut oak, laurel oak, and white ash as secondary species. Succession from young to relict canopy was estimated to require 300 years. Culler (1974) records the sizes of the incredible Congaree trees. A loblolly pine on the edge of the Congaree River floodplain was 320 years old, Culler (1974). The national record overcup oak (CBH 21' 10") is 150 feet tall, with a crown spread of 87 feet. We learn in the Congaree, contrary to some foresters, that a mature forest is a healthy forest, with few dead and dying trees. Gaddy *et al* (1975) indicate that sweet gum dominated regeneration following fire or clearcutting, with laurel oaks soon invading. They also point out that wind-throw is much more prevalent on floodplains than on drier sites.

Georgia's only virgin gum-cypress swamp is described in the next section, [21] TIDEWATER RIVER. The only area of bottomland hardwoods that I have seen in Georgia that approximates the Congaree is about 200 acres on the extreme north end of Bear Island (Effingham Co.). It lies on a terrace several feet higher than the general island elevation and is composed of approximately 80% sweet gum (many having a circumference of 15 feet DBH), 20% American ash, and 20% water hickory and laurel oak. Large areas are covered with river cane. On its death, a rank growth of poke, muscadine, and the false nettle become temporary ground cover.

The river cane, variously identified as *Arundinaria tecta* or *A. gigantea*, is an important floodplain plant. As one of the earth's most productive plants, it produces up to 4,000 pounds of edible leaves per acre per year. It is said to burn every five years in some areas, but reaches a maximum fuel storage in three years, with 5 to 7 tons of flammable material per acre. Its leaves contain from 9-26% protein and are relished by herbivorous mammals, such as the canecutter rabbit and, formerly, buffalo. Its growing tips and rhizomes provide fine food for cattle.

Meanley (1972) found Swainson's Warbler to be closely associated with river swamp canebrakes. By the 1970's the canebrakes along the upper Ocmulgee (to 25 miles south of Macon) were still the most extensive of any that he could locate in the South.

Bartram (1791) and Hawkins (1799) made numerous references to cane bottoms and canebrakes, which apparently covered extensive areas. Johnson (1972) cites buffalo hunting in Georgia from 1722-1725 and indicates their presence in 1739 between Augusta and Columbus. Much fire hunting and controlled burning were practiced by the Indians prior to 1750.

On the Oconee floodplain in Wilkinson County is an interesting variant of floodplain forest—a hickory flat—almost exclusively containing pignut, water and bitternut hickories. This remarkable area also contains numerous northern paw paw (*Asimina triloba*). The understory is predominately possum haw (*Ilex decidua*), false nettle, the swamp palm (*Sabal minor*), with needle palm (*Rhapidophyllum*).

The floodplain is far from a homogeneous habitat. Along riverbanks and in openings, vine-dominance is the rule. The most conspicuous of these vines is the pepper vine (*Ampelopsis arborea*), followed by the trumpet creeper (*Campsis radicans*) and the cross vine (*Bignonia (Anisostichus) capreolata*). Various grapes, such as muscadine, are nearly always present along the *Vitus vulpina, V. riparia,* and *V. palmata*. The ratten-vine (*Berchemia*) is relatively common. Less common are climbing dogbane (*Trachelospermum difforme*), ladies' eardrops (*Brunnichia cirrhosa*) found especially along the Flint, and the climbing milkweed (*Gonolobis*). The ubiquitous poison ivy (*Toxicodendron radicans*) is widely distributed. Various greenbriers, such as *Smilax laurifolia* and *S. walteri,* are also widespread.

The most common floodplain floor herbs seem to be the swamp or false nettle (*Boehmeria cylindrica*), *Justicia ovata, Analema* sp., *Eupatorium coelestinum, Blephilia* sp., *Ruellia* sp., *Lycopus* sp., *Verbena rigida,* and *Liatris* sp. Bozeman (1964) lists common herbs or the Lower Altamaha floodplain. This herbaceous cover is little studied. Nor have the successional stages following timber harvest been described. At one clear-cut on the Ocmulgee floodplain in late August, I found the following plants to be common: *Heliotropium indicum, Diodia virginica, Trichostema* sp., *Froelichia floridana, Monarda punctata, Hypericum* sp., and *Thyellia* sp. This is a lush initial pioneer "weed" stage of secondary succession on the floodplain.

### Floodplain Fauna

**Floodplain invertebrates.** Grey (1973) described invertebrates of the soil litter (humus depth 2.0 cm. pH 5.4) of the upper Santee swamp in South Carolina. Mites (Acarina) are the dominant litter invertebrate, comprising by number 48% of the fauna in the fall and 77% in the summer. The most important family is the flood-tolerant Sminthuridae followed by the Entomobryidae and the Poduridae. Springtails (Collembola) are the second most important group. Both the mites and springtails are important decomposers of organic detritus, and their densities are significant to energy flow in floodplain foodwebs. Other widespread insect families are ground beetles—(Carabidae), rove beetles (Staphylinidae), and wrinkled bark beetles (Rhysodidae). Two important fly families (Diptera) are important, the Empidae and the Mycetophilidae.

Sniffen (1976) indicates that the most abundant invertebrates on a clay substrate in a North Carolina Coastal Plain swamp are chironomid fly larvae, the amphipod *Crangonyx serratus,* the copepods *Asellus* sp., and the crayfishes *Procambarus acutus* and *Fallicambarus uhleri.*

**Floodplain vertebrates.** Vertebrate distribution is CP; the gum-cypress association has fauna H, the bottomland hardwoods, fauna M, Appendix VI. Among the amphibia inhabiting floodplains are the two large, nearly legless forms locally called "conger eels," *Amphiuma,* and *Siren.* We have never found them in the Piedmont. They and the waterdogs (*Necturus*) seldom, if ever, emerge from the waterways. The waterdogs are apparently more common in the upper northeast and southwestern Coastal Plain. The Alabama waterdog (*Necturus maculosus beyeri*) may be confined to the Appalachicola system. The red-spotted newt breeds on the floodplain as does the spotted salamander, but both frequent the second bottoms and terraces more than the lower portions. The southern red, mud (probably confined to floodplains) and dwarf salamanders are found in moister situations. The other Ambystomids, the marble and mole salamanders, are also found in the floodplain. The marbled, as in the Piedmont, is confined to this environment.

Although a number of Coastal Plain frogs may resort to the floodplain, few are restricted to the river swamps. One is the bird-voiced tree frog (*Hyla avivoca*); it breeds in the inundated backswamps. On the banks of swamp streams one frequently finds the river frog as far north as the Kinchafoonee (Flint system). Also bronze, bull and carpenter frogs may be floodplain breeders. The beautiful green tree frog will breed among emergent water plants in quiet sections of the larger streams, such as the Satilla or Ogeechee rivers. The narrow-mouth toad, the southern toad, the cricket frog, and the leopard frog are often encountered on the floodplains, although they are not restricted to them.

Among the reptiles our largest freshwater turtle, the alligator snapper (*Macrochelys*), comes into Georgia in the larger rivers of SW Georgia Coastal Plain. The mud and musk turtles are river and stream forms. The rare spotted turtle is more often found near the smaller streams and branch swamps than in the large river floodplains. The very unusual clam-eating Barbour's map turtle (*Graptemys barbouri*, with an enormous head in the female) comes up the Flint well into the Piedmont; its Chattahoochee distribution is unknown. In Coastal Plain streams, the Florida cooter (*Chrysemys floridana*) and river cooter (*C. concinna*) are the dominant forms along with the yellow-bellied (*C. scripta scripta*), the latter seeming to prefer the quieter rivers and sloughs. The red-eared turtle (*C. scripta elegans*) enters southwest Georgia along the Apalachicola system. There are two species of softshells in south Georgia streams, the spiny and Florida softshell. The chicken turtle (*Deirochelys reticularia*), if it occurs on floodplains, is confined to sloughs and quiet water.

No lizards are confined to the floodplains. The green anole and the five-lined skink (*Eumeces fasciatus*) prefer high humidity conditions and usually live in or on the edge of river floodplains.

Among the snakes, the black swamp, the glossy water, and the striped swamp snakes are small, secretive swamp dwellers, but not confined to river floodplains. The beautiful rainbow (*Abastor*) and mud (*Farancia*) snakes come as close to being characteristic of the great river swamps as any, and they occur in rice field marsh created in the floodplain. They feed to some extent on the elongate salamanders, siren and amphiuma. The rainbow snake, in particular, also inhabits spring runs and large springs. Three other water snakes—the brown, red-bellied, and southern banded—are riverine forms, especially the brown and red-bellied. The brown is our largest water snake; pugnatious and bloated, these snakes adorn dead trees along most Coastal Plain rivers, and may resemble cottonmouths. The cottonmouth itself is a southern floodplain snake. It will inhabit sloughs and surprisingly small channels, cuts, and sucks; it seems to prefer moving water, but avoids rapidly moving water. Boyd (1976) found the most common snakes of the Oconee River bottomland hardwood community to be the cottonmouth, canebrake rattlesnake, copperhead, gray rat snake and pine snake.

John Dennis (Preliminary list of birds of the Congaree Swamp—unpub. manuscript) in 1966 observed birds in the virgin 15,000 acre Beidler tract on the Congaree floodplain. The most abundant breeding birds were, in order of abundance: Red-eyed Vireo, Parula Warbler, Cardinal, and Carolina Wren. Other permanent or breeding residents were Yellow-crowned Night Heron, Wood Duck, Red-shouldered Hawk, Chimney Swift, Woodcock, Barred Owl, Pileated and Hairy Woodpeckers, Bluejay, Chickadee, Tufted Titmouse, Swainson's Warbler, common grackle, and Towhee. Additional summer (or spring) residents were Green Heron, Swallow-tail Kite, Mississippi Kite, Acadian Flycatcher, Veery, White-eyed Vireo, Prothonotary, Swainson's and Hooded Warblers. Straney, Briese, and Smith (1974) found a similar fauna in a summer survey of the unaltered cypress-gum swamps of a Coastal Plain tributary of the Savannah (Aiken Co., S.C.).

Other river floodplains have additional species. Bald Eagles nest on General's Island (McIntosh Co.). In Four-Hole Swamp (S.C.) there are White Ibis rookeries—the birds apparently feed on the abundant crayfish, probably *Procambarus troglodytes*. I have seen both Glossy and White Ibis feeding along the lower Altamaha, and Wood Ibis are seen flying over. Although it is not restricted to the large rivers, the unusual "crying bird" or Limpkin is found along the Altamaha above tidewater and on the Ocmulgee. It feeds almost entirely on snails, largely *Vivipara georgiana,* the shells of which it places in little piles.

Appendix VI lists river (H) and floodplain (M) mammals. See also [39] BEAVER DAM TYPE. Boyd (1976) found that cotton mice (*Peromyscus gossypinus*) comprised 84% of the small mammals trapped in Oconee River bottomland hardwoods. Other mammals (and their abundance in percent) were: golden mouse (.09), short-tailed shrew (.03), wood rat (.014), house mouse (.012), rice rat (.005) and southeastern shrew (.004).

**Natural and Cultural Values**

(1) Natural Flood Control—The floodplain minimizes damage from high flows by a spreading-out and retarding action;

(2) Silt Removal—Silt is removed by overbank deposition, and this mineral and organic subsidy is used by the biota of both river and floodplain;

(3) Natural Filtration—Floodplains act as sediment and pollutants traps preventing downstream water contamination. When high levels of radioactivity were discovered in deer on the Savannah River Plant (AEC), a study of the food chains by which the radioactive elements went from sediments of Savannah tributaries into the food chains revealed that the radioactive sediments were stopped by the swamps—very little radioactivity was escaping into the Savannah River, although some minor biological magnification of cesium 137 and strontium 90 occurred in bream and catfish.

In a study of fly pollution of a swamp stream, Guthrie *et al* (1974) found that major clean-up mechanisms were the settling out of particulate matter and the biologic food webs that used and recycled chemical elements from waste effluent.

Natural floodplain filtration and treatment has probably saved Georgia communities countless millions in primary, secondary and tertiary treatment of human and industrial wastes, although not without costs to the environment in many cases. Pressure on the river systems is increasing. Patrick (1967) cites the growth of Augusta from a population of 162,000 in 1950 to 216,000 in 1960 and lists 10 major new industries during this period. The Savannah receives considerable industrial wastes at Augusta. Otherwise the major sources of wastes are numerous towns throughout the drainage basins that empty their sewage into it. Wharton (1970) indicated the purification ability of Piedmont swamps and of oil degradation by other swamp streams. By passing through swamp systems, waters are made potable for downstream consumers.

Some industries pose special problems. The effect of the Rayonier Mill is to add cellulose wastes—wood sugar nutrients—to the Altamaha at Doctortown (Wayne Co.). This causes mats of the white filamentous bacterium (*Sphaerotilus* sp.) to grow as periphyton on the bottom and on debris as far south (in the fall) as Paradise Park. These organic mats wash downstream in the high waters of winter and clog the nets of fishermen. The total impact of *Sphaerotilus* on the aquatic ecosystem is unknown. Twelve pulp and paper plants discharge into Georgia rivers large amounts of lignins in approximately 335,000,000 gallons per day of treated effluents. The 69 textile operations in Georgia discharge large volumes of polychlorinated biphenyls and dyes, largely into the Alabama system.

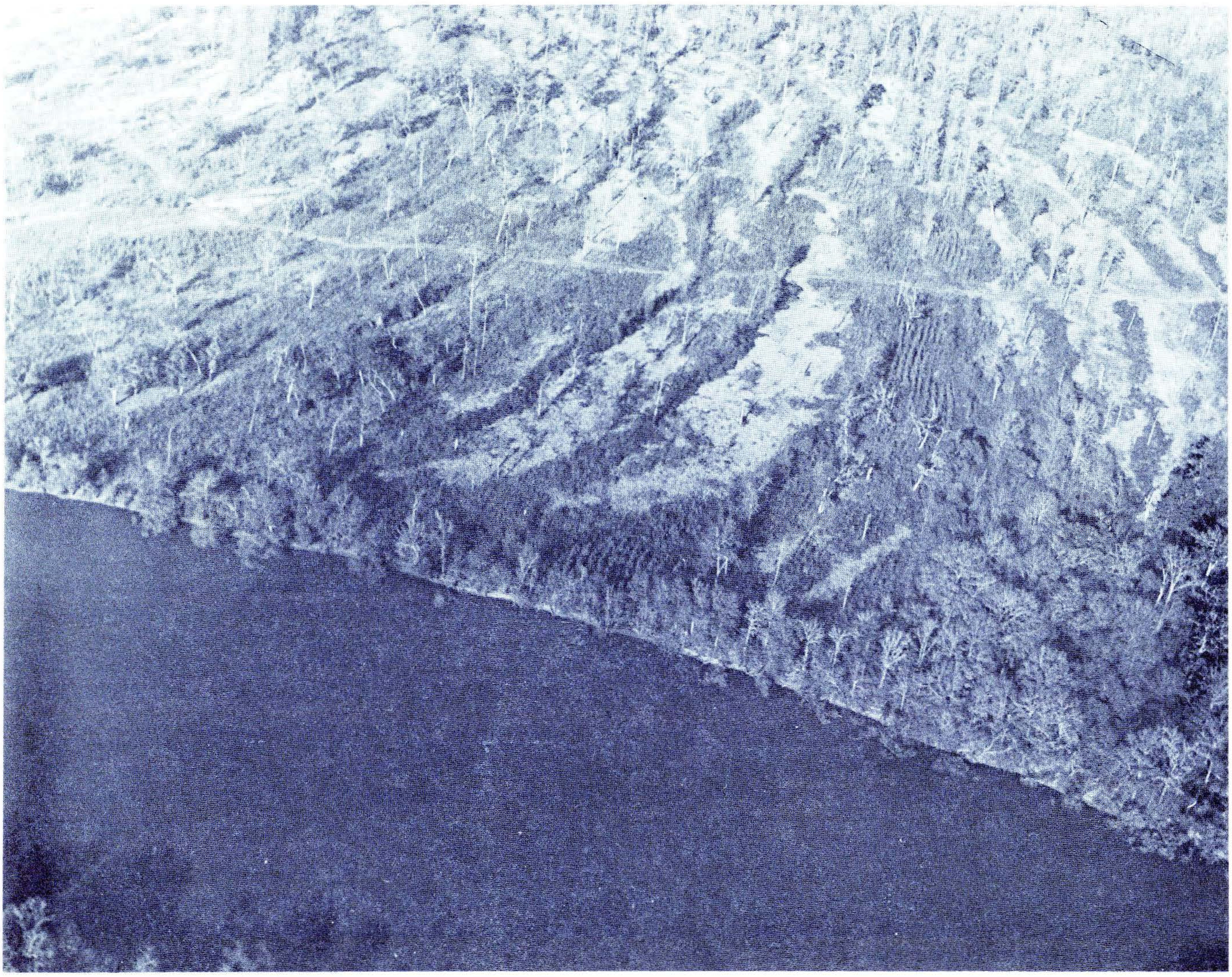

Photo M. This aerial view of the Altamaha floodplain indicates the impact of the bulldozer on bottomland hardwood sites [10] which are to be planted in pine. Such modification of the vital river greenbelts by large industry destroys a wildlife resource base and reduces the supply of scarce hardwoods.

Sam Pickering, using high-altitude photography has pointed out that the waters of the Flint River and the muddier Chattahoochee do not mix in Lake Seminole, but keep a sharp division all the way to the dam. Pickering suggests that the Flint is kept clearer by the purification action of its large swampy areas, and by a certain amount of exchange of water while it courses through the limesink region.

One of the few studies on the ability of the river swamps to assimilate nutrients (tertiary treatment) has been recently done by Kitchens *et al* (1974) in the Santee Swamp of South Carolina, which receives treated sewage pollution from the city of Columbia (16,000,000 gallons/day) via the Congaree River and heavy influxes of agricultural run-off from the Wateree River Strikingly Lake Marion, only five miles downstream, has not shown eutrophication symptoms. These authors found significant reductions in nutrient concentrations (especially phosphorus), lowered bacterial counts (including fecal coliforms), and little or no oxygen depletion as the waters coursed through the swamp. They attribute some of this purification to the deposition of suspended silts and clays, but more to extensive assimilation by aquatic vegetation and associated epiphytes, and by the trees themselves. The authors cite evidence from a study by Day *et al* (1974) and others that swamps whose river water source has been cut off begin to export nutrients, suggesting that the nutrient "sink"mechanism is fragile and can be disrupted by man. Kitchens *et al* suggest that the nutrients are delayed and incorporated into living tissues which later after a time lag, go downstream through aquatic food chains (direct grazing) as organic humics, tannins, and lignins from decomposition, or as organic detritus physically or biologically exported.

Kitchens *et al* (1974) conclude that "the southeastern deciduous swamp is a highly efficient water treatment facility with no fossil fuel costs" and is of great economic value in the undisturbed state. For this reason, they state that "channelization and timber clearing should be evaluated in terms of effects on this role."

Brown, Bayley, and Zottek (1974) found similar waste treatment by a series of four small swamps totaling 186 acres which had been treating the sewage of Wildwood (Sumter Co., Fla., population 2,500) for 19 years. The sewage received essentially only primary treatment. The authors noted a significant decrease in nutrient concentrations (total phosporus reduced 98%, total nitrogen reduced 89.7%) as the water flowed through the swamp; the concentrations of phosphate and nitrate in the water leaving the swamps are lower than those found in Lake Panasoffkee into which the swamps empty. Such reductions are similar to those obtained in advanced waste water treatment facilities. Fecal coliform bacteria were reduced from 1,600,000 at the Wildwood, Florida sewage plant to 300,000 at the first swamp station to 1,600 on entering the main swamp, to 300 in the next two miles of swamp, Wharton *et al* (1976). Cypress receiving nutrients were growing faster (5.5 cm/20 years) than those in control areas (3.87 cm/20 years). This small swamp (506 acres) was calculated to be worth at least $79,399/year to man, Wharton *et al* (1976).

(4) Source of Food, Sport Fishing, and Recreation. Tupelo honey is a well-known commercial swamp product. The Savannah supports an intensive commercial fishery for catfish, principally the southern channel catfish (*Ictalurus punctatus*), but including the white catfish (*Ictalurus catus*) and the flat bullhead (*Ictalurus platycephalus*). The fish are sold to restaurants near the river.

Gold *et al* report a limited shad fishery on the Savannah using 5 to 6" mesh (stretched) gill nets. Fishing for American shad (*Alosa sapidissima*) and hickory shad (*Alosa mediocris*) begins in January at mile 48, and continues into April when the long-nose gar and bowfin become so numerous as to interfere with operation of the nets. A few shad may remain until mid-June. Fishermen sometimes take the alewife (*Alosa pseudoharengus*), striped bass (*Roccus saxatilis*), and sturgeon (*Acipenser oxyrhynchus*).

In 1968, 568,908 pounds of American shad and 11,308 of hickory shad were landed commercially in Georgia. This increased to 617,749 and 12,295 in 1969 (value $184,255), according to Adams (1970). U.S. Department of Commerce figures report shad captures in 1975 amounted to 183,209 pounds ($99,745). More than 65% of Georgia's total shad production occurs in the Altamaha, which is yet not seriously dammed or polluted. Biologists indicate, however, that the shad fisheries are virtually without management, with no limitations on gear or number of fish taken.

Dahlberg and Scott (1971) report that the Alabama shad is caught by sport fishermen in the Chattahoochee—other shad species are caught by sport fishermen in other areas. In 1952, sport fishing was more intensive in the Savannah tributaries and floodplain lakes than on the main river itself. The knowledge that one's line can always be taken by a giant striped bass (up to 60 pounds) makes fishing in the Coastal Plain streams exciting. The world's record largemouth bass came from Montgomery Lake, an oxbow in the floodplain of the Ocmulgee River (Telfair Co.).

Most Georgia streams receive 50 man-hours per acre per year. Satilla River figures ranged from 34 to 45 man-hours/acre/per yr. For a two-year period the catch ranged from 38 fish/acre/(17 pounds) to 82 fish/acre (31 pounds), DNR (1976). Bass (1974) calculated the annual value of the Suwannee River sport fishery in Florida at $2,265 per mile; for the Santa Fe River, $3,088 per mile.

(5) Use in Education and Research. Wharton (1970) gave estimates of swamp value to the school system.

As one flies over much of south Georgia, especially over the Tifton Upland, it is obvious that the only near-natural environments remaining, other than some cypress ponds, are rivers and their hardwood-forested floodplains, representing corridors of life through biologically sterile (comparatively) pinelands . Their value in recreation and education is incalculable.

Large segments of these green belts are needed for river parks and scenic rivers where the experiential type of education, with an emotional involvement with nature, can be used. A river park should ideally be 25 miles long by a reasonable width, averaging perhaps 2.5 miles on the lower Altamaha, since sand ridges intervene for much of the distance across the eastern floodplain.

The river swamps are ideal multi-interest areas. Parts can be wilderness, other parts are of great historical and archaeological interest. The botanical and zoological opportunities are varied because of the wide varieties of habitats within the floodplain ecosystem, such as sand ridges, natural levees, terraces, sloughs, cuts, oxbows, lakes, flats, sand bars, and so on. The recreational use of a poorly accessible area of South Carolina's Santee swamp (66,300 annual visits) was high, Gahan and York (1975).

Importantly, the water ways serve as roads and the many smaller channels as trails. Senior citizens and handicapped individuals can thus enjoy experiences never available elsewhere because of the ease of energy-conserving boat travel. The sand bars afford excellent, economical, isolated camping grounds sought by many people. Travel, expecially by canoe or small outboard, is probably the most economical means of conserving energy available to us today. One need not drive far to reach a suitable river or stream. Exploring unknown waterways is an exciting experience.

(6) Groundwater recharge. Some geologists believe that the rivers may recharge the principal underground aquifer when they cross this zone of the upper Coastal Plain. Just above this zone are the very wide swamps reaching up to the Fall Line. These large swamps serve as natural reservoirs and may affect low-water flows through the aquifer recharge zone. High water inundations on the floodplains do aid, however, in maintaining higher water tables in agriculturally important shallow aquifers and in permeable soils adjacent to the streams and floodplains of the Coastal Plain area. This was documented for Florida's Gordon River, Wharton *et al* (1976).

(7) History. Up until the early 1900s, large rivers like the Altamaha were the arteries carrying the life-blood of Georgia. There were numerous eras in river history, the most exciting of which were the dug-out era, the pole-boat era, the log-rafting era (largely to export longleaf pine—called "yellow pine"), and the steamboat era. The final periods were largely brought to an end by railroad construction, but the historical use of the great rivers is a neglected portion of our history. Darien at one time was the greatest lumber shipping port on the eastern seaboard. As late as 1916 there was one steamboat operating between Doctortown and the Forks, two between Lumber City and Hawkinsville, and one between Dublin and points south. These boats carried cotton, fertilizer, naval stores, lumber, and general merchandise. In 1924 a boat operated between Doctortown and Brunswick, but that year saw the end of regular scheduled steamboat traffic on the Altamaha River, according to the U.S. Army Corps of Engineers (1935).

(8) Archaelogy. Indians made frequent use of the river bluffs and sand ridges for their villages and middens, and built mounds on or near the floodplains of the major streams. Dennis (1973) reports a probable Indian mound in the middle of the Santee Swamp (Sumter Co., S.C.). Dennis (1967) also discusses the grazing of cattle on the floodplains of South Carolina rivers in Colonial times. He refers to large mounds called "cattle mounts" (measuring 50 feet wide, 90 feet long and 6 to 7 feet high), thought to have been constructed by slave labor to serve as refuge for cattle during high water. He describes the vegetation of one called "Cooner's Mount" in the Congaree Swamp. Meanley (1972) pictures an Indian mound in bottomlands and states that the Indians of the Southeast "mostly lived in or near the river bottoms." The river bottoms furnished a large variety of shellfish, fish, game, nuts of acorn, hickory, and pecan, and more abundant fruits (such as sugarberry and grape) than the upland forests.

(9) General Productivity. Wharton (1970) summarized the productivity of floodplains and listed the animal and plant products utilized by animal and human food chains, and made an estimate of timber productivity. I have already recounted the high growth rates of sweet gum, tupelo gum, swamp blackgum, and other trees when inundated during the early growing season (up to 50% gains in radial growth). Recent studies by Day *et al* (1974) (tupelo-cypress), Carter *et al* (1973), and Brinson (1975) (tupelo) indicate that river swamp systems are more productive than temperate deciduous forests. Conner and Day (1976) estimated total net primary productivity of Louisiana bottomland hardwoods (red maple-tupelo gum dominant) at 1733 g/dry wt/m$^2$/yr and cypress-tupelo forest 1516 g/dry wt/m$^2$/yr, compared with the low productivity of a cypress pond (200 to 600 g/m$^2$/yr). These authors emphasize the importance of seasonal flooding and moving water to increased growth rate of trees, especially cypress-tupelo gum.

A general picture of swamp floor productivity is emerging through work on the North Carolina Coastal Plain, outlined by Brinson (1975). During the first four months after leaf fall, leaves gain nitrogen (from bacterial growth). Following this, there is a dense growth of filamentous algae which recycles nutrients until the forest floor becomes dry and shady at spring leaf-out time, when billions of tiny tree rootlets, along with extensive mycorrhizal fungi (Filer, 1973) take over the nutrient absorption. There thus appears to be a continuous mechanism for the removal of nutrients from the floodplain floor. Kuenzler (1976) indicate that the two dominant filamentous algae are *Hyalotheca dissilians* and *Eunotia pectinalis.*

The sheet flow of the high water sweeps both dissolved and particulate organic material into the main stream as well as into downstream oxbows and water courses of all types. It also must sweep floodplain floor organisms along with it, leading to a vast augmentation of food for the life in the river. Wallace *et al* (1976) presented data suggesting that considerable amounts of particulate organic matter in Coastal Plain rivers may originate on the floodplain during periods of high water.

There is evidence of the relative production of benthic organisms by the floodplain as compared to the channel itself. From July 1, 1969, to June 30, 1070, Holder (1971) examined benthos production of the Suwannee River ecosystem, comparing mainstream sloughs and floodplain. In spite of the difficulty of closing the Peterson dredge on the floodplain floor (with possible loss of organisms), the species diversity and biomass were higher in the slough and floodplain stations than in the Suwannee channel. Table 5 compares the average numbers of organisms per square foot and in grams biomass (average weight per square foot).

TABLE 5. Numbers of Benthic Organisms and their Biomass from Channel, Slough, and Floodplain Sites of the Suwannee River, after Holder (1971). T=Trace.

| | Suwannee Channel | | Suwannee Sloughs | | Suwannee Floodplains | |
|---|---|---|---|---|---|---|
| | No. Organisms | Biomass | No. Organisms | Biomass | No. Organisms | Biomass |
| insects | 1.24 | .028 | 15.46 | 84.7 | 21.35 | 31.3 |
| annelids | .33 | T | 2.74 | 15.0 | 10.01 | 30.1 |
| crayfish | 0 | 0 | .05 | .3 | .19 | 38.2 |
| other | 0 | 0 | .01 | T | .10 | T |
| Total | 1.57 | .028 | 18.26 | .204 | 31.65 | .329 |

In the channel the dominant benthos were *Molannus, Progomphus,* and Ceratopogonids. The more frequent forms from the slough were oligochaete worms, *Molannus, Phylocentropus, Polycentropus,* chironomid fly larvae, *Progomphus, Libellula, Enallagma, Hydroporus, Corydalus,* and *Lissorhoptrus.* The most common forms on the floodplain were oligochaete worms, crayfish, and the larvae of chironomid and tabanid flies.

Holder noted a wide fluctuation in floodplain benthos from zero in September 1969 to 1.783 grams in April 1970. As noted under Piedmont swamps, organisms become much more abundant in winter and early spring. Holder indicated 19 crayfish per 100 ft$^2$ on the Suwannee floodplain. There are several species that burrow on the floodplain and emerge at night or underwater to feed. They move extensively over the floodplain floor and are preyed upon by raccoons, otter, and even the barred owl.

Holder comments: "The fact that a stable benthic population established itself on the floodplain during high water conditions is significant in showing the role of floodplain when compared to that of the mainstream. Wharton (1970) points out the values of river bottom swamps in the Southeast and the importance of fluctuating water levels over the floodplain to the ecology of the river. This study supports Wharton's contention that the periodic inundation of the floodplain plays a vital role in the area of fish production."

Holder indicates that floodplain benthos production is 15 to 20 times greater than the channel, and suggests that the potential of floodplain benthos production is from 300 to 500 times greater than the riverbed. High production, however, never materializes because of fluctuating water levels. Holder feels that his data help explain "the bumper crops of large fish reported from Coastal Plain streams following a sustained wet cycle." Lower Coastal Plain streams are more variable in their water level fluctuations than are those whose headwaters lie in the Piedmont or upper Coastal Plain.

Crayfish, which are detritus scavengers, have been documented by Holder (1970 B) and Wyatt and Holder (1969) to be one of the major food items of the larger fish of the Suwannee. Holder indicates that the production of benthos on the floodplain as well as in the sloughs explains "in part, the phenomenal standing crop of unusually large fish that were reported by Wyatt and Holder (1969) to exist in the Suwannee River."

Other indirect data indicate the importance of floodplain productivity. Wyatt and Holder (1969) stated that the average size of harvestable bass in the Satilla was much smaller than those in the Suwannee, and those in the Alapaha smaller still (bass $< .5$ pounds). These data seem to coincide with the amount of swamps and sloughs which these three rivers have. The difference in floodplain productivity between the alluvial Oconee and the non-alluvial Canoochee has been demonstrated by Boyd (1976) who found that laurel oaks of comparable age are both taller and larger in diameter on the Oconee floodplain. Furthermore, the density of cotton mice (*Peromyscus gossypinus*) was higher in the alluvial system.

Photo N. Floodplain forest [10] removed by a regeneration cut (clear-cut) in the great swamp of the Flint River just below the Fall Line (Crawford Co.). The long-range effects of such a practice are undocumented.

### Use of the floodplain by fish

It is well known to sport fishermen on the Ocmulgee and other south Georgia streams that, during high water bass, pickerel, bream, and other fish leave the channel and forage among the oaks and hickories on the floodplain floor John Adams (pers. comm.) has found that these resident river fish are very sensitive to water rise and fall, moving off the floodplain at the slightest drop in water level. Fishermen set traps in drainways to catch the retreating fish, Don Scott (pers. comm.). Adams found an abrupt change in the diet of these channel residents from predominantly aquatic insects to predominantly terrestrial floodplain forms. Sunfish, bass, and catfish were the major participants in these feeding explorations.

Woodall *et al* (1975) examined 230 fish of 16 species from the Altamaha River Nine of the 16 species had .5 to 12% of food items of terrestrial origin, including floodplain pool organisms such as the isopod *Lirceus* and crayfish, terrestrial beetles, and butterfly and moth larvae/pupae. These foods did not appear in the stomachs until the river elevation at Baxley reached 69 feet, and water began to cover the floodplain.

The floodplain of southern streams contains many sloughs, oxbows, and interconnected channels. These areas appear to be important as spawning and nursery areas. Floodplain pools and lakes that become overpopulated during low water serve as feeding grounds for predatory river fish at high water Wyatt and Holder (1969) have indicated sloughs as prime spawning and nursery areas on the Suwannee River

Adams and Street (1969) and Adams (1970) found that the anadromous blue-back herring actually spawns on the hardwood floodplain floor during high water At one Altamaha site the river was six feet above normal (mile 109), and the water temperature was 20°C. How many other fish utilize the floodplain floor itself for spawning is not known. Since the high water covers the floodplains of the larger rivers for longer periods of time than it does on Piedmont streams, it is more probable that fishes are adapted to floodplain spawning in the Coastal Plain. Some supporting data for such movement is suggested by the findings of Holder (1968) who studied fish that moved over the sill where the Okefenokee Swamp spills over to form the Suwannee River Ripe males and females of several species tried to enter the Suwannee River coincident with high water at the following time and water temperatures: Fliers, bowfin (Feb., Mar., 52-56°F); yellow and brown bullheads (Mar., 52°F); warmouth (Mar.-Apl., 60-67°F); chain pickerel (Mar.-Apl.); lake chubsucker (Apl. 70-76°F).

Holder *et al* (1970) compared the fish populations of inundated floodplains and sloughs of the Suwannee River, Table 6.

TABLE 6. Productivity of Sloughs Versus Inundated Floodplain in the Suwannee River Ecosystem, after Holder *et al* (1970).

| | Standing crop (lbs. per acre) | No. fish (per acre) |
|---|---|---|
| floodplain | | |
| Oct.3, 1970 | 9.85 | 656 |
| May 8, 1970 | 14.9 | 744 |
| slough | | |
| upstream May 19, 1970 | 196.5 | 7,823 |
| downstream May 21, 1970 | 272.3 | 16,589 |

The average depth of water over the floodplain was 1.8 feet. In the slough, 2.8. The species composition was similar. The most common fish in both habitats were the pickerels, warmouth, flier, lake chub-sucker, yellow bullhead, bowfin, mud sunfish, bluespotted sunfish, banded sunfish, and madtom.

If one multiplies the biomass of fish on the floodplain by the total acreage of inundation, a respectable figure results. The data from the above study show that, according to the authors, the standing crop over the floodplain averages 10-15 pounds per acre during an inundation period of 3 to 10 months. The inundations were from February 1969 to May 1969 and from August 1969 to May 1970. Since the slough was sampled after the water had ceased flowing off the floodplain, the data show that fish are concentrated in sloughs by falling water levels.

These authors state that "high water over the floodplain provided space, food, and increased habitat for the reproduction and growth of fish . . . It is during these periods of inundation that most of the changes in the population occurred. This generalization is supported by the abundance of fingerling and intermediate size fish . . . ."

Work by Gasaway (1973), using two-way weirs on Alligator and Jones-Tatum Creeks (Clinch Co., Ga.) has shown the tremendous importance of tributary streams and headwater swamps as spawning, nursery and restocking areas for replenishing the fish faunas of our south Georgia waterways. Gasaway found that peak movements for certain fish species correlated with periods of high water flow and sexual development. More fish by number moved downstream, but a heavier biomass of fish moved upstream. Not only are the tributaries thus shown to be vital, but the natural fluctuating water levels in these tributaries are also important.

After Gasaway's study, there is now little question about the damage that channelization and drainage will do to tributaries and headwater swamp areas of Coastal Plain streams, and the subsequent impoverishment of the mainstream fauna, with poor fishing as the result.

Holder *et al* (1971) and Germann (1972) studied fish populations of two sloughs on the Suwannee River. The species composition was generally the same as cited above, except for the addition of spotted gar, channel catfish, scalyhead darter, golden topminnow, swamp darter, and the tadpole and speckled madtoms. Red Bluff Slough (av. depth 1.9 ft.) had a standing crop (pounds per acre) of 162.0 (1971) and 117.2 (1972), while Mud Lake Slough (av. depth 2.8 ft.) showed 365.5 and 481.1 pounds at the same time.

Holder (1971) recorded two periods of within-bank flows of the Suwannee River (mid-May to July 1970, mid-October to late January, 1970) during which time fishermen took by census over 70,000 fish, attesting the productivity of streams with areas of overbank and slough habitats available to mainstream fish.

Work by Game and Fish biologists thus provides the data that support the assumption of the importance of the floodplain and its complex of sloughs and feeder streams. Modification of the floodplain or tributary streams by clear-cutting, or ditching directly threatens the fish fauna of the mainstream.

Another aspect of productivity is the linear use of a river by various species. Most of the larger rivers of Georgia and their floodplain waterways serve as spawning and nursery grounds for the marine anadromous fish. The Altamaha, which produces 65% of our shad, has been observed by biologists more closely than other streams. Adams (1970) studies three species of herrings in the Altamaha. Examination of their behavior gives important clues as to the value of this river system, not only as regards the floodplain-channel relationship, but as regards the necessity for basin-wide preservation of a river system.

Adams found that American shad spawn mainly between river miles 60 and 120, beginning in March with water temperatures about 12°C. Unlike the other two species, American shad spawn in the main channel, and most of the length of the Altamaha is used as nursery grounds. There are, however, two primary nursery areas at river mile 21-30 and river mile 100-110. Juveniles emigrate by December and disperse into the Atlantic by January. Hickory shad (*Alosa mediocris*), unlike the above species, spawn in oxbow lakes, sloughs, and tributary streams, between river mile 20 and 137. They do not remain in the river as do the American shad but move to the sounds and offshore waters soon after hatching, augmenting the drifting organisms for larger fish. Blueback herring (*Alosa aestivalis*), as discussed above, spawn in the bottomland hardwoods, and have remarkably adhesive eggs which adhere to twigs and objects on the floodplain floor to avoid being swept away by sheet flow. Ripe bluebacks were taken between river miles 5 to 137 in backwater lakes and flooded low areas "that are accessible to these fish only during spring flood stages." Primary nursery areas for juvenile blueback herring lie between river miles 10 and 30, but juveniles were taken as far upriver as mile 40. Most leave the river system in November and December. Shad appear to prefer the Ocmulgee over the Ogeechee and, according to Adams (pers. comm.), may go up until stopped by the first dam. Striped bass (rockfish) move up river systems in the spring prior to spawning, remaining upstream until July. Some appear in the estuaries, but a significant proportion remain in the rivers for several years. Spawning has occurred up to

50 miles inland on the Savannah, but most developing eggs are found in our rivers in the first 23 miles inland, possibly dependent on the tidal ebb and flow, Georgia Game and Fish Division (1970).

River swamps serve as refuges for dog-driven deer and raccoon. The acorns (mast) from bottomland hardwood oaks are perhaps the greatest wild food resource in the Coastal Plain, feeding ducks, deer raccoon, turkey and squirrel. The white oaks (overcup, swamp chestnut) produce acorns yearly the red oaks (cherrybark, etc.) require two years, and the live evergreen oaks (live, laurel) produce yet another type—all combine to reduce the possibility of mast failure. Forestry practices aimed at reducing this diversity must be used with extreme caution.

### Man's Impact

Diverting part of the flow of one river into another can set off a series of costly ecological blunders. Kjerfve (1976) has reported the effects of diverting 88% of the flow of the Santee River (from 525 to 62 $m^3$/sec.) into the tidally dominated Cooper River (from 2 to 442 $m^3$/sec.) in order to gain only 1.51% of South Carolina's electric generating power This diversion forced the Cooper River to erode so that the U.S. Corps must annually dredge $7{,}600 \times 10^3 m^3$ of sediments at a cost of $5 million. Severe erosion of some coastal islands near the Santee's mouth has probably been caused by loss of Santee sediments. Salinity intrusion changed lower Santee vegetation at heavy cost to duck hunters and landowners, the latter being reimbursed with tax dollars. Santee plantations were converted to brackish waterfowl management, and a hard clam (*Mercenaria mercenaria* industry developed on the 3 $km^2$ delta. Rediversion, at a 1975 cost of $91 million, is now being considered. This should renew spit development on South and Cedar islands, and possibly halt beach erosion in the Cape Romain area. The duck and clam industries will again be affected. Kjerfve concludes that "intelligent coastal management would have been to leave the Santee alone in the first place."

Large canals pose a major threat because they are not that necessary An enormous expenditure was made to make Columbus an inland port. Reservoirs now cover the only floodplains along the Chattahoochee. Few barges use the Apalachicola system, and the Corps is unable to maintain a sufficient channel in the river

Drainage, channelization, and levee building are highly destructive of the natural systems. There have been numerous attempts to drain Coastal Plain floodplains for agricultural purposes. The British are said to have financed a scheme to drain large areas of the great Oconee swamp near Toombsboro (Wilkinson Co.). This is the general area where the present owner Kimberly-Clark, has undertaken a large drainage program. It is the same area where, its forester told me, had grown some of the largest trees of certain species he has ever seen, and the growth rates were phenomenal. It is also the area where beaver are blocking the lateral canals, not only defeating the drainage attempt but destroying the very timber the company had hoped to grow. Other evidences of drainage, including an extensive system of artificial levees, can be seen along the Flint Fiver floodplain in Taylor County several miles below Highway 137 Bridge (west of Roberta) on the west bank of the river The levees principally protect the second bottoms. Presumably cotton was grown here with success and floated down the river to Apalachicola, which became the third largest cotton port in the United States with up to 200 stern and side wheel steamboats plying the water of the Apalachicola, Chattahoochee and Flint rivers.

Photo O. Attempted drainage of the great Oconee swamps [10] of Wilkinson County by industry will lead to lowered growth rates for tree species adapted to floodplain conditions. The subsequent reduction in diversity and the increased beaver activity may result in both short and long term damage to an important natural life support system of state-wide importance. Recharge zones for the principal aquifer lie directly downstream from the great fall line swamps.

Diking poses the threat of heavily modifying Coastal Plain floodplains. One project involves the building of an 11-mile levee on the west side of the Altamaha River (Glynn Co.), apparently to block off and dry out a large portion of the Altamaha floodplain. Such projects can result in untold damage to floodplain forest or anticipated tree plantations, as well as affect the ecology of state-owned lands and the water distribution in the Altamaha distributaries downstream. Another proposed project building dikes connecting linear sandhills, would prevent the annual high water in the Altamaha from entering at least three distributary pathways, two of which nourish and provide essential fresh water dilution for two tidal rivers.

In south Florida it has been shown to be more practical to dike in crops with water inside pumped to cypress ponds, rather than try to drain the whole countryside, Wharton *et al* (1976).

Carter *et al* (1973) document the quadrupling of groundwater recession near Florida canals and indicate the number of people who could have been maintained by this wastage (2 million). They also state that "cypress forests in undrained regions maintained primary productivity rates nearly ten times that of drained areas." Reduction in productivity is thus directly proportional to the availability of fresh water to cypress swamps. These authors also indicate that canopy thinning follows drainage, interfering with leaf break-down and leading to increased fuel for destructive wild fires. This may be true for cypress ponds as well. Carter *et al* (1973) indicate that the "apparent super abundance of water in south Florida is a pernicious illusion," and point out that "the inevitable series of low rainfall years will impose economic hardships on the human population . . . "

Patrick *et al* indicate that dredging by the U.S. Corps of Engineers has restricted the habitats for aquatic organisms in the Savannah River. They discovered that by 1960, dredging operations severely reduced insect species of larval mayflies, stoneflies, true flies, and beetles. The mayflies (especially *Stenonema* and *Heptagenia*) and the stone flies were most strongly affected. No orders were eliminated, so the community structure remained essentially similar, but fewer species were present in each order (from 46 in 1956 to 26 in 1960). As Odum (1971) suggests, pollution stress may have reduced the community to generalized species so that succession must start over again. It will then take a long time for the biotic community to readapt to the pollution flow.

Clearcutting, as a silvicultural method on the floodplains, is being employed by the pulp and paper industries. There is some evidence that certain tree species may grow better in clearcut areas, but if other values are considered, such as education-recreation, the need for species diversity, esthetics, and the retention of the soil by living root crowns, then it is not the method of choice.

Cut-over floodplains may have more mosquitoes. This is especially true at Four-Hole Swamp (S.C.) where a large acreage was cut adjacent to a virgin area. In other areas, the tracks of motorized equipment create long lasting ruts which retain water without the accompanying biological controls, such as mosquitofish, and appear to lead to heavy pest infestation.

Logging, grazing, and clearing have been deleterious to many plants and animals. Meanley (1972) states that the great canebrakes of the southern bottomlands are rapidly disappearing due to cattle over-grazing the young growth and the clearing of the cane for farm land. He also states that the gradual disappearance of the rare Bachman's Warbler has been linked with cutting of the virgin swamps in the early part of this century, and possibly to the disappearance of canebrakes that had formerly been a prominent part of the understory of primitive bottom land and swamp forest.

Dams change water quality downstream, especially if the release is from the lake bottom. The lake water, freed of silt, must pick up its load below the dam; hence erosion may be pronounced downstream. The sudden heavy flows of a weekly or daily nature as the turbines are run and then shut off does not allow the bank community to stabilize. It is highly probable that flow regulation, by interfering with the spawning and nursery areas of fish which depend upon the floodplain, and by preventing floodplain detritus from feeding the stream, damages the stream food chains and diminishes the commercial and sport fishery. Dams may confer benefits, but it is doubtful that they could benefit floodplain communities dependent on annual winter-spring inundation. Local fishermen credit Lake Sinclair with the demise of the cat-fishery on the Oconee, claiming that the overnight drop of 5 feet interfered with spawning, leaving the eggs to dry out.

Patrick *et al* indicate that Clark Hill Dam may have resulted in higher productivity for the river, possibly from an increase in photosynthetic plankton and attached algae by reduction of turbidity. Since some flow stabilization has been achieved by the dam also, it is difficult to accurately state which variable is most important.

A drive down I-75, I-16, or almost any other highway will quickly show that the technique of using landfill to cross the floodplain damages or destroys the ecosystem upstream and sometimes downstream. The gums upstream seem to be dead or dying, with much adventitious (epicormic) branching. The landfill acts as a dam and encourages beaver to compound the damage. The area goes towards a shallow marsh, rather than a closed canopy forest. Piers or pylons should be employed so as not to interfere with the water getting on and, more pointedly, getting off the floodplain.

About 1800 the tidally influenced floodplains of our major streams, tributaries, and tidal creeks were heavily modified by Colonial rice plantations. Using slave labor, the great cypress and other virgin timber were completely destroyed by burning or burying, and extensive dikes and canals occupied the entire floodplain for several miles upstream. This area was used because it was flat and the tide would elevate the fresh water so that it could be brought into the fields at high tide and let off at low tide. Occasionally, huge buried cypress logs are yet found. The rice field dikes are readily visible from the air. A number of these areas (Santee, Savannah, and Altamaha) are now used as waterfowl refuges, being flooded and drained by new gates and frequently planted to foods relished by the birds. They are variously under state, federal, or private control.

## Floodplain Management and Use

Wharton *et al* (1976) have reviewed natural functions of river swamps, including a summary of uses that damage the floodplain and uses that are compatible with natural function.

For people-problems dealing with high water, Fairey (1975) has written an excellent recent treatise on floodplain management in South Carolina with numerous references and recommendations for state legislation, local controls, and research on floodplains. He recommends specific state statutes against construction in floodplains and states that we have been unaware of assets "such as ecological, wildlife, recreational, or educational values of our floodplains."

Photo P Vast virgin gum-cypress TIDEWATER SWAMP [12] on the deltas of the Savannah, Ogeechee and Altamaha rivers were destroyed, and the floodplain converted to rice plantations about 1800. The dikes, especially visible from the air are often maintained so that the old fields can be used as winter refuges for waterfowl.

## [11] COOSA RIVER AND SWAMP SYSTEM

Maps of Alabama reveal that the Coosa floodplain is a broad band of level terrain extending from Alabama's Coastal Plain well into Georgia. The Coosa is the principal drainage of the Great Valley Because of its size, appearance and elements of its biota, it is here considered with other Coastal Plain streams. Perhaps because of its flooding regime, it is different from typical Coastal Plain streams, and most of the Coosa floodplain has been cleared and cultivated. Pockets of original biota are isolated and scarce.

### Location and Description

The Coosa is formed by the Conasauga and Coosawatee, which drain the north and south slopes of the Cohuttas, and the Etowah, which drains the western flank of the Georgia Blue Ridge. It is formed at Rome and just below Horseleg Mountain it emerges onto a broad floodplain where it forms large meander loops characteristic of Coastal Plain streams. According to Lipps (1966), floodplain soils are the poorly-drained Stendal, the Taft soils of low terraces (often with an impermeable clay layer), and the Monongahela from older stream terraces. Lipps indicated that because of Cherokee cultivation these three soils now bear 13% pine. In 1926 Huntington fine sandy loam, and silt loam soils of the Etowah floodplain, were over 90% in cultivation, USDA (1926).

### Flora

A river bank forest at the Highway 100 Bridge at Coosa, Georgia, consisted of dominant tulip popular water hickory and black oak, with some sweet gum, basswood (*Tilia heterophylla*), and silver maple. Some of these trees are characteristic of Coastal Plain streams. Remnants of true hardwood floodplain forest were observed at Foster's Bend (Floyd Co.). There is a large oxbow lake (elev 564') there, photo Q. In a transect across the floodplain I encountered at least three stages of succession in old oxbows. The upper end of the oxbow lake is a dense swamp of pole stage black gum (*Nyssa biflora* and tupelo gum (*Nyssa aquatica*). A filled-in drier oxbow, partially set in the midst of cotton fields, had as dominants water oak, willow oak, overcup oak, hickory (mockernut?) and persimmon. A third-stage relict oxbow bore a much more diverse forest of willow oak, water oak, ash, hackberry blackgum, mockernut hickory and water hickory with invasion by upland trees typified by white oak, walnut, southern red oak, silverbell, redbud and dogwood. Lipps (1966) cites dense grows of river cane along the Oostanaula floodplain, probably the result of repeated firing by the Indians.

Photo Q. An oxbow lake of the COOSA RIVER AND SWAMP SYSTEM [11] in the **Great Valley** at Foster's Bend (Floyd Co.) is a locality of a relict (now disjunct) population of the cotton mouth moccasin (*Agkistrodon piscivorus* a Coastal Plain snake which may have formerly occurred throughout the **Great Valley** south of Tennessee. Numerous Coastal Plain plants and animals penetrate northwest Georgia in the **Great Valley.**

Foster's Bend is a very interesting locality There are several archanic indian sites (6000-2000 BC) on the high floodplain in the bend (on small rises); one was at an elevation of 582 feet, Lucy Tally (pers. comm.). Another proto-historic site (mid-1500's) being excavated by Grey Paulk *et al.* (pers. comm.) was a year-round village at 572 feet elevation. The village was apparently ditched for drainage. The Coosa has an annual rise and fall, but probably not as great as many Coastal Plain streams. Hence a village at 572 feet would rarely be flooded. The watershed of the Coosa at this point is largely montane, which will account for more irregular inundations and, rarely very high ones. The great 1886 flood reached 578 feet (John Webb, pers. comm.).

The riverbank community on the natural levee is relatively intact at Foster's Bend. At the water's edge grow sycamore, willow silver maple and mulberry On top of the levee the dominant trees are water oak, hackberry and pignut hickory Also present are basswood, American elm, black oak, sweetgum, Florida sugar maple, swamp chestnut oak, southern red oak, with *Cornus stricta* and red bud in the sub-canopy

Jones (1940) described an ash-hickory-sweetgum lowland forest, but since he did not contrast *floodplains* with *low woods* his communities tend to be confusing.

### Fauna of the Great Valley

The general fauna in Georgia is poorly known. I suspect that it is strongly represented by Coastal Plain elements. We have collected a number of cottonmouths (*Agkistrodon* from the oxbow lake at Foster's Bend. A relict population has survived there because of the oxbows, the absence of general public use and adjacent forested high ground for denning purposes. The cottonmouth is not known downstream within a reasonable distance, suggesting that agriculture has largely eliminated its habitat. Lipps (1966) reports a historically prominent bivalve community and land-locked sturgeon from the Oostanaula. DeSoto reported large pearls from clams in the Coosa Valley which Jones (1940) interprets to indicate a former abundance of stream molluscs.

French and Wharton (1975) found the smaller Coastal plain short-tailed shrew (*Blarina carolinensis* in the Great Valley while the much larger *Blarina brevicauda churchi* appears to be restricted to the Georgia mountains and Piedmont, French (pers. comm.).

(D) WATER DAM SYSTEMS

## [12] TIDEWATER RIVER AND SWAMP SYSTEM

### Location and Description

This subdivision of the Coastal Plain alluvial stream is popularly called the "tide water section." It comprises the lower portion of our rivers up to the point at which tidal influence ceases to affect the biota. The fauna is probably more strongly influenced than the flora. Tidewater cypress are reputed to grow larger than "upstream" varieties. Love *et al* (1972) classify this area as "tidal swamp" under a tidal wetland category While all the normal communities of the Coastal Plain river swamps may be present, the gum-cypress community appears to dominate—on the Altamaha there does not seem to be any bottomland hardwood much below tidal influence (Seaboard R.R. Bridge). An example is the lower Altamaha north to the Seaboard R.R. bridge, and probably the lower Ogeechee and Savannah, although we have no studies of these streams. The 6,000-acre Lewis Island tract on the Altamaha (McIntosh Co.) is state-owned.

This community is distinguished by an unusual hydrologic regime. It, of course, has the typical annual high water—low water fluctuation, but, in addition, this river section experiences daily fluctuations in water level due to the tides. Further on outgoing tide the currents are swift; on incoming tide the river may scarcely flow.

In addition, during spring tides, especially if augmented by onshore winds, a rise of several feet of water over the floodplain is possible within a few hours which I have experienced in the virgin gum-cypress groves at Lewis Island. This must influence the fish and aquatic life. Daily water table fluctuation may likewise influence the growth rate of trees. I do not mean that there is a daily inundation of the floodplain. If anything, there may be a rise of the goundwater level at high tide (modified by the rather heavy silts that form the soil layers). The floodplain floor is comprised of low areas normally standing with several inches to a foot of water interspersed with drier area (where *Sabal* palms live), so that the floor of the virgin timber area is not uniformly flat.

### Flora

**Trees.** Cypress, sweet gum, tupelo gum, and swamp black gum.

**Shrubs.** Swamp red bay (understory), swamp privet, swamp palm (*Sabal minor*); streamside (levee) fringe: black willow, silky dogwood, water elm, alder and *Viburnum obovatum* (uncommon).

**Herbs.** Yellow stargrass (*Aletris aurea*), climbing hydrangea, bead fern (*Onoclea sensibilis*), green dragon, royal fern, swamp grass (*Leersia* sp.), *Justicia ovata, Analema* sp.

Along the river margin, the pink-flowered *Physostegia* is common, with pink Sebatia, some swamp mallow (*Hibiscus*), *Clematis crispa,* and wild potato vine (*Impomaea*); spider lilies are another attractive streamside flower Along some waterways including man-dug ones, such as the Rifle Cut, ogeechee lime and swamp red bay are the dominant trees leaning out over the water

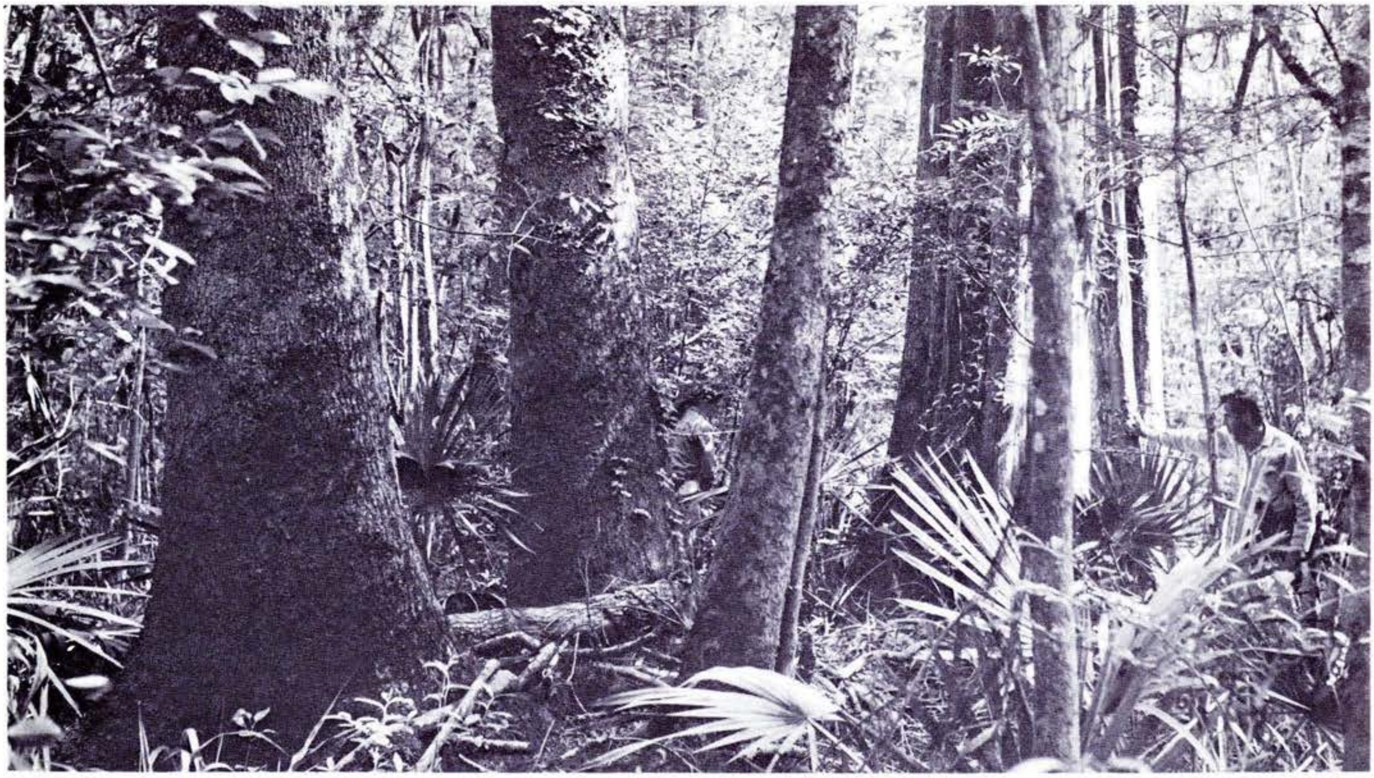

Photo R. Virgin gum-cypress forest on the Lewis Island (McIntosh Co.) tract, Altamaha floodplain. Figure is leaning on cypress, the other trees are either tupelo or sweet gum. The swamp palm (*Sabal minor*) is characteristic of the higher portions of the floodplain. This TIDEWATER RIVER AND SWAMP SYSTEM [12] receives some fresh water from tidal action through the dry season when most alluvial floodplains are dry

A surprising aspect of the virgin gum-cypress is the large amount of sunlight reaching the ground—mature trees are widely spaced. There is good cypress reproduction. The seedlings seldom reach the transgressive stage but appear to be "standing by" in the event of the death and fall of one of the forest giants. Ground vegetation appears simple and undiverse.

On new logging roads in virgin swamp dog fennel (*Eupatorium compositifolium*) is dominant, growing with primrose (*Oenothera* sp.), swamp dayflower (*Commelina* sp.), and knotweed (*Polygonum virginianum*). Sweet gum seedlings (roadways) and woolgrass bulrush (*Scirpus cyprinus* (ditches) establish within two years. Sand bar succession in the area is from knotweed to giant cutgrass to willow.

Salt concentration is probably 1 ppm at Lewis Island. Five miles downstream in the Darien River it is 8 ppm, but in Butler River it is only 1 ppm, Eugene Love (pers. comm.).

### Fauna

The vertebrate fauna in Appendix VI is distribution CP· habitat H in the gum-cypress, M if there are bottomland hardwoods, with elements of SX on the sand ridges.

Oddly fiddler crabs are abundant on Lewis Island at water edge, not on the floodplain floor We do not know what other brackish coastal species inhabit the area. Mud snakes and rainbow snakes appear to be relatively common, and we have encountered king snakes on the logging road bed in the virgin timber area. Other dominant reptiles are yellow rat snake, red-bellied water snake, cottonmouth, yellow-bellied turtle, florida cooter and alligator

The most common birds casually observed on or near the Lewis Island tract are: (D) Parula Warbler (D) Mississippi Kite, White Ibis, Glossy Ibis, (D) Yellow-crowned Night Heron, Louisiana Heron, Common Egret, (D) Green Heron, (D) Pileated Woodpecker Chickadee, Blue-grey Gnatcatcher Carolina Wren.

The Wood Ibis occurs in the area. the Limpkin is found largely in the bottomlands north of the Seaboard railway bridge where snail populations appear more stable, and the Swallowtail Kite is suspected of nesting in some of the virgin cypress on Big Buzzard Creek. See **floodplain fauna** under environment [10] for a more complete bird list.

Deer and otter are common mammals; feral pigs do occur in the area and beaver are present in the smaller creeks of Lewis Island. Grey squirrels and raccoons are dominant smaller mammals. The endangered manatee has been a frequent visitor being recorded as far up the Altamaha as Fort Barrington.

## [13] BACKWATER STREAMS

### Description and Location

Like the tidewater river system, I feel that this type of environment deserves special recognition. It is the result of a hydrologic phenomenon. It occupies the lowermost section of streams which empty into the larger rivers. The natural levees of these rivers and water levels in the river create a damming effect forming an elongate lake stretching up the tributary stream. These elongate lakes seldom go dry but the water in them may fluctuate as much as eight feet and remains high for long periods of time. The cypress trees appear very old, yet above the buttress are scarcely large enough to provide saw timber Hence, we can often see virgin forests of dwarfed cypress here. What is remarkable is the tremendous enlargement of the buttress base, from 8 to 12 feet in diameter Photo S.

Photo S. The remarkably large buttresses developed by cypress in a BACKWATER STREAM [13], such as Ebenezer Creek (Effingham Co.), make this area a striking scenic waterway The difference between high and low water may be 6 to 8 feet. Although the trees may be quite old, they do not attain large trunk diameters.

Low nutrient input, water levels never falling sufficiently, and lack of a floodplain to provide nutrients may cause dwarfing. Long periods of deep inundation with low oxygen levels may be responsible for the enormous buttresses. The gum buttresses are not as strikingly enlarged as those of the cypress, but they exhibit a remarkable counter-clockwise twisting. Examples are : Ebenezer Creek (Effingham Co.) below Seaboard R.R. bridge; Sandy Lake or "Brammer's Hole," and Doe Lake on the Satilla, 5.5 miles below the Seaboard R.R. bridge.

### Flora

This is largely an aquatic realm. There are button bush and a few other shrubs, but this environment appears simply a domain of cypress and tupelo growing in water, with much water ash (*Fraxinus caroliniana*). The largest "swell butt" cypress I have seen stands in Lockner Creek near its junction with the Savannah. *Myriophyllum* and alligator weed are locally common. The abundance of mistletoe in the shrub zone is notable, especially on a winter visit.

### Fauna

The fauna will be CP, habitat: H. On one visit, turtles were abundant, snakes few. Bull and pig frogs probably dominate, but the river frog is present along the banks farther upstream.

For **Natural and Cultural Values, Man's Impact** see following environment [14].

## [14] RIVER MARSH AND FRESH WATER MARSH

### Location and Description

Natural river marsh is confined to narrow strips along the major rivers of the Coastal Plain, especially within tidal influence and where there are numerous distrubutaries or outlet channels. Old oxbows, some beaver ponds, and some Carolina bays may pass through a marsh stage. Some of the latter two examples may be kept in the marsh stage by periodic fire.

### Flora

In drifting down the lower Ogeechee or Altamaha (approaching Highway 17), patches of giant cutgrass (*Zizaniopsis miliacea*) are encountered with increasing frequency along the river's edge. This species appears especially dominant where water levels are stabilized by daily tides or other phenomena. Mellinger (1974) reports it from the Flint River (Pike-Meriwether counties) where the rock ledges at Flat Shoals form what is almost a lake. M.B. Mellinger (pers. comm.) also reports that it was formerly present up the Savannah as far as Augusta.

Common dominants that occur with it are wild rice (*Zizania aquatica*), pickerel weed (*Pontederia cordata*), and arrow-arum (*Peltandra virginica*). Other common plants that frequently appear are the giant plume grass (*Erianthus gigantea*), beak rush (*Rhynchospora corniculata*), water hemlock (*Cicuta maculata*), and marsh daisy (*Boltonia asteroides*). The pink-purple flowering heads of false dragon head (*Physostegia denticulata*) and the unique white blooms of the spider lilies (*Hymenocallis*) are highly attractive components. Shoreward there may be indigo bush (*Amorpha*), salt bush (*Baccharis*), or shrubby St. John's Wort. *Panicum gymnocarpon* may be present on islands.

Figure 11 indicates the area of fresh water marsh (fresh marsh, I) on the delta of the Altamaha River. Gallagher and Reimold (1973) determined salinity gradients in this area. While the soils of this portion of the delta had zero residual salinity, the tidal water had a low salinity, altered by changes in river and estuarine fluctuations. Fresh water species tolerant of these low (oligohaline) salinities are giant cutgrass, while rice, pickerel weed, softstem bulrush (*Scirpus validus*), arrowarum, spike rush (*Eleocharis albida*), and tropical cattail (*Typha domingensis*).

Extensive fresh water marshes are generally confined to old rice field areas within tidewater delta sections of major Coastal Plain rivers. In this aspect, they are not natural environments but are included since they occupy extensive areas of riverine delta. In Figure 11, depicting the lower Altamaha, it can be seen that all of General's, Butler, and Champney, the western third of Broughton, and the eastern half of Chamber's and Wright's islands have been under rice cultivation.

The original vegetation was gum-cypress river swamp. The present vegetation is indicated on Figure 11. Most of the old rice fields are dominated by giant cutgrass; the remainder supports species of the genera *Zizania, Scirpus, Typha, Peltandra,* and *Eleocharis.*

A comprehensive study was done by Mellinger and Mellinger (undated) on the Savannah National Wildlife Refuge. This refuge, as well as the Butler Island Refuge (state-owned) on the Altamaha Delta, uses the old rice fields as managed wintering grounds for waterfowl. Love *et al* (1972) refer to the old rice fields as "fresh marsh" under a tidal wetlands category.

The Savannah National Wildlife Refuge is located in the floodplain delta of the Savannah River where the original forest was destroyed and rice agriculture was conducted in the early 1800s. The tidal amplitude there is seven feet and rainfall is 45 inches. The refuge (established 1931) contains 12,689 acres—5,460 are in Chatham County, Georgia and 7,229 acres in Jasper County, South Carolina. The soils were reported by Mellinger and Mellinger (undated) in old rice pools to be surface muck 12 to 24 inches thick, underlain with a 48 to 60 inch thick layer of peat subsoil, in turn underlain by 72 inches of clay.

Mellinger and Mellinger recognized **peltandra marsh**, dominated by the arrow-arum (*Peltandra virginica*), as a tidal marsh covered with one foot of water at high tide; **cutgrass marsh** having the same water regime but dominated by the giant cutgrass (*Zizaniopsis miliacea*) which covered much of the undiked tidal marsh; and **semi-tidal marsh** where water levels did not fluctuate with the tides and might reach 20 inches depth and dominated by plants, such as sawgrass (*Cladium jamaicense*), giant plume grass (*Erianthus giganteus*), golden club (*Orontium aquaticum*), and scratch grass (*Polygonum arifolium*).

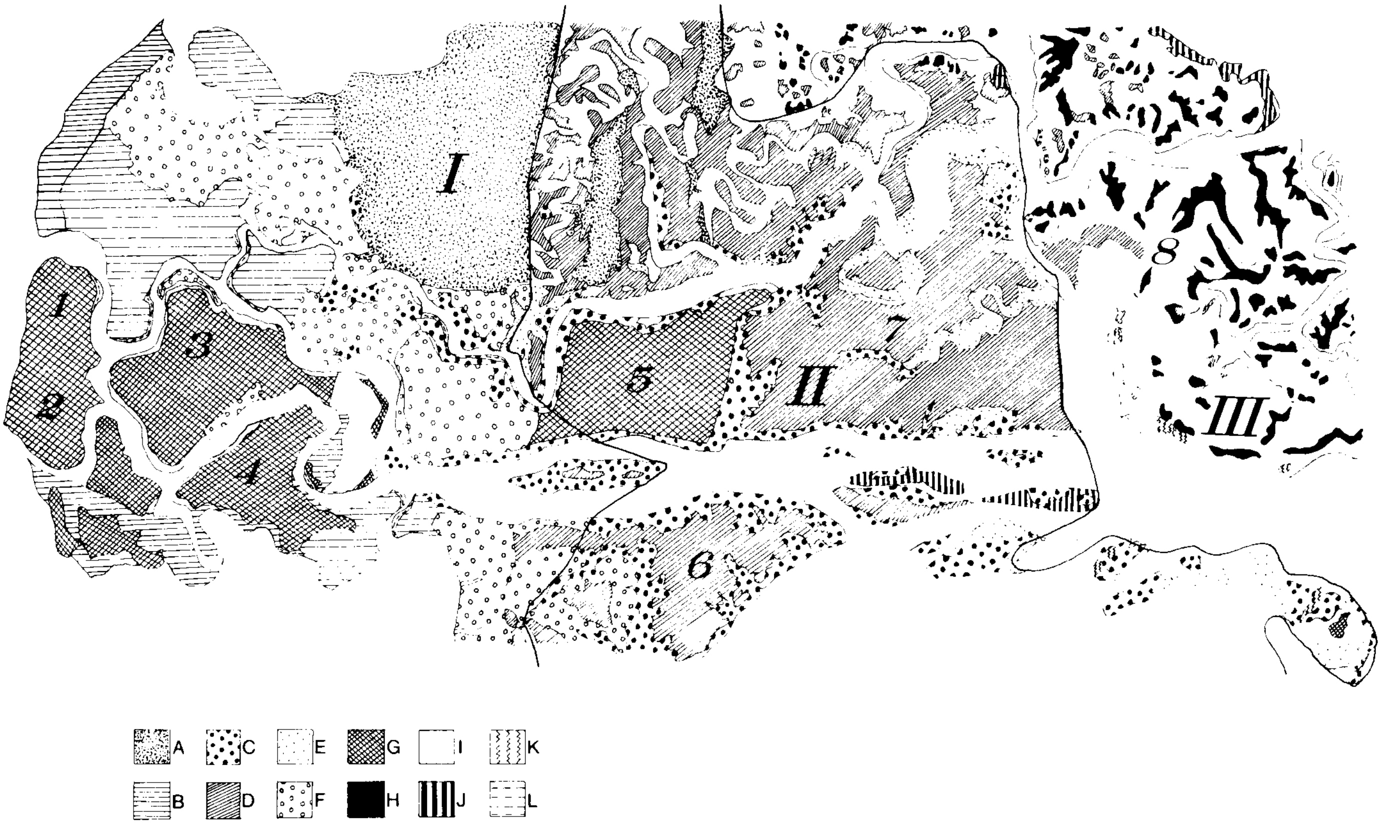


Fig. 11. The present vegetation of the Altamaha delta and adjacent marine tidal marshes, adapted and modified from Gallagher, Linthurst, and Reimold (1975) and Gallagher and Reimold (1973). Three major divisions are indicated (Roman numerals) I — **Fresh marsh** (or upper estuary of Gallagher and Reimold; no detectable soil salinity). Plant communities, F-G.
II. **Brackish marsh** (or middle estuary; soil salinity in parts per thousand: 2 - 20°/00, August, fresh water input low; 0 - 14°/00, April, fresh water input high). Plant communities, C-E. Plants here are tolerant of low salinity.
III. **Salt marsh** (or lower estuary; soil salinities 25 - 42°/00). Plant communities, H-J, tolerant of high salinity. **Plant Community Key:** A. upland, B. river swamp (dominantly gum-cypress), C. giant cordgrass (*Spartina cynosuroides*), D. needlerush (*Juncus roemerianus*), E. bulrush-cordgrass (*Scirpus americanus-Spartina alterniflora*), F. giant cutgrass (*Zizaniopsis miliacea*), G. mixed fresh marsh (ruderal or disturbed areas), H. short cordgrass (*Spartina alterniflora*), I. creekhead cordgrass (*Spartina alterniflora*) (not shown is the very narrow border of tall cordgrass along the water ways), J. Salicornia flats K. salt grass marsh and ruderal areas. Major islands: 1. Chamber's, 2. Wright's, 3. Butler, 4. Champney, 5. Generals, 6. Broughton, 7. Rockdedundee, 8. Wolf. This area is atypical of coastal marshes because of rice cultivation and the effects of the fresh water discharge of the Altamaha River. See text for further discussion.

At the Kinlock plantation on the Santee Delta (S.C.), the old rice fields are managed for waterfowl under slightly brackish conditions. Such species as *Polygonum setaceum* and *Ruppia maritima* are important duck foods.

#### Fauna

The smaller fishes are not generally known. Frogs, such as the bull, pig, bronze and green tree, are common and generally permanent water breeders. Cottonmouths and banded water snakes usually dominate the snake fauna. Mud snakes and rainbow snakes can be locally common. A migration of rainbow snakes has been observed crossing Highway 17 in the Savannah Refuge. The eel-like salamanders (*Amphiuma, Siren*) are abundant in the permanent pools and canals, and alligators are also present as well as garfish and large bowfin. This is a haven for wintering ducks, and a feeding ground for rails, coots, gallinules, herons, egrets and ibis, long-eared owls, marsh hawks, osprey, and bald eagle. Common mammals are marsh rabbits, rice rats, mink, and otter.

#### Natural and Cultural Values of Environments [12] [13] [14]

Existing tidewater environments (near-original or recovered from original logging) make spectacular river parks and outdoor laboratories for outstanding recreation and educational use. They are very accessible by boat because of numerous channels that serve as trailways. During winter high water, one can travel for miles over the forested floodplain as, for example, in the Buffalo Swamp (McIntosh Co.), visiting isolated sandhills by canoe. The 6,000-acre Lewis Island tract (McIntosh Co.), now state-owned, contains about 50 acres of virgin gum-cypress forest with some trees exceeding 1,000 years old. Human use by water minimized modification by over-use.

Backwater streams are also accessible by boat at all seasons and provide the most spectacular of all aquatic scenic trips in my opinion. Their cypress may be virgin and quite old but of a small diameter, thus not tempting logging. Young tupelo stands on the other hand, which may replace the original cypress-dominated forest, are vulnerable to the veneer industry. Scientific study of both environments [12] and [13] would be rewarding.

Fresh water marshes along river edges may provide some wild rice and other grains, especially to birds. Louisiana delta marshes support high populations of muskrat, nutria, and alligator. Fresh water marshes in old rice fields can provide human food (rice, duck potato, (*Sagittaria*), water chestnut, taro), high-protein animal forage or be used for the aquaculture of frogs, crayfish, turtles, and fish. Old rice fields serve as important refuges for overwintering waterfowl and as feeding grounds for wading birds, bald eagles, osprey, and long-eared owls.

### Man's Impact on Environments [12] [13] [14]

Some of these river sections, because of their numerous channels and general inaccessibility, were among the last virgin forests to be logged in Georgia. They were logged from barges whereon winches with about 1,200 feet of cable were mounted. In some cases cypress were deadened and floated out, and some logging railroads were built (Buffalo Swamp) on pilings or cribbing. Logging may lead to almost pure stands of gum trees. The rice era resulted in the destruction of a large part of the virgin gum-cypress forests on the deltas of Atlantic Coastal rivers south of North Carolina. The old dikes and paddies are still visible, especially from the air. Few have yet progressed to forest, probably because the dikes have altered plant succession.

The damming of rivers by reservoirs, as well as canal construction, brings many problems. One of these is salt water intrusion as occurred on the Santee delta (see **man's impact,** environment [10]. Another is eutrophication where deposition of organic plant remains exceeds decomposition, and another would be the build-up of submerged and aquatic plant communities to distressing levels.

Judging from the prevalence of oystershell middens upstream at Lewis Island, American Indians must have used the tides to assist travel in heavy dugouts in these sections of our rivers. Permanently anchored houseboats are a special problem in this area.

## B. SALT WATER ENVIRONMENTS

## (1) COASTAL MARINE MARSH TIDAL SYSTEMS (SALT MARSH)

Kinetic tidal energy is usually low to moderate. Import of nutrient silt occurs during major winter-spring river floods. There is some organic detrital import from rivers, especially those with intact floodplain forests. Internal nutrient cycles are important; trophics are largely detrital, with intra-system use plus considerable export to offshore marine systems. Autotrophic productivity divided between emergent grasses, algae mats on mud, and phytoplankton in water. Location, description, geology, and soils will cover environments [15] through [18].

### Location and Description

The Coastal Marine Marsh system or "salt marsh" lies between the coastal barrier islands and the high tide line and extends up tidal creeks and rivers, where its upper boundary is generally marked by the black rush (*Juncus roemerianus*). It is difficult to draw a boundary between the salt marsh and estuarine systems, because the salt marsh contains a system of tidal creeks and rivers which interconnect with open water. In fact, some authors (Schelske and Odum, 1961) include salt marsh within the definition of esturaries.

Basically the salt marsh is a salt-tolerant grassland within which there are zones of single species of grasses, such as cordgrass (*Spartina*), salt grass (*Distichlys*), and rushes (*Juncus*). According to Johnson *et al* (1971), the four-to six-mile-wide band of Georgia's marshland comprises 393,000 acres, of which 286,000 acres are covered by the smooth cordgrass (*Spartina alterniflora*).

### Geology and Soils

Hoyt (1967), discussing the origin of the salt marsh, indicated that the marshes are lagoons filled in by sands, silts, and clays, located behind islands formed as high dunes along older shorelines. Johnson *et al* (1971) have summarized the sources of the sediments in the salt marsh, as derived either from the continental shelf, the mainland rivers, the marsh itself, or organic deposits.

Substantial contributions of silts and clays to the salt marsh may be made by the major rivers following high water. Lunz (1938) describes the effect of a Santee River flood in April 1936, which deposited a layer of silt from 2 to 25 mm deep over a huge area of South Carolina marshland. At one of the peripheral stations 25 mm of silt was deposited at a distance of 12 miles from the river across the salt marshes of the Cape Romain area. From records of the U.S. gaging station at Ferguson, S.C., Lunz calculated that a flood of this magnitude had occurred every 5.8 years since 1907. Using the average thickness (10.8 mm) at 17 stations, this implies a deposition rate of 7.4 inches per 100 years. In this way, the great rivers deliver nutrients to salt marshes on a more or less regular basis.

Carl Feiss, in the introduction to the Grosselink, Odum, and Pope (1973) paper, says, "Since tidal marshes depend in great part for their biological richness on fresh water nutrients, the value of the tidal marsh is clearly dependent in substantial part on the normal quality and quantity of nutrient feeding systems from inland or upland sources."

Windom *et al* (1976) indicate that rivers can contribute the total annual inorganic phosphate requirement of salt marshes, but only about 20% of the nitrogen. Rivers may affect offshore productivity in other ways. Haines (1975) states that the annual fresh water discharge into shelf areas is equal to 39% of total water volume out to the 20 m contour, perhaps contributing significant amounts of trace minerals, silicates, and organic nutrients, such as vitamin $B_{12}$ and humic acids. While the bulk of nitrogen is regenerated in coastal waters themselves, the "new" nitrogen from sources outside the coastal waters appears important, Dunstan and Atkinson (1975).

The upper few centimeters of salt marsh soils are brown, those below black and, because of anerobic conditions, contain sulfides, methane and ferrous compounds, with a circumneutral pH. If these sediments are exposed to the air by drainage, sulfuric acid is produced. The soil becomes extremely acid and no plants can grow, the area remaining barren for years. The problem cannot economically be solved by adding lime.

Pomeroy *et al* (1969) determined how nutrients were exchanged between sediments and the salt marsh community. They found that the uppermost meter of sediments contains enough phosphorous to support the *Spartina* production for 500 years and enough zinc for 5,000 years. The marsh grass removes the P and Zn from the subsurface, reducing sediments and, on its death, transfers them to the aquatic community via bacteria and detritus feeders. The P and Zn in the subsurface reservoir is apparently replaced by the conversion of oxidized surface sediments to reduced subsurface sediments, the oxidized sediments receiving "inputs of P and Zn from both land and sea."

(a) HIGH SALINITY MARSH

## [15] SMOOTH CORDGRASS MARSH

### Flora

Zonation of vegetation in the salt marsh is determined by elevation which controls depth and duration of inundation by saline water, Fig. 12.

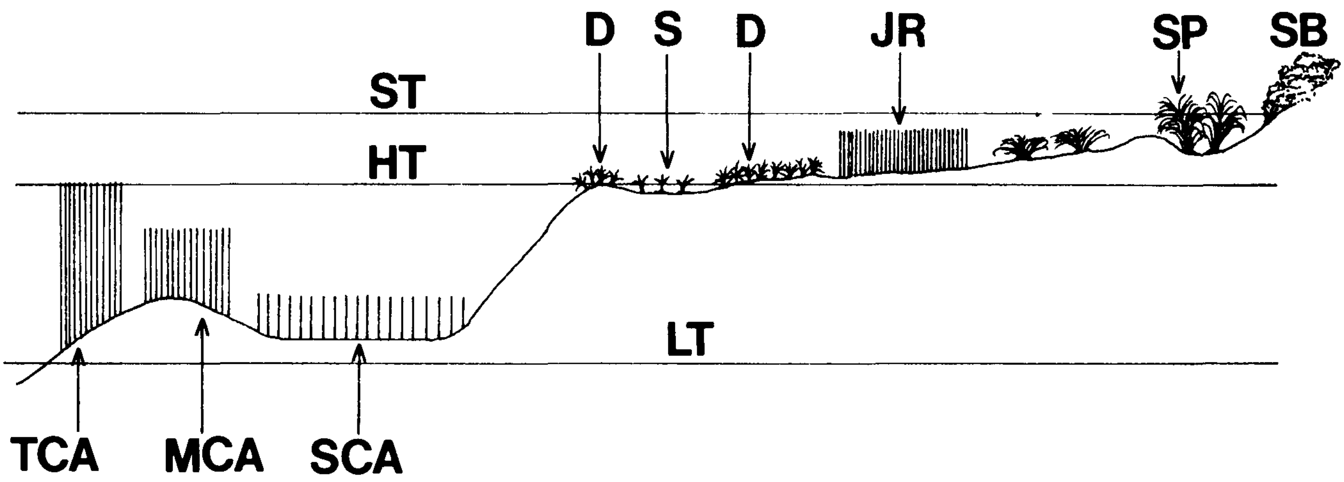


Fig. 12. Salt marsh cross section (strong vertical exaggeration). LT, low tide level; HT, high tide level; ST, storm tide level; TCA, tall cord grass marsh; MCA, medium cord grass marsh; SCA, short cord grass marsh; D, salt grass marsh; S, salt flats with glassworts; JR, needlerush marsh; SP, edge zone marsh (*Spartina bakeri*); SB, edge zone, shrub border.

Teal (1962) recognized three areas in which the smooth cordgrass (*Spartina alterniflora*) is the dominant and very nearly the only plant species: Streamside Marsh has the tallest cordgrass (3-10 ft.); Levee Marsh occurs on the natural levees, and supports grass of intermediate height while short *Spartina* marsh grows on flat areas behind the levees where the plants are short and widely spaced. The short *Spartina* marsh has a low sand content (0-10%). On the inner fringe of it, the sand content increases (10-70%), inundation is less frequent, and a dwarf form of smooth cordgrass occurs. Soil salinity may be higher here than on more seaward communities (Johnson *et al* 1971). As to areal coverage, Teal estimated the following: creekbank and tall *Spartina* 20%, medium *Spartina* 35%, short *Spartina* 12%, and salt grass 45%.

The tall *Spartina* is deeply and regularly flooded; the short *Spartina* marsh is less regularly and less deeply flooded. Sea strength salinity is limited to tall and medium *Spartina* marshes. Salinity increases away from tidal creeks reaching highest values in the short *Spartina* and in the bare sand flats, where values can be twice that of sea strength.

Gallagher, Linthurst, and Reimold (1975), using remote sensing technology and ground checks, classified the marshes of McIntosh County. They apparently lump Teal's streamside and levee marshes into a streambank *Spartina alterniflora*, category, a narrow zone difficult to show on plan view maps. The majority of the salt marsh (soil salinities 25-42 parts per thousand) is classified by them as creekhead *Spartina alterniflora*, with a standing crop averaging about ⅓ that of the streambank community (see fig. 11). Inter-creek areas support, in their classification, short *Spartina alterniflora* with still lower standing crop and with a thick root mat, unlike the other two zones (fig. 11).

## [16] SALT GRASS MARSH

This slightly higher marsh terrain is said to flood about one hour daily, and supports the dominant salt grass (*Distichlis spicata*), along with marsh dropseed (*Sporobolus virginicus*), cord marsh cordgrass (*Spartina bakeri*), sea ox-eye (*Borrichia frutescens*), and sea lavender (*Linomium carolinianum*). On the flatter and lower areas, salt water ponds up and evaporates, increasing the salt content to twice that of the sea. In such salt or sand flats, only the succulent glassworts (the perennial *Salicornia virginica* and the annuals *S. europaea* and *S. bigelowii*) and saltwort (*Batis maritima*) can grow. Naturally, one finds varying proportions of salt grass and succulents. The area of this community on Figure 11 is limited, elsewhere it is more obvious.

(b) LOW SALINITY MARSH

## [17] NEEDLERUSH MARSH

This marsh lies at slightly higher elevations and is rarely inundated, except at storm and spring tides, and supports a dense stand of the needlerush or blackrush (*Juncus roemerianus*), photo T It occurs along the headwaters of tidal creeks and as a zone on the inner landward edge of the salt marsh. This is called the "irregularly-flooded marsh" by Marshall (1974). In North Carolina, it covers many more acres than the regularly-flooded *Spartina* marshes. Marshall reviews reports stating that there is no significant export from *Juncus* marsh, but quotes other work which concludes that 41% of nitrogen entering the marsh did not leave and that the marsh appeared to export organic phosphorus.

Photo T This salt marsh at Colonel's Island (Glynn Co.) shows zonation of three species of marsh grass. Next to the shore is a zone of marsh cordgrass (*Spartina bakeri*). The foreground is a broad band of needlerush (*Juncus roemerianus*) marsh. The vast bulk of the salt marsh is occupied by smooth cordgrass (*Spartina alterniflora*), seen here in the distance. Photo courtesy John R. Bozeman.

## [18] EDGE ZONE MARSH

Although Johnson *et al* (1971) apparently considered this zone lower in elevation than the needlerush zone, it is considered here as the ecotone between the salt marsh community and the terrestrial shore environments. Flying over the marsh in a plane, the needlerush zone is obvious, and shoreward of this is an edge zone. This is a complex and poorly-studied area, and I am lumping together what may appear to be discrete communities, largely because, due to varying degrees of salinity, the biotic zones here are not uniform and easily recognizable. Sometimes the marsh cordgrass (*Spartina bakeri*) is dominant, photo T forming large bushy tussocks. Along the shoreline, which is inundated during spring tides and at other times (strong onshore winds coinciding with high tides, etc.), occur broad-leaved dicot plants, such as the groundsel tree (*Baccharis halimifolia*) and the marsh elder (*Iva frutescens*). The grass in this zone may overlie several inches of raw, brownish peat. Ponds frequently occur Salinity is generally less than in the needlegrass zone.

Bozemen, in Hillestad (1975), records the milkvine (*Cynanchum palustre*). sea lavender and the bulrush (*Scirpus americanus* from this zone on Cumberland Island. He also records the Florida privet (*Forestiera porulosa*), wax myrtle, and yaupon as major shrub components on Cumberland shores. Bozeman calls this zone the "salt marsh shrub-border community."

Bozeman places the needlerush marsh and salt grass marsh in a complex which he calls the "salt marsh grass-forb-rush community "

### Other Flora

Teal (1962) indicates that bacteria account for the consumption of 59% of the available *Spartina* grass in the salt marsh. He also indicates that colonies of blue-green algae were present and active, the genera *Thiploca*, *Beggiatoa*, and *Oscillatoria* being found in the lightless, reducing zone of the mud-water interface.

## [19] BRACKISH MARSH

In the vicinity of the mouths of rivers is found a wide ecotonal zone which can be called "brackish" marsh, where plants are tolerant of low salinity (fig. 11). Gallagher and Reimold (1973) refer to this as the "middle estuary" and indicate that the salinities vary from 0 to 14 parts per thousand (ppt) when the Altamaha is high in spring to 2-20 ppt when fresh water input is low in the fall. Two plants characterize this zone, giant cordgrass (*Spartina cynosuroides*) and three-square bulrush (*Scirpus americanus*). If my interpretation of the Gallagher *et al* (1975) map is correct, neither of these two plants occur farther north than the Altamaha delta zone indicated in Figure 11, except for an anomalous patch in the Sapelo River (which suggests fresh water dilution at that point). Because the needlerush is evidently tolerant of low salinity, it greatly expands its distribution here and dominates the brackish zone (fig. 11).

Other plants that may be locally common in the brackish zone are salt marsh bulrush (*Scirpus robustus*), the softstem bulrush (*Scirpus validus*), the tropical cattail (*Typha domingensis*) and the narrow-leaved cattail (*Typha angustifolia*). Pickerel weed (*Pontederia cordata*) can also tolerate low salinities. Gallagher and Reimold (1973) noticed, however, that pickerel weed started dying in early September, while three-square bulrush was dead by early August.

**Fauna of Coastal Marine Marsh Tidal System** (Salt Marsh)

Teal (1962) indicates that of the aquatic animals inhabiting the salt marsh, 60% are estuarine forms colonizing the lower portions of the salt marsh where exposure at low tide is short. Of these, only six (isopods, amphipods, oligochaetes, and the snail *Melampus*) are confined for their life cycle to the salt marsh. Nearly one-half of the salt marsh fauna is derived from the land.

The primary herbivores grazing the cordgrass marsh are the grasshopper (*Orchelium fidieinium*) and the plant hopper (*Prokelisia marginata*), who consume 4.6% of the net production. The most conspicuous detritus-algae feeders are two fiddler crabs (*Uca pugilator, U. pugnax*) and the square-back crab (*Sesarma reticulatum*). Teal made the observation that the *pugilator* population on the tidal creek banks is killed each autumn and replaced the following spring. *Uca pugilator* prefers sandy marsh while *U. pugnax* and *U. minax* dwell in muddy marsh.

Among the annelid worms, *Capitella capitata, Manayunkia aestuarina,* and *Streblospio benedicti* are the most numerous. The first two are basically estuarine forms. The worm *Neanthes succinea* is also common, and some dipteran larvae are present.

About 2.76 g fresh weight/m$^2$ of nematode worms are present in the salt marsh. The considerable burrowing fauna of the tidal flats is described by Gray (1974). Rudloe (1972) indicates that at the bottom of the cordgrass stalks along Gulf shores are thousands of tiny flat barnacles (*Cthalamus fragilis*) that form a dominant animal community in the tidal marsh. More conspicuous molluscs are the periwinkle snails (*Littorina irrorata*) and the pulmonate snail (*Melampus lineatus*).

In the salt marsh mud along the Gulf, Rudloe (1972) indicates the occurrence of the ribbed horse mussel (*Modiolus demissus*), and in highly brackish situations the hard-shelled clam (*Rangia cumacea*). Marshall (1974) mentions Kuenzler's finding of *Modiolus* populations in *Juncus* marsh.

Teal and Teal (1969) document some 50 species of insects from the tidal marshes. Besides the insects mentioned above, there is a common ant (*Crematogaster clara*) adapted to live within the stalk of the cordgrass. Two mosquitoes (*Aedes taeniorhynchus* and *A. sollicitans*) are common on the coast, but the former is by far the dominant pest in most areas. Several species of blood-sucking midges (*Culicoides*) or "sand flies" occur along the coastal marshes and can penetrate all but the finest netting. The mud crab (*Eurytium limosum*) is listed by Teal (1962) as a secondary consumer.

There are no amphibians in the salt marshes. (The marine toad (*Bufo marinus*) has been introduced to brackish areas of southern Florida). Among the reptiles, the diamondback terrapin is a permanent resident. Of the birds, there are salt marsh species, such as the Long-billed Marsh Wren studied by Kale (1965), the Seaside Sparrow, and the Clapper Rail or "marsh hen" studied by Oney (1954).

Many birds feed in the salt marsh but nest elsewhere. Important among these are the Willet, Great Blue Heron, Little Blue Heron, Louisiana Heron, and Common and Snowy Egrets. I have often observed White Ibis feeding in the marshes of Cumberland Island at low tide. A few birds, such as the Long-eared Owl, winter in the salt marsh.

The rice rat is one of the few mammals that adapts to the salt marsh, where it leans heavily to carnivory. Raccoons and mink are the most abundant larger mammals and can become locally quite numerous.

It is now recognized that the salt marsh, with its many tidal creeks, forms an important nursery for young fish, shrimp, and crabs. The Gulf Marsh near Panacea is graphically described by Rudloe (1972). "A sweep of a fine-meshed minnow seine . . . will reveal the thousands of croakers, mullet, grass and juvenile penaeid shrimp, young crabs, killifish, and in certain seasons, young redfish, sand trout, and skipjack. The autumn sees young spotted sea trout, tarpon, drum, and sheepshead moving into the marsh. Threadfin herring and shad, not more than an inch long, live in the mud-bottomed marshes by the millions. When the marsh flowers and starts to turn brown, juvenile white shrimp swarm into the creeks and grow at a fantastic rate, gobbling up the tiny diatoms and minute animals that are so prevalent."

(2) COASTAL MARINE AQUATIC TIDAL SYSTEMS

The next five environments are primarily aquatic and are described almost completely in terms of their fauna. The oyster reef appears to form a distinct habitat located at the edges of estuaries, sounds, and tidal creeks, more or less widely distributed. The faunal reports are from Heard and Heard (1971) and Hackney (1972) for the invertebrates, and from Hackney (1972) and Dahlberg (1971a), (1971b), and James Richardson (pers. comm) for the fishes.

## [20] TIDAL POOLS

Dahlberg (1971b) identifies two types of tidal pools. One type is found in salt marsh behind the high marsh (levee) where the salinities range between 13 and 34 ppt, and the characteristic border plants are *Spartina alterniflora* and *Juncus roemerianus*. The other tidal pools are located on Sapelo and are flooded only at high tide, the salinity varying from zero to 24.4 ppt.

James Richardson (pers. comm.) has made detailed studies of tidal pools in the Little Cumberland Island salt marsh. These pools appear to originate in low areas where water does not adequately drain off and kills the *Spartina,* leaving steep-walled pool sides down to root depth penetration. Richardson indicates that these pools may have their bottoms lowered by scouring and may persist for 20 years. They are filled by spring tides and rain, and are euryhaline (salinities range widely, from 5 to 25 ppt).

In the euryhaline pools studied by Richardson, there is a summer flora consisting of an algae mat (on the mud) composed of green algae, filamentous diatoms, colonial diatoms, and perhaps some blue-green algae. In winter, the flora is pure filamentous algae.

### Fauna

Dahlberg (1972) found in the low salinity pools three common semi-aquatic crabs, two fiddlers (*Uca minax* and *U. pugilator*), and *Sesarma* sp., also the shrimp *Palaemonestes pugio* and juvenile blue crabs. In the high salinity pools, he found three common crabs, *Uca pugnax, Uca pugilator,* and *Sesarma* sp. and in the water in decreasing order of abundance, the shrimp *Palaemonetes pugio*, blue crab, white and brown shrimp.

Tidal pools contain small species and small individuals of larger species. Marsh killifish (*Fundulus confluentus*), fat sleeper (*Dormitator maculatus*), and freshwater goby (*Gobionellus shufeldti*) are restricted to the low salinity tidal pools.

High salinity tidal pools seem to have greater diversity; they also have greater access from habitats of high diversity, such as the beach and lower reaches of the sounds. In shallow pools, there were large numbers of sailfin mollys, (*Poecilia latipinna*), mummichogs (*Fundulus heteroclitus*), sheepshead minnows (*Archosargus* sp.), mosquitofish, (*Gambusia affinis*), striped killifish (*Fundulus majalis*), and spotfin majarra (*Eucinostomus argenteus*). In deeper pools, these were present in smaller numbers and, in addition, larger numbers of young silver perch (*Bairdella chrysura*), spot (*Leiostomus xanthurus*) and fresh water eel. Large numbers of striped mullet (*Mugil cephalus*), silver mullet (*M. curema*), ladyfish (*Elops saurus*), and bay anchovy (*Anchoa mitchelli*) were found in both shallow and deep pools.

In Little Cumberland pools, Richardson found a remarkable fish fauna comprised of euryhaline and heat-tolerant (water temperature as high as 40°C) prey fishes which are largely insectivorous, composed of the following (arranged in order of abundance); mosquitofish (*Gambusia affinis*), molly (*Poecilia latipenna*), topminnow (*Cyprinodon variagatus*), and mummichog (*Fundulus heteroclitus*). Some *Palaemonetes* shrimp are present. The predator species are very young tarpon (*Megalops*), ladyfish (*Elops*), and two species of drum (silver perch and black drum). Richardson has documented a fantastic crop of mosquitofish (*Fundulus affinis*), up to 1000/m$^2$ of tidal pond surface.

## [21] OLIGOHALINE CREEK

These are brackish or low salinity creeks emptying into tidal rivers, such as lower Riceboro Creek near the town of Crossroads, Georgia (Liberty Co.).

Salinity ranges from 0-13.6 ppt, depending on the tide. Along the creek the dominant plants were stands of *Spartina cynosuroides* and sawgrass (*Cladium jamaicense*). The arrowhead (*Sagittaria* sp.) was widespread.

Invertebrates collected by seines and trawls in Riceboro Creek were, in order of abundance: a shrimp (*Palaemonetes pugio*), blue crab (*Callinectes sapidus*), white shrimp (*Penaeus setiferus, Rhithropanopeus harrisi*), and brown shrimp (*Penaeus aztecus*).

Common creek bank invertebrates are the crabs *Uca minax* and *Sesarma cinereum;* isopods *Cyathura polita, Cassidinidea lunifrons, Munna reynoldsi, Sphaeroma destructor, Ligia exotica;* the amphipods *Ochestia grillus, O. uhleri, Gammarus tigrinus, Corophium lacustre, Melita mitida;* the barnacle *Balanus improvisus,* the polychaete worms *Namalycastis abiuma* and *Nereis succinea;* the gastropods *Littoridinops tenuipes, Hydrobia* sp., *Melampus bidentatus, Detracia floridana;* the clams *Polymesoda carolinae* and *Cyrenoidea floridana.*

This environment has a low diversity (39 species) when compared to more saline habitats. There are 13 fresh water species, 20 euryhaline marine species, five anadromous species (including *Alosa* and *Dorosoma*), and one catadromous species (eel).

## [22] TIDAL CREEK (AND TIDAL CANAL), TIDAL RIVER

The salt marshes are watered and drained by an intricate dendritic network of tidal creeks and rivers. Hackney (1970) studied a tidal creek called Crooked River (Glynn Co.) and states that the tidal creek and tidal river appear synonomous except for size, and for the fact that the tidal river receives a large input of fresh water.

Salinity levels range from 1 to 28 ppt, but 12-18 ppt is most common. Salinity fluctuations varied in Crooked River from 12 ppt near the mouth to negligible changes near the creek. Low salinity fluctuations and large temperature and dissolved oxygen (D.O.) fluctuations apparently led to higher diversity, whereas fluctuating salinities with stable temperatures and D.O.'s led to many individuals of fewer species of fish.

A sponge (*Microciona*) and a coelenterate (*Leptogorgia*) are widespread. There are eight gastropod molluscs; Hackney (1970) adds the mud snail (*Nassarius obsoleta*). There appear to be nine species of bivalves, including the bent mussel (*Mytilus recurvus*), the false angel wing (*Petricola pholadiformis*), and the oyster (*Crassostrea virginica*). The squid *Lolliguncula brevis* occurs throughout these marine systems. There are 14 polychaete worms and three isopods, including the ubiquitous *Cyathura burbanckii.* Hackney adds five species to the Heard and Heard (1971) list: *Cyathura polita, Lironeca reniformis, Cymothoa excisa, Aegathoa oculata,* and *Cleantis planicauda*. The barnacle *Balanus* appears confined to tidal rivers. Twenty amphipods are recorded. There are 16 species of natantid shrimps. Hackney found four dominant: the grass shrimp (*Palaemonetes pugio*), the brown shrimp (*Penaeus aztecus*), the white shrimp *(P. setiferus)*, and the snapping shrimp (*Alphaeus normanni*). There are 16 true crabs. Two echinoderms and one sea squirt (*Molgula manhattensis*) seem confined to tidal creeks and rivers.

## [23] ESTUARIES AND SOUNDS

Lauff (Ed.) (1967) defined an estuary as a " . . . semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage." Following a 1964 conference at Jekyll Island, a number of important papers have appeared on estuaries. Papers by Teal cited above, a paper by Dahlberg and Odum (1970), and a number of papers in the Lauff (1967) volume attest to the interest in estuarine systems. Smith (1966) deals with commercial estuarine organisms. Estuaries are the upper parts of sounds and are frequent along the Georgia coast, most easily seen at the mouths of the larger rivers where fresh and salt water mix and interface. Further out, they are called sounds. Unlike tidal rivers and sounds, estuaries receive no proper names. Apparently, Heard and Heard consider parts of the Newport River to be estuarine from which the invertebrate data are taken (no figures on estuarine salinities, etc., are available).

### Fauna

Sounds seem to have fewer sponges than tidal creeks, and share the widely distributed species like the sponges *Microciona prolifera* and the coelenterate *Leptogorgia lactens* with other saline communities. Sounds (again, comparing against tidal creeks and rivers) seem to have markedly more bryozoans. They have eight gastropods recorded, six of which seem to be unique, and six clams, five of which also seem to be unique (one very common, *Ensis directus*). Thirteen polychaete worms (11 in tidal rivers) occur, of which six are unique to sounds. There are 14 amphipod species (less than in tidal rivers), of which five have not been recorded elsewhere. Two shrimps (*Automate evermanni* and *Leptochela serratorbita*) appear to occur only in sounds. The mole crab (*Lepidopa websteri*) has not been recorded elsewhere. There appear to be 21 species of Brachyurid crabs (true crabs) compared to 17 in tidal creeks and rivers.

Jacobs (1968) has reported on some zooplankton (Copepods) of the Duplin River and Doboy Sound. He found the most common species to be *Acartia tonsa* (20,000 per $m^3$ near Sapelo), *Pseudodioptomus caronaius* and *Paracalanus parvus*, with *Centropages hamatus* and *Labidocera aestiva* common at certain seasons. Dahlberg (1972) found in the middle and upper reaches of estuaries that the most common invertebrates in his seine hauls were, in order of abundance: shrimp (*Palaemonetes pugio*), white shrimp (*Penaeus setiferus*), blue crab (*Callinectes sapidus*), shrimp (*Palaemonetes vulgaris*), and the brown shrimp (*Penaeus aztecus*).

As for fish, dominant species from estuary and sound are listed by Dahlberg (1971a, 1972, 1975).

Estuarine-dependent fish comprise 63% of the Atlantic catch; each estuarine acre produces a yield of 535 pounds on the continental shelf, Johnson *et al* (1974). Estuaries provide many continental shelf fish with a "nursery ground" rich in food and low in enemies, diseases, and parasites that do not thrive in the rigors of variable salinities and temperatures. Dahlberg (1972) records 100 species in lower estuaries and 61 in upper and middle reaches. The family Sciaenidae are the most important sport fishes (and potentially commercial species) on the Georgia coast—13 species have young dependent on estuaries. The bay anchovy, Atlantic and rough silverside are important forage fish in estuaries. Some pass an entire life cycle there: i.e., marsh and spotfin killifishes, mummichog, and others characteristic of oyster reefs.

Dahlberg and Odum (1970) found the following fish in the lower reaches of sound (in order of abundance): star drum (*Stellifer lanceolatus*), weakfish (*Cynoscion regalis*), blackcheek tonguefish (*Symphurus plagiusa*), sea catfish (*Arius felis*), southern kingfish (*Menticirrhus americanus*), silver perch (*Bairdiella chrysura*), bay anchovy (*Anchoa mitchilli*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogon undulatus*), and spotted hake (*Urophycis regius*).

## [24] OYSTER REEFS

### Location

These unique aggregations of life occur along the edge of estuaries, sounds, tidal rivers and creeks. Oysters (*Crassostrea virginica*) occur where stong currents bring suspended food in particulate and planktonic form. They have a wide range of tolerance to salinity.

### Fauna

Chestnut (1974) lists microorganisms associated with oyster reefs. Dahlberg (1971b) lists the fishes that remain within the interstices of the oysters at low tide (in order of abundance): naked goby (*Gobiosoma bosci*), feather blenny (*Hypsoblennius hentzi*), skilletfish (*Gobiesox strumosus*), seaboard goby (*Gobiosoma ginsbingi*), striped blenny (*Chasmodes bosguianus*), oyster toad fish (*Opsanus tau*), and the crested blenny (*Hypleurochilus geminatus*).

## [25] BEACH

### Location and Description

There are 13 Georgia barrier islands with 88.3 miles of beach, largely of Holocene age, Johnson *et al* (1971). The beach is the seaward side of the coastal barrier islands. Beach sands are predominantly fine quartz, but contain heavy minerals derived from the Piedmont, although continental shelf material is an important sediment source, Johnson *et al* (1971). Sandy beaches receiving strong wave action are called "high energy beaches," Odum *et al* (1974). Waves and tidal flows sort sands into coarser and finer zones. Large amounts of surface sands transport daily and and the beach profile changes with wave action, especially during storms. The "beach" is also called the intertidal zone, between low and high tides (4.5-10.5 feet). Storms and onshore winds during high tide amplify tidal heights and cause foredune erosion. There is also longshore (north to south) movement of sand—Georgia's barrier islands erode at the north end and build up at the south. Rafts of continental and offshore biota are deposited as "wrack" at high tide line. Wrack may be composed of local salt marsh grass, water hyacinths from rivers in flood, or rafts of the brown alga "sargassum weed," sometimes containing algal fauna elements, such as the sargassum fish (*Histrio histrio*).

### Flora and Fauna

Because of the wave energy and the tidal advance and retreat, most of the biota are sand dwellers (**psammon**). Part of these burrowers are snails and clams called **endopsammon**, and part are a microfauna living between sand grains called **mesopsammon.** Together they form an elaborate filtering system to extract food from the water.

Riedl and McMahan (1974) summarize the trophic relationships. Primary producer plants are restricted to blue-green algae at depths and single-celled diatoms in the top centimeter of sand. Some filter feeder organisms, such as the crustacean *Emerita*, lancelet *Amphioxus*, and clam *Donax*, filter water and deposit feces in the sand. Others (polychaete worm *Arenicola* and acorn worm *Balanoglossus*) filter particles from the water and deposit feces in the water. Detritus feeders are by far the most important group, with four subtypes: browsers (ostracods, snails, clams), pumpsuckers (flatworms, nematode worms, polychaete worms), puncture suckers (water bears or tardigrades), and sand-lickers (certain amphipods). Predators are nematode worms (up to 10,000/liter), crabs, creeping starfish (Ophiuroidea), and various fish and rays. Bacteria (up to an average of 200,000/gram of sand) comprise the bulk of the decomposer fauna. Many members of the sand fauna migrate, either vertically or horizontally with the tides (crustacean *Emerita*, clam *Donax*). Some sand-dwelling turbellarian worms expose their symbiotic algae to sunlight on the sand surface at low tide.

Most of the **endopsammon** build permanent burrows. Where wave energy is strong, the fauna is limited to robust, quick moving forms, such as crabs; in sheltered areas lancelets and tube-dwelling worms are common. The dominant polychaete worms collected by Dahlberg (1972) on Georgia beaches were *Onuphis microcephala* and *Diopatra cuprea*. Among amphipod crustacea, the genera *Haustoria, Orchestia,* and the "beach flea" *Talorchestia* predominate. Dahlberg found the most common beach isopod to be *Aegothoa oculata*. Hippid crabs (*Emerita*); the chief dune burrower, the ghost crab (*Ocypode quadrata*); some snails (*Oliva, Terebra*), clams (*Donax, Cardium*), and the sand dollar (*Mellita quinquiesperforata*) are characteristic beach animals.

The drawings of Pearse, Humm, and Wharton (1942) show the distribution of burrowing beach organisms on gradients from sand to mud on North Carolina beaches: **snails,** *Oliva–Sinum–Polinices–Terebra–Nassarius;* **clams,** *Cardium–Donax–Venus–Dosinia –Macrocallista–Tagelus,* and **crustacea** from the exposed beach outward, ghost crab (*Ocypode*), ghost shrimp (*Callianassa*); *Lysiosquilla–Arenaeus–Emerita–Ovalipes–Calappa–Lepidopa–Ogyris,* and blue crab (*Callinectes*).

The micro-sand fauna (**mesopsammon**) between sand grains has the greatest diversity of all—each beach system may have 1,000 species. The dominant groups are diatoms, protozoa (ciliates, foraminifera), turbellarian worms, gnathostomulids, gastrotrichs (extremely abundant), and nematode worms (most abundant of all). There are also tiny annelid worms, brachiopods, sea cucumbers (holothuroideans), sea squirts (ascidians), water bears (tardigrades), and mites. There are six groups of microscopic crustacea.

Of the larger members of the fauna above the sand (**epipsammon**), Dahlberg (1972) listed for Georgia beaches as dominant: hermit crabs *Clibanarius vittatus, Pagurus longicarpus,* the whelks *Busycon carica, Nassarius obsoletus, N. vibex,* the sea cucumber *Thyone briareus,* and the squid *Lolliguncula brevis.* Johnson *et al* (1971) present a preliminary list of Georgia beach fauna.

Fish, certain beetles, and birds are also members of the epipsammon. Dahlberg (1972, 1975) lists fish common to abundant along Georgia beaches. A tiger beetle (*Cicindela dorsalis*) is a beach visitor seasonally as is the loggerhead turtle (*Caretta caretta*) which nests above the high tide line on Georgia beaches. Many common shore birds, such as plovers, sandpipers, sanderlings, and turnstones, probe the sands for the sand fauna.

### Natural and Cultural Values of Coastal Marine Environments

Productivity in the salt marsh amounts to 200 g carbon/m$^2$/yr–and up to 10 tons of dry matter/acre/year, mostly by *Spartina alterniflora*. The decomposition of this much organic matter feeds the shellfish and fish in the marshes and estuaries and even on some of the continental shelf offshore, making Georgia coastal waters quite rich and capable of supporting an extensive resource important in commercial fishing and tourism. The marshes are classed by Odum as a compromise environment, offering protection to the landscape, such as preventing erosion by tidal currents and storms, and production to maintain fisheries and recreation. Reference is made above to the value of the salt marsh as a nursery ground for marine shellfish. It also entraps nutrients from the large rivers, stabilizes them, and converts them to a food resource (marsh grass) which in turn feeds the coastal consumers, the shellfish and fish. It thus helps maintain clear water and clean beaches by its filtering action.

Grosselink, Odum, and Pope (1973) and Odum (1973) have computed the value of the tidal marsh in two ways: (1) adding the values of commercial and sports fishing (based upon the nursery ground concept), intensive agriculture potential, and tertiary waste treatment potential. These values reach $4,075.00/acre/yr. A second approach gave a similar figure ($4,100/acre/yr), based upon evaluating this environment as an energy-conversion system. The annual gross primary productivity was estimated to be 1,250 gm/m$^2$ for high marshes (with a dollar value of $2,703/acre/yr), and 3,750 gm/m$^2$ for the more productive low marsh (high grass) stands (dollar value $6,220/acre/yr). The dollar equivalent is derived from using $10^{16}$ kilocalories consumed yearly in the United States to produce a GNP of $10^{12}$ dollars, so that $10^4$ kilocalories equal one dollar.

The Grosselink, Odum, and Pope paper reviews data, estimates, and facts about the marsh which I summarize: (1) Forty-two precent of net primary production of *Spartina alterniflora* is flushed into the adjacent bay by tidal action; (2) The net export of organic matter (including minerals) from 25 hectares of marsh was 40 Kg on a neap tide and 140 Kg on a spring tidal cycle (Odum and de la Cruz, 1967). Nutrient plumes of silt leaving the salt marsh and spreading seaward over the continental shelf have been pointed out by Sam Pickering from high altitude (10 miles) photography; (3) One half of the total production of organic matter in Louisiana estuaries originates from the surrounding marshes (Stowe *et al*, 1971); (4) Two-thirds of the cash value of species harvested on the Atlantic and Gulf coasts are "estuarine dependent," McHugh (1966); (5) The dockside value of fish and shellfish on the Georgia coast was 3.7 million dollars in 1965, processing raises this to $8,900,000; (6) Sport fishing involves 280,000 fishermen/year; (7) Annual yields of oyster meat of 1,800 pounds per acre from rafts could be achieved. (Three acres marsh and 3 acres estuary needed per 1 acre of raft); (8) An acre of marsh-estuary can assimilate daily about 19.4 pounds BOD (cost of artificial tertiary treatment is $2.00/pound) and thus does $14,000 work/acre/year; (9) The estuaries are not economically efficient in secondary waste treatment, but are effective in the more costly tertiary treatment which removes and recycles inorganic nutrients; (10) Marsh sediments act as source and sink for some inorganic compounds, such as phosphates, and buffer the effects of large additions to the system, Pomeroy *et al* (1972); (11) Nitrogen and sulfur cycling is dependent on microbial action in a reducing environment, Deevey (1970). Nitrogen wastes are increasing. Nitrogen of biological origin is oxidized to nitrate in the oxidized layer of marsh mud, diffuses downward to the nearby reducing anaerobic zone, and becomes reduced to nitrogen gas which escapes to the atmosphere; (12) Sulfates from industries fall on environments. Industrial contributions have increased to about one-third of the total atmospheric load. Marsh muds reduce these sulfates in the anaerobic layer to sulfur and sulfides, releasing oxygen. It is efficient because sulfuric acid does not accumulate; (13) The salt marsh absorbs wave energy and acts as a water reservoir. Marshes protect the sand beaches of the barrier islands by absorbing energy and trapping silt.

Thomas (1966) thought that the Altamaha flushed the estuaries and their richer phosphates seaward to the extent that primary production levels 24 km off the mouth of the Altamaha River equalled the production within the salt marsh-estuary complex, and had a greater value (547 g carbon $m^{-2}$ yr $^{-1}$) than that reported off the Columbia or Mississippi River, and among the highest known production values on the continental shelf.

Vitamin $B_{12}$, synthesized by bacteria and fungi, is found in high concentrations in dark water rivers, Burkholder and Burkholder (1956), and is found in tidal creeks, with highest concentration in detritus from the head of tidal rivers. Georgia estuaries contain a standing crop of 2 to 20 micrograms of ash-free, dry organic matter per liter, greater at the head than in the sounds.

Beck (1972) indicates that the organic matter of Georgia streams flocculates in the estuaries. He claims that with the introduction of low pH, low $SiO_2$ waters by swamp flushing at high water, silicate minerals interact in the estuary to modify water chemistry. Montmorillinite (mg++ the dominant exchange cation) appears involved, either forming kaolinite or dissolving incongruently. Estuarine levels of aluminum and iron appeared to be controlled by pH dependent precipitation reactions in addition to mixing.

River systems "feed" marine systems in a variety of ways. The influx of silt into the salt marshes from flooding rivers has been described above (see Lunz, 1938 under salt marshes). Day *et al* (1975) found that a river swamp system fed a Louisiana estuary (accounting for 45% of state commercial fish production) with pulses of carbon, nitrogen, and phosphorus at the precise time when migrant species were entering the estuary for growth and spawning. Ninety percent of shrimp caught offshore near Apalachicola Bay and 75% of all commercial fish landings in Franklin County, Florida depend on Apalachicola Bay as a nursery and feeding ground, Livingston *et al* (1974, 1975). The Apalachicola River apparently provides the bulk of nutrients to the highly productive bay, which also furnishes 80% of Florida's oysters, Livingston and Thompson (1975). During high water flows, in addition to the nutrient silt, the river supplies the bay with large amounts of detritus (leaves and twigs) which undergo rapid (4-8 weeks) decomposition by a microfauna. Thus, the leaves of floodplain trees may feed detritus-eaters, such as shrimp, and also help support a major center for crab spawining and dispersal. Unlike the deltas of Georgis's coastal streams, the Apalachicola was not stripped of forest for rice culture. It thus remains to be determined how forestation or deforestation might affect the nutrient supply by regulating the flow of leaf material into the estuary.

Other values include the feeding grounds of birds, and the esthetic appeal of this environment which offers opportunity for educational use because of its simplicity. Obviously, the estuaries, tidal creeks and rivers, and sounds have value to pleasure boating and commercial traffic of all types, including barges. Marsh hen and winter duck hunting are important sports—some trapping of mink is practiced on the edge of the coastal marshes.

The salt marshes, to some extent, protect the coastal islands from overuse. An overview of the marshes reveals that turbulent and destructive combinations of silt and water are kept both orderly and productive by the biotic community of the marsh. Otherwise, disorder would prevail and hydrologic and geologic forces would present a deteriorating scene.

The beach-dune system protects the barrier islands from erosion by wind and wave action. The beach presents many values in education and recreation. Its myriad and easily observed microenvironments and organisms, from bacteria to birds, make the beach a living laboratory which will sustain much digging and physical abuse. Each tide erases the signs of man. Intangible benefits are of great value. Because of the white noise from the surf, the ceaseless wave motion, the limitless horizon, the mysterious and changing visible fauna, and the sense of isolation that it provokes, beaches have strong effects on primitive brain centers and, like mountain streams, have a therapeutic and quieting effect on the human mind.

Commercial shrimp species are the white shrimp (*Penaeus setiferus*) and the brown shrimp (*P. aztecus*). Shrimp eggs hatch offshore, but the planktonic larvae move into the estuaries and tidal creeks where they live near the bottom. The two commercial crabs, *Callinectes sapidus* and *C. ornatus,* are collectively called "blue" crabs. Johnson *et al* (1971) have summarized the value of the coastal fishery resource, stating that the harvest for 1960-65 averaged 21.4 million pounds ($3.4 million); shrimp account for 83% of the value, crab for 10%, and oysters 1%. Shrimp are harvested (by day only) between June 1-December 31 within a 3-mile limit. The pink shrimp (*Penaeus duorarum*) is sometimes taken. In 1975, commercial fish landings amounted to: fish, 750,293 pounds ($278,697); blue crabs, 8,865,380 pounds ($1,154,720); shrimp (heads on), 8,089,591 pounds ($10,488,279); oyster meats, 44,062 pounds ($25,613); U.S. Dept. of Commerce.

There are about 10,180 acres of oyster reefs, but ⅓ to ½ of the area is polluted. In Altamaha Sound, a population of brackish water clams (*Rangia cuneata*) are commercially valuable but polluted. The quahog (cherrystone clam) *Mercenaria mercenaria* is dug, but not commercially. Finfish account for 5% of the value of marine protein foods. The approximate contributions (1967) are as follows: American shad 45%, whiting (3 species) 15%, red snapper 17%, and grouper 10%. Some 40,000 tons of menhaden (juveniles frequent the estuaries) are taken in Georgia but sold outside of the state.

## Man's Impact on Coastal Marine Environments

The salt marsh can be heavily used, but the type of use needs restriction. If the marsh is filled in or the tidal creeks blocked, it cannot perform its important services. The most damaging impacts are land-fill which consumes marsh acreage, or land-fill for bridges and dikes which cuts the natural waterways on which the system depends.

Other dangers are secondary waste overload, industrial wastes and toxins which kill the fauna, or accumulate in animals like shellfish. The wastes may overtax the estuaries' capacity to purify them.

Another danger is near-shore mining, and another is oil spill possibilities from oil tankers or offshore drilling, especially if the dredge spoil is dumped on the marsh or blocks channels. Suspended clays from dredging can smother shellfish, although limited (intracoastal waterway) dredging has not proved damaging to oysters, according to studies by Lunz on South Carolina marshes.

A potent potential source of damage may be dam-building on the major rivers, such as the Altamaha, in connection with a large canal. Such dams may remove the normal bed load transport of sand needed for island maintenance, or they may remove sediments, both inorganic and particulate organic matter, that would otherwise be delivered to the estuaries and salt marshes. (See **man's impact** on the rivers). Dams also diminish the height of floods and deprive the marshlands of both a fertility increment and freshwater dilution. Another threat may lie in clearcutting the bottomland forests which may increase silt transport.

Carter *et al* (1973) found that while a canal system (Fahka Union Canal, Collier Co., Fla.) put more nutrients in an estuary, its nutrient load was short-circuited to the Gulf of Mexico where these substances were apparently lost to the coastal ecosystems. Due to the canal system, however, the concentration of metals was 2X or 3X that of an estuary receiving only natural flow. These authors found that salt marshes were fed nutrients and minerals by normal overland sheet flow of water, and that drainage canals short-circuited these substances to estuarine waters where they were incorporated into sediment and exported into the Gulf of Mexico. Another important finding of this team was that the gross productivity of the Floridian salt marsh community decreased with a reduction of fresh water availability. They discovered that drainage canals posed a serious threat to the welfare of estuarine ecosystems by disrupting the seasonal water patterns and reducing the overland flow of fresh water. This lack of normal fresh water run-off creates hypersaline conditions upsetting the physiology of larval and juvenile fishes and shrimp, and also allowing marine predators to enter the nursery grounds. Fingerling striped bass, for example, inhabit estuarine waters with salinities lower than 3.2 ppt, Ga. Game and Fish Division (1970). A salinity gradient is essential for estuarine-dependent species, as E.P. Odum has stated.

Channelization and diking of floodplains, as proposed for the lower Altamaha, may cause changes in deposition, sediment load, and scouring—the effects are difficult to predict. Diking off or modifying river flow can damage coastal marine systems by increasing the salinity in nursery areas (see **man's use** of rivers). Low salinity is not only necessary to oyster survival, but may cause an influx of predatory fish and the destructive oyster drill (*Urosalpinx cinerea*).

There are suggestions by Robert Livingston (pers. comm.) that diking off 32,000 acres of the Apalachicola floodplain has cut off a nutrient supply in the form of leaf detritus from Apalachicola Bay. Livingston has found pH changes in run-off waters from areas of the floodplain clearcut by private industry. He found that drainage canals and clearcutting go hand in hand, and that the drainage canals open directly into the bays, affecting detritus decomposition. Clearcutting and canal drainage has occurred on approximately 20,000 acres of the Apalachicola delta, formerly one of the last great wild areas of the Southeast. We can learn much about managing floodplains from observing the impacts of man along the lower Apalachicola.

Of all coastal systems receiving surface-floating wastes, beaches are most affected, although their capacity for processing and mineralizing wastes is also large, Odum *et al* (1974). Obviously, oil spills pose critical problems for the complex beach fauna. Sewage and industrial wastes can ruin beaches and their shellfish and fish populations. Large industries are prone to locate on otherwise uninhabitable high ground in or near the salt marsh, resulting in water, air, and visual pollution. From the south end of Cumberland, a large paper mill at Frederica dominates the horizon and is visible day and night. This spoils a good part of the sense of isolation that this environment brings to its visitors. The effects of interfering with the river's task of contributing sand to beaches is discussed under **man's impact**—environment [10] and DNR (1976).

Johnson *et al* (1971) have summarized environmental problems of the coastal aquatic zone, organized into the following categories — (1) Depression of the principal artesian aquifer and the resultant possibility of salt water intrusion into the water supply of coastal cities; (2) Pollution by industry and municipalities, intentionally or accidentally—most of the coasts' oyster reefs are contaminated (State Public Health authorities publish maps of these areas). Oysters may concentrate chlorinated hydrocarbons, radionuclides, and heavy minerals (8 ppm DDT 24 hours after spraying a beach). Mirex is lethal to juvenile crabs and shrimp. In 1970, Mirex was sprayed over McIntosh County and wiped out a local crab and oyster operation in business since 1919, and killed many salt marsh animals, such as birds, raccoons, and crabs, DNR (1976); (3) Dredging, filling, diking, and ditching—about 2,700 acres of marshland were destroyed between 1954-1968, principally by navigation projects. Dredging reduces photosynthesis by phytoplankton, and depletes oxygen; (4) Grazing by cattle, hogs, and horses; (5) Fish and shellfish culture (now being practiced by Thiokol Chemical Corporation on the Satilla) by Marine Land Farms south of Brunswick and by S.L. Lewis between Wassaw and Ossabaw. A diamond-back turtle farm on the Isle of Hope is reported, Alex Barbee (pers. comm.); (6) Mining—phosphate deposits of major economic potential lie about 70 feet below the Wassaw-Ossabaw island area. In 1968, the Kerr-McGee Corporation applied for a mineral lease, intending to create artificial islands from the overburden spoil and sell them as a real estate, in addition to procuring the phosphate.

## B. NON-FLOWING WATER SYSTEMS

Fluctuation may be regular (annual) or irregular. In most non-flowing water systems, phytoplankton (unicell algae) productivity may exceed periphyton (attached algae).

1. DEPRESSED SURFACE HYDRIC FEATURES

These are of two basic geological origins—(1) Depression relicts from formerly submerged tidal systems, such as estuaries and salt marshes behind ancient dune systems and (2) The product of undergound solution (sagponds, limesinks) or subsurface collapse (limesinks). There may be an outlet for excess water (cypress ponds in part, Okefenokee) or no outlet (sagponds in part, limesinks in part, Carolina bays in part). Some (cypress ponds) may be the result of wind erosion in riverine dunes or artesian water in depressions (Ohoopee dunes).

Water stands in these terrain features through some portion of the growing season. The fluctuations of the water result in alternating wet and dry conditions important in seed regeneration; in allowing fire to sweep through sporadically; in promoting eutrophic conditions at low water; in leading to high acidity with low amounts of peat in those depressions going completely dry annually, and with peat accumulation moderate to heavy in those depressions not going dry annually. Some ecological relationships are indicated in Figure 13.

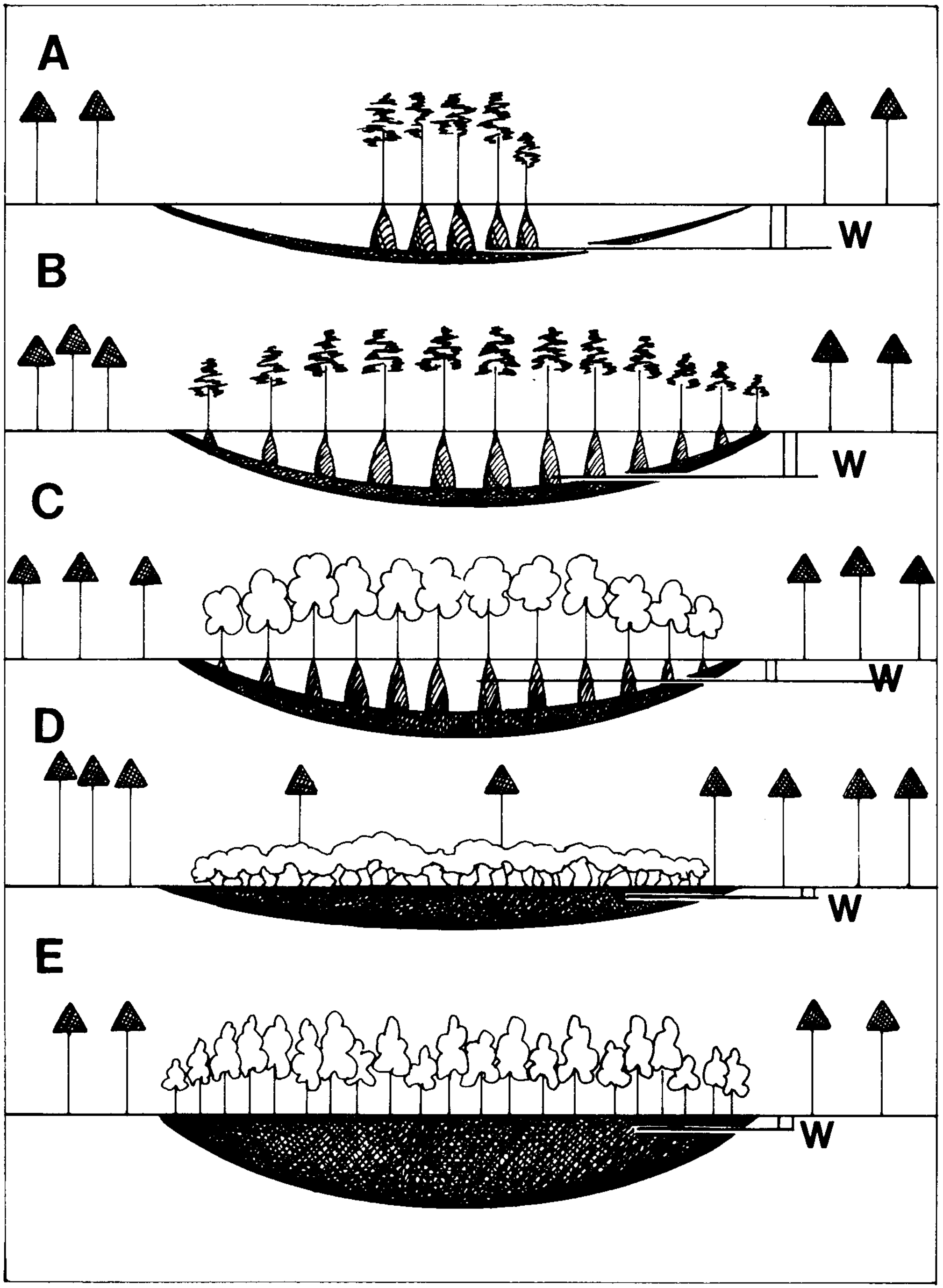


Fig. 13. Idealized ecological relationships in some depressed surface wetland environments (vertical scale of basin depth exaggerated). A, Carolina Bay [28]; B, cypress pond [26]; C, gum pond [27]; D, shrub bog [33]; E, bay swamp [29]; Symbol to left of "W" indicates depth to which water falls in dry season. Depth of peat (organic matter) is indicated by dark color. Water depth in upper units tends to fluctuate more, both oxidation and fire keep peat from accumulating.

It can be argued that some of these environments, such as the Okefenokee with its slow, steady sheet flow, are indeed flowing water situations. Our present knowledge suggests, however that this is not the major ecological factor Fire, especially in drought years, is thought to play a prominent role in the ecology of these systems.

**Effects of fire on non-flowing systems**—Some wetlands are dependent on fire. Long intervals between droughts obscure the importance of fire in modifying and maintaining many wetland environments. Various wetlands burn on different cycles. **Short interval systems** (3 to 9 years) include the herb bog (which *may* burn as often as once a year) and the high-diversity shrub bog. **Long interval systems** (20 years or longer) include the low-diversity or titi shrub bog (20 to 50 year interval); many cypress and gum ponds and bog swamp (Okefenokee) (20 to 30 year interval); and the bay swamp and some cypress ponds (50 to 150 year interval).

Fire can thus be said to be obligatory for herb bogs, occasional for shrub bogs, and rare for bay swamps. Type of soil and soil moisture are controlling factors. For example, herb bogs are usually on sandy soils which dry out rapidly Shrub bogs and bay swamps either have more constant seepage or layers of peat which hold huge amounts of water

Stoddard (1955) indicates a 20-30 year fire interval for the Okefenokee. Droughts are fairly well documented. In 1860 Billy's Lake was apparently dry for three months, and entirely dry again in 1879. During the 1930-1934 drought, the Okefenokee caught fire at Dinner Pond in the spring of 1932. Not much cypress was damaged, but a large percent of sweet bay several million board feet of slash pine, and 40 to 50 million feet of swamp blackgum were estimated destroyed, Stoddard (1955). Smouldering moss fell in the streets of Folkston, 10 miles away

Again, during the drought period of 1951-55, the Okefenokee caught fire from lightning (October 6, 1954) and burned 284,000 acres of refuge land. It was reported that the peat burns were so deep that cypress trees fell like jackstraws. Stoddard recorded smoke so thick across Highway 17 that he had to use a flashlight to tell whether his car was crossways or lengthwise to the road.

During these same droughts, fires also burn through many wetland environments, including those that form peat. Stoddard (1955) estimates that, in the 1930-1934 drought, one-half of the cypress and slash pine bays were burned, and in 1951-55, many semi-permanent cypress ponds apparently burned following as long as 50 years fire absence. Stoddard cites an instance where fire in a gum pond consumed the peat to a depth of six feet, so that the gum trees fell in every direction. Carl Monk (pers. comm.) states that he has repeatedly found charcoal fragments in soil samples from bay swamps and cypress ponds.

## [26] CYPRESS PONDS

### Location and Description

We can categorize cypress ponds into two types, **cypress domes** or "heads," largely round with the tallest trees in the center and tree size diminishing towards the edge, Photo U, and irregular (in outline) **cypress ponds**. Cypress ponds occur throughout the Coastal Plain. The best development of both the dome-shaped and the irregular ponds is to be found in the Pleistocene region; small filled-in limesink-type ponds are frequent in the Limesink Region (aquifer recharge zone). The origin of the numerous, roundish ponds in the elevated portions of former marine dune systems is presently unexplained. Love *et al* (1972), surveying the coastal tiers of counties, classified cypress ponds in their area as "basins" under an inland wetland category

Photo U. A CYPRESS POND [26], "head" or "dome," showing the characteristic form. Here revealed by industrial clear cutting of the MESIC PINE LOWLAND FOREST [94], these ponds are common in the Pleistocene area. They are important in treating run-off wastes, storing water and serving as nesting and refuge areas for wildlife. Pine flatwoods life centers around such ponds.

The most recent theory of the origin of cypress ponds in the Pleistocene region is that of Hoyt (1968) and Hoyt and Hails (1967, 1969). These authors determined six Pleistocene shorelines (paralleling the present coast) as follows: Wicomico, Penholoway, Talbot, Pamlico, Princess Anne, and Silver Bluff. The age of the youngest or Silver Bluff shoreline is estimated (based upon radiocarbon dating) between 25,000-40,000 years. Inland, former barrier islands now stand as low ridges, representing ancient shorelines when sea level was higher—Savannah is located on such an island of the former Pamlico shore. The Satilla River crosses another, the Penholoway island arc which runs south between it and the next younger beach series (the Talbot), and then cuts around the south end of Talbot barrier island and heads seaward. Trail Ridge is a long barrier island of the former Wicomico marine shoreline and it effectively dams up the Okefenokee. Remnants of Wicomico barrier islands can also be found near Jesup and Springfield.

The seaward side of the barrier islands may slope up to 25 meters per kilometer. The broad areas (up to 30 kilometers wide) behind the barrier island chains were formerly called "coastal terraces." They are considered by Hoyt and Hails to be old estuary-salt marsh areas called "lagoonal-marsh" by the authors. Present day irregular-shaped cypress ponds occupy these old lagoonal-marsh areas. The sediments of the lagoonal-marsh areas are clayey and silty sands overlain with 0.5 to 1 meter of fine sand. Clayey sands weather to bright red or orange with gray mottlings. Old river channel deposits of coarse sand, fine gravel, and clay are common in the lagoonal-marsh area. some present day streams are thought to flow in relict tidal channels.

The barrier islands are composed of fine-grained sand, deeply weathered with oxidation and leaching exceeding 10 feet. A concentration of iron and organic matter is characteristic at 0.5 to 2.5 meters depth. This "humate" layer, dark-grown to black, may be up to two meters thick and forms a hard, impervious layer. Some cypress ponds are "perched" on similar hardpan layers.

Ancient lagoon widths vary, being two miles wide (Talbot), eight miles wide (Penholoway, south of Jesup), and 10-20 miles wide (Pamlico). The most recent and present shoreline is the Holocene—its marshes are six miles wide behind Wassaw Island, but are just seaward of the Silver Bluff on most of the coastal islands; in this case, the lagoon-marsh of Silver Bluff time has been reoccupied by the present Holocene salt marsh.

Cypress domes in Georgia may be similar to many in Florida, which are underlain by impermeable clay or, in some areas, a hardpan continuous with that beneath the pine flatwoods. Some resemble sinks, with a distinct clay plug in the center, bordered by phosphatic dolomite doposits. These types possibly drained to the underground aquifer at one time, Ewel (1976).

The soil of cypress ponds is acid, pH 5.5. Phosphorus is extremely low. The following are the mean figures for five environmental variables of cypress ponds as given by Monk (1968) in ppm: calcium 185, magnesium 55.2, potassium 15.8, phosphorus 1.2, moisture 35. Water is often trapped by a thin clay lens, Pool *et al* (1972).

Monk and Brown (1965) provided additional soil data from cypress heads. The ranges were: pH 4.6 to 4.1; calcium 28 ppm; magnesium 15 and 20 ppm; potassium 5-30 ppm; phosphorus 1-5 ppm; organic matter 1-17%; litter depth 13 inches maximum; clay (at 48 to 60 inches deep) 2-6.5%. In Florida, phosphorus accumulates in clays beneath cypress domes, Ewel (1976).

### Flora

Brown (1963) listed the important trees, saplings, shrubs, and herbs of cypress heads in north Florida, and calculated importance values—**trees:** pond cypress (*Taxodium nutans*) 182; slash pine 48; black gum 47; red maple 14; **shrubs:** fetter bush (*Lyonia lucida*) 55; wax myrtle 39; red maple 24; pond cypress 22; button bush 20; black gum 31; **herbs:** Virginia chain fern 53; poison ivy 20; bamboo brier 18; lizard's tail 17; hard head (*Xyris* sp.) 13; Virginia willow 13; St. John's Wort (*Hypericum fasciculatum*) 10.

Monk (1968) recorded the presence of trees and shrubs (in %) from cypress domes of north central Florida as follows: pond cypress 100, swamp blackgum 100, slash pine 93, wax myrtle 93, button bush 67, sweet bay 60, pond pine 53, red maple 53, and dahoon holly 53.

Faircloth (1971) recognized three distinct vegetation zones of Georgia cypress ponds: (1) in deepest water an almost pure stand of cypress; (2) a shallower zone of large and small cypress with an equal number of swamp blackgum; (3) the largest, most shallow portion of the pond with cypress, swamp blackgum, and slash pine with some sweet bay, red maple, sweet gum, *Ilex myrtifolia,* and swamp red bay. Some permanent ponds have rooted aquatics of the genera *Brasenia, Nymphaea, Nuphar, Nymphoides, Nelumbo, Potamogeton,* and *Cabomba*.

Cypress ponds are numerous on Quacco Road (Chatham Co.) in sandhills lying east of the Ogeechee River. One pond had the following edge plants dominant: gallberry, fetterbush lyonia, *Vaccinium* sp., wax myrtle, possumhaw, small red bay, *Hypericum sufridicosum,* and *Ludwigia pilosa*. Yaupon holly and sweet bay were present but less abundant. Slash pine borders some of these ponds.

A permanent water cypress pond (average depth two feet) with no inlet or outlet was examined east of Valdosta. It rarely went dry but levels did fall in late summer. The small scattered swamp blackgums showed large buttresses (indicating fluctuation). There were both *Nuphar* and *Nymphaea* lilies, and bladderworts (*Utricularia*); the latter an indicator of low nitrogen. There was a huge stand of emergent hardhead (*Xyris gabrafolia*) and a border of *Juncus, Carex, Polygonums,* and *Hydrocotyl.*

Harper (1960) states that cypress ponds are probably the most stable of all phytogeographical units on the Tifton Upland. Cypress domes (Laessle, 1942) can go to climax hardwood hammocks following the accumulation of sufficient organic debris (peat). Normally, organic matter accumulations are kept down by decomposition and, sporadically, fire. Calcium is lowest around the periphery of the cypress head, soil organic content, and clay decreases outward from the center. Cypress importance values increase directly with flooding and potassium, and inversely with calcium and pH (Pool *et al*, 1972). Water depth in the center may range to four feet. Only a few of the largest ponds hold water the year around—most go dry or nearly so.

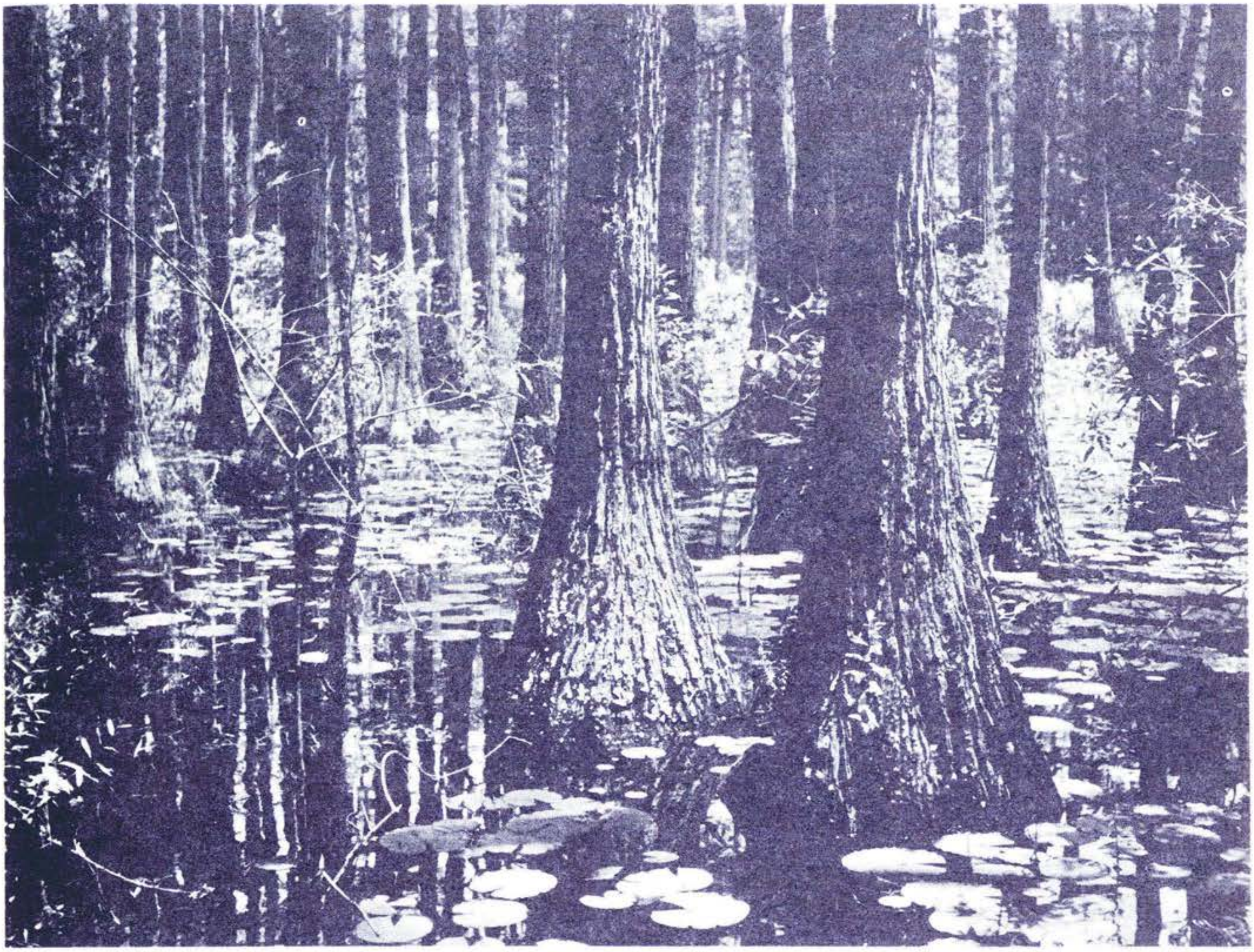

Photo V This cypress pond [26] on Joiner Island (Long Co.) occurs on one of the numerous sandhills completely surrounded by the gum-cypress drainways on the broad Altamaha floodplain south of Ludowici. A large Indian village occupied part of Joiner Island.

**Fauna**

Common aquatic and bottom-dwelling animals in north Florida domes are the oligochaete worm *Nais obtusa,* the isopod *Asellus militaris,* the amphipod *Synurella dentata,* the damselfly *Enallagma triviatum,* the predatory beetle *Bidessus* sp., and the midge fly larvae *Stictochironomus exquisitus,* Ewel (1976). Such vertebrates as mosquitofish *Gambusia* sp. and cottonmouth mocassins occur in permanent water ponds. Often a series of cypress ponds will be connected by drainways during wet periods.

The vertebrate fauna is CP Appendix VI, habitat H, with SH invading during the dry season. Little reliable information is available on the fauna of Georgia cypress ponds. I record the following as dominants: southern dusky salamander dwarf salamander cricket frog, little grass frog (edge grass areas), narrow-mouth toad, oak toad (edge), black racer (edge), southern banded water snake, cottonmouth, and southern ringneck (edge). The black racer and oak toad are intruders from the surrounding pine flatwoods. Since the true faunal picture is seldom attained by occasional collecting, refer to the faunal section of GUM PONDS [27].

Around the edge of cypress ponds in the ecotone, where pines may die because of high water levels, a number of rare animals may appear The earth snakes (*Haldea*) are reported commonly taken here, Walter Auffenberg (pers. comm.). Scarlet king snakes are sometimes found beneath bark of stumps around cypress ponds, as are scarlet snakes, and rare yellow-lipped snakes may also be collected here.

There is little fish life. We found a pond near Waycross (Ware Co.) in drought stage with several cottonmouths congregated around the small pool of water that remained. No fish, however remained. The larger frogs (*Rana*) may bury themselves in moist litter during such times.

In cypress ponds on the Quacco Road (Chatham Co.), in the low sandhill country lying east of the Ogeechee, Gerald Williamson has found the three Ambystomid salamanders breeding; the frosted flatwoods, marbled and mole salamanders. The dwarf, many-lined, slimy salamander and carpenter frog are also found. Two glass lizards, crowned and indigo snakes occur at ponds in pine flatwoods.

Some of the larger wading birds nest in cypress and gum ponds. According to Milton Hopkins (pers. comm.), who has inventoried pond rookeries by airplane in the Tifton Upland, all the ponds used as rookeries have cypress, and most all have swamp black gum and some have ogeechee lime. the smallest rookery pond noted had from 10 to 15 acres. Most have a button bush shrub layer and show fire scars in the center Only a few, such as Spring Hill Pond (Wheeler Co.) fed by an artesian well, have more or less stable water levels. Hopkins indicates that about 90% of the birds nest in gum trees. The average composition of the rookeries is 90% Cattle Egrets and 10% Little Blue Herons, with scattered nests of American Egrets, Great Blue and Green Herons. Hopkins has found one pond with 500-800 nests of White Ibis.

Pruitt (1971 surveyed the literature and listed 17 mammals common to the cypress swamp. Among these that I consider as permanently associated with this environment are the marsh rabbit, golden mouse, and roundtailed muskrat, (*Neofiber*) (with permanent water ponds), and (periphery only): wood rat, southeastern shrew least short-tailed shrew (*Cryptotis parva*), and three bats, eastern pipistrell, hoary and seminole. The fauna is depauperate, but because of the presence of water and its annual fluctuations, cypress ponds are extremely important to the life of surrounding flatwoods, from small vertebrates like frogs and salamanders to large ones like deer and wading birds, although the usage may be seasonal and thus not obvious. (See fauna, GUM POND for details.)

## [27] GUM PONDS

### Location and Description

Gum ponds are without cypress and dominated by the swamp blackgum (*Nyssa biflora*), Photo W and are found mostly in the Coastal Plain. They are less abundant than cypress ponds. Occasionally gum ponds occur in the Piedmont; there is one on a terrace in the Flint River floodplain below Dripping Rock (Upson Co.). I examined ponds near Savannah in high sandy terrain supporting near-original stands of longleaf pine. Even though this locality is just across the Savannah River (Highway 46) in South Carolina (3.3 miles SE Hardeeville), it is extremely important because it was preserved by a series of large plantations and gives an idea of original forest composition.

Photo W A GUM POND [27] near Big Sandy Creek (Wilkinson Co.). The swamp black gums (*Nyssa biflora* are weakened and dying due to excessive ponding produced by the damming effect of highway landfill and inadequate drainage. A thick growth of emergent plants is present.

It is suspected that most gum ponds are underlain by an impervious clay layer. I have found peat layers three feet thick. Water fluctuations may be less in gum ponds than in cypress ponds, Wharton *et al* (1960). In the Florida panhandle swamp blackgum occupies the lowest and wettest sites on mucky sands of the Ponzer and Rutledge groups, Clewell (1971).

### Flora

The Hardeeville gum ponds were small, scarcely exceeding 100 feet in width. Fringed by tall gallberry (*Ilex coriacea*), most also had scattered button bush shrub. One had an almost solid layer of button bush shrub with sweet gums and slash pine around the edge (pond #2), and one (pond #3) resembled a grass-sedge savannah with *Xyris, Oenothera, Sagittaria* sp., pickerel weed, *Scirpus,* and *Juncus,* and several grasses. Another had several huge old gums and a stand of willow oak at one end. On November 2, 1974, only pond #2 contained water. Pond #1, examined more in detail, had a few wax myrtle and red maple, with an herbaceous stratum dominated by cinnamon fern, *Smilax laurifolia, Eriocaulon* sp., a strap-leafed *Sagittaria,* and with areas of *Sphagnum* moss. The Piedmont pond had as dominant shrubs witherrod viburnum, red chokeberry (*Aronia arbutifolia*) and sweetbells leucothoe.

### Fauna

With the aid of drift fences, funnel traps, and can traps, Gerald Williamson and James D. Anderson (pers. comm.) have documented an amazing assemblage of animals from these ponds. When the ponds dry up, many supposedly aquatic animals, such as sirens (*Siren* sp.) survive the dry season by burrowing beneath the root system of the gum trees and utilizing crayfish burrows. Here is a partial list of vertebrates taken at one small gum pond: mole salamander, frosted flatwoods salamander, marbled salamander, dwarf salamander, dwarf siren, lesser siren, greater siren, southern dusky salamander, red-spotted newt, glossy water snake, ribbon snake, garter snake, black racer, cottonmouth, copperhead, corn snake, king snake, mud snake, mud turtle, chicken turtle, and box turtle.

Williamson and Anderson are finding differences between these ponds. For example, pond #2 has newts, *Siren,* and dwarf salamander, but no *Ambystoma*. *Manculus* is characteristic of ponds with more or less permanent water. Apparently aquatic predation limits the survival of slow, heavy *Ambystoma* larvae, which are typically temporary water breeders. The pond which dries to a grass-sedge savannah evidently provides hunting grounds for southern banded water snakes, corn and king snakes and cottonmouths, who presumably move elsewhere when the pond dries up. Pond #4, which fills later in the year than the others, had no frosted flatwoods salamanders (*Ambystoma cingulatum*) but did have marbled and mole salamanders, *Siren* and *Amphiuma*. The dominant small mammals appear to be the least shrew *Cryptotis* (Williamson and Anderson have taken as many as 20 in 3 weeks) and the short-tail shrew (*Blarina*).

The number of species and the number of individual animals moving to and from these ponds has scarcely been recognized. Since species aggregate during the breeding period, there are regular pulses of life which invlolve the ponds: the arrival of the breeding adults, followed by the deposition of huge numbers of eggs, then the departure of the adults, then the cycle of the larvae and what they consume, and the departure of the immature frogs and salamanders. Few studies have illustrated the biomass exchange that occurs. In terms of mineral cycling, Spring and Gibbons (1974), considering adult mortality and juvenile emigration only, found a net outflow of biomass and nutrients from Karen's Pond on the Savannah River plant (Upper Coastal Plain, S.C., 800 $m^2$) to the surrounding pine and turkey oak environment near Augusta, Georgia. In the same pond, Linda Briese (pers. comm.) has captured the following species and numbers of salamanders moving to the pond during one year: red-spotted newt 429, dwarf 168, slimy 103, mole 899, marbled 5, and tiger 31.

An artificial pond (Risher's Pond, 2.5 acre) bordered by bottomland hardwoods on one side, showed that a number of the species of salamanders (mud, 2-lined, 3-lined, marbled, spotted, and dusky) are typically floodplain forms, and had apparently migrated from the adjacent swampy area.

To illustrate the flow of life using one small pond (Karen's Pond), Gibbons and Bennett (1974) found 3,784 frogs moving to the pond on an annual basis. This flow of biomass to this tiny pond is all the more remarkable considering that buildings, fields, and parking areas block one quadrant, and the plant community is a desolate, cut-over scrubby remnant of original xeric pine uplands. The following illustrates the relative abundance of the different species taken at Karen's Pond by Gibbons and Bennett (two year period): leopard frog 294, bronze frog 9, bull frog 34, gopher frog 62, southern toad 1,544, oak toad 57, spadefoot toad 1,321, narrow-mouth toad 231, cricket frog 48, chorus frog 73, ornate chorus frog 36, spring peeper 51, barking frog 3, green tree frog 1, and squirrel tree frog 98.

### Natural and Cultural Values of Cypress and Gum Ponds

Obviously, from the above data, even the smallest cypress and gum ponds are veritable storehouses of animal life and focal points for the animal communities of the surrounding pinelands. There are obviously grand movements of life in cyclic waves across otherwise seemingly barren mesic and xeric pinelands because of these ponds. The ponds maintain not only their own food webs, but the life web of the pinelands of the southern Coastal Plain and sandhill areas. They provide the only breeding opportunity for many vertebrates, including a number of tree frogs, several of the toads, the gopher frog, and various salamanders. Apparently, they are watering places for the birds, mammals, and reptiles. Many birds, especially herons and egrets, must nest there.

One of the most important functions of these ponds may be as reservoirs for maintaining the water table high, i.e., the recharge of surface aquifers, Ewel (1976). In Florida's Green Swamp, studies showed that 30% of rain was held in cypress storages from which recharge was taking place, Wharton *et al* (1976). It is also likely that the pond communities can assimilate excessive pollutants and detoxify wastes in surface run-off.

Studies by Mitch (1975) indicate that Lake Alice, a cypress pond near Gainesville, Florida, assimilates 2.8 mgd (million gallons per day) of sewage. Experiments in north Florida (Ewel, 1976 and Odum *et al*, 1974) since 1973 have shown that even small cypress domes can serve as tertiary sewage treatment facilities in improving water quality, recharging ground water, and possibly increasing cypress growth rates at costs of $0.27 per 1,000 gallons for 25,000 gallons daily. Decomposition in sewage-fed ponds occurs as rapidly as in control ponds. The ponds may respond with a heavy duckweed growth, *Lemna perpusilla, Spirodella oligorhiza* (and water fern *Azolla caroliniana*), which removes heavy metals, nitrogen, and phosphorus (but also reduces pond life diversity). Both bacteria (97% retained) and viruses appear to be retained by the pond and underlying clays, but further tests are necessary.

Large acreages of south Georgia are in cypress and gum ponds. Many can perhaps be used for tertiary waste water treatment. Succesyful dwellings have been erected in the center of some Floridian ponds, either bolted to trees or reached by a causeway, Wharton *et al* (1976). Aquaculture in the gum ponds and the more permanent water cypress ponds is a possible alternative use. Permanent water is detected by the presence of emergent water lilies, sunfish, or certain frogs, such as the bullfrog and pig frog (*Rana gryllio*). Frogs, crayfish, and warm water fish offer the greatest potential. Common aquatic plants (*Sagittaria, Orontium, Justicia, Alternanthera*) could be grown, and yield high protein roughage and mineral supplements, Boyd (1968).

### Man's Impact on Cypress and Gum Ponds

By far the greatest threat to cypress and gum ponds is drainage. Large wood-using industries are ditching from one pond to another or ditching from pond to stream. Ditching operations may be seen on Highway 84 south of Waycross. The theory is to dry the ponds slightly so that regular fire will damage or destroy the remaining cypress and the peat or litter which has accumulated. When the mineral soil has been exposed, pines can perhaps be grown in some of these former cypress ponds, but generally these areas grow pines very poorly. Normally, the occasional fire that passes through a cypress pond in drought years does little major damage. There are hundreds of thousands of these important biotic units in southern Georgia. Because they manage water so well, aid in fire protection, have a potential as waste water disposal basins, grow quality timber, and are indispensible for wildlife, drainage is not recommended, Odum *et al* (1974).

## [28] CAROLINA BAYS

### Location and Description

Carolina bays are elliptical or oval wetlands with irregular water levels; some are spring-fed, Photo Y, and support permanent lakes. They range in size from several hundred feet up to nearly five miles in length. They are located in the Coastal Plain, largely the SE sector of the state, generally speaking, south of a line drawn from the SW corner of Thomas County to Augusta, Figure 14. From the air, they may be confused with limesinks. According to Sam Pickering, more than 1,000, occupying about 250,000 acres, have been mapped by the Geologic and Water Resources Division from aerial photography.

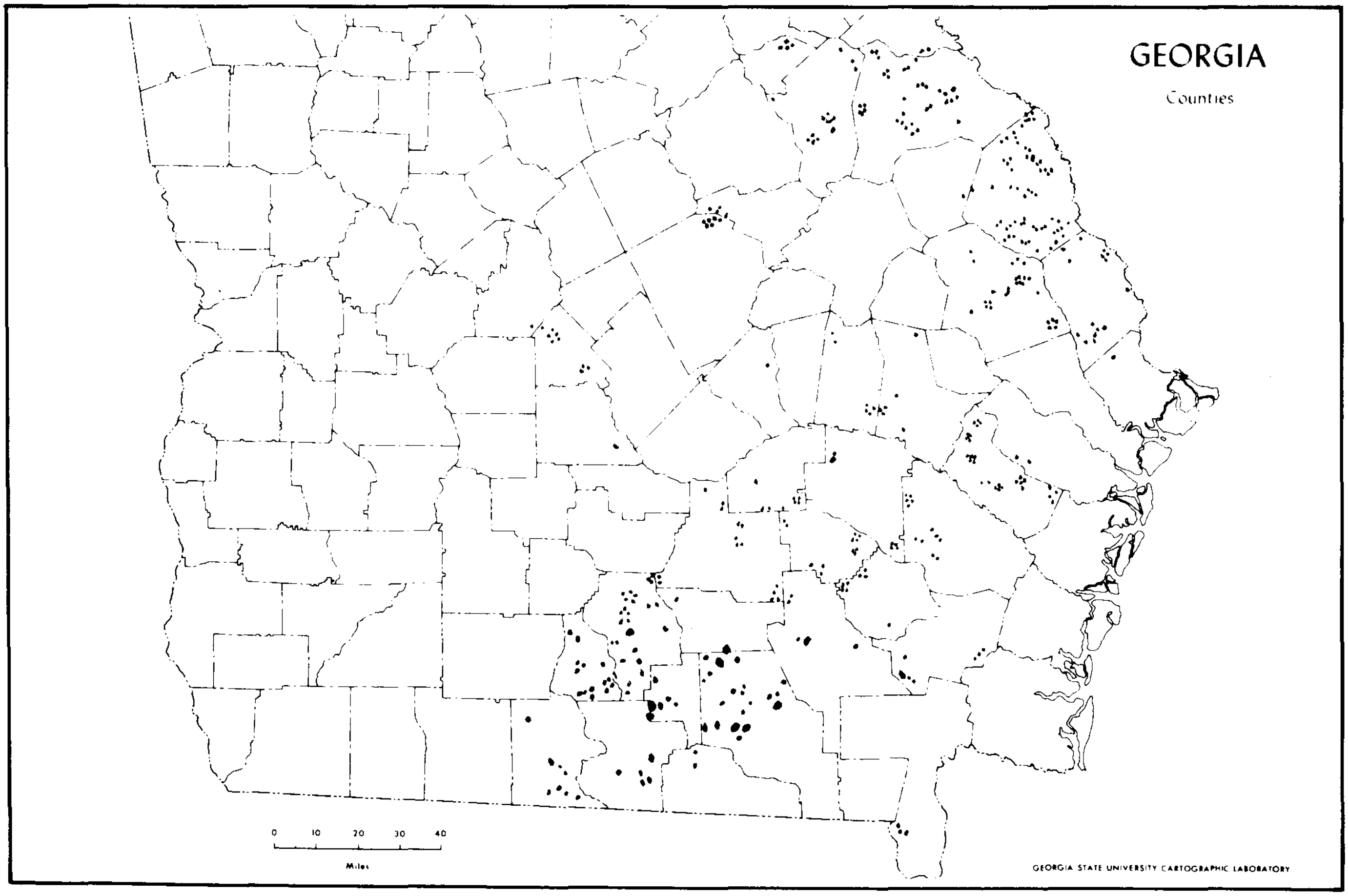


Fig. 14. The distribution of Carolina Bays in Georgia. All bays are enlarged approximately 2X. Data provided by S. Pickering, Geologic and Water Resources Division, Georgia Department of Natural Resources.

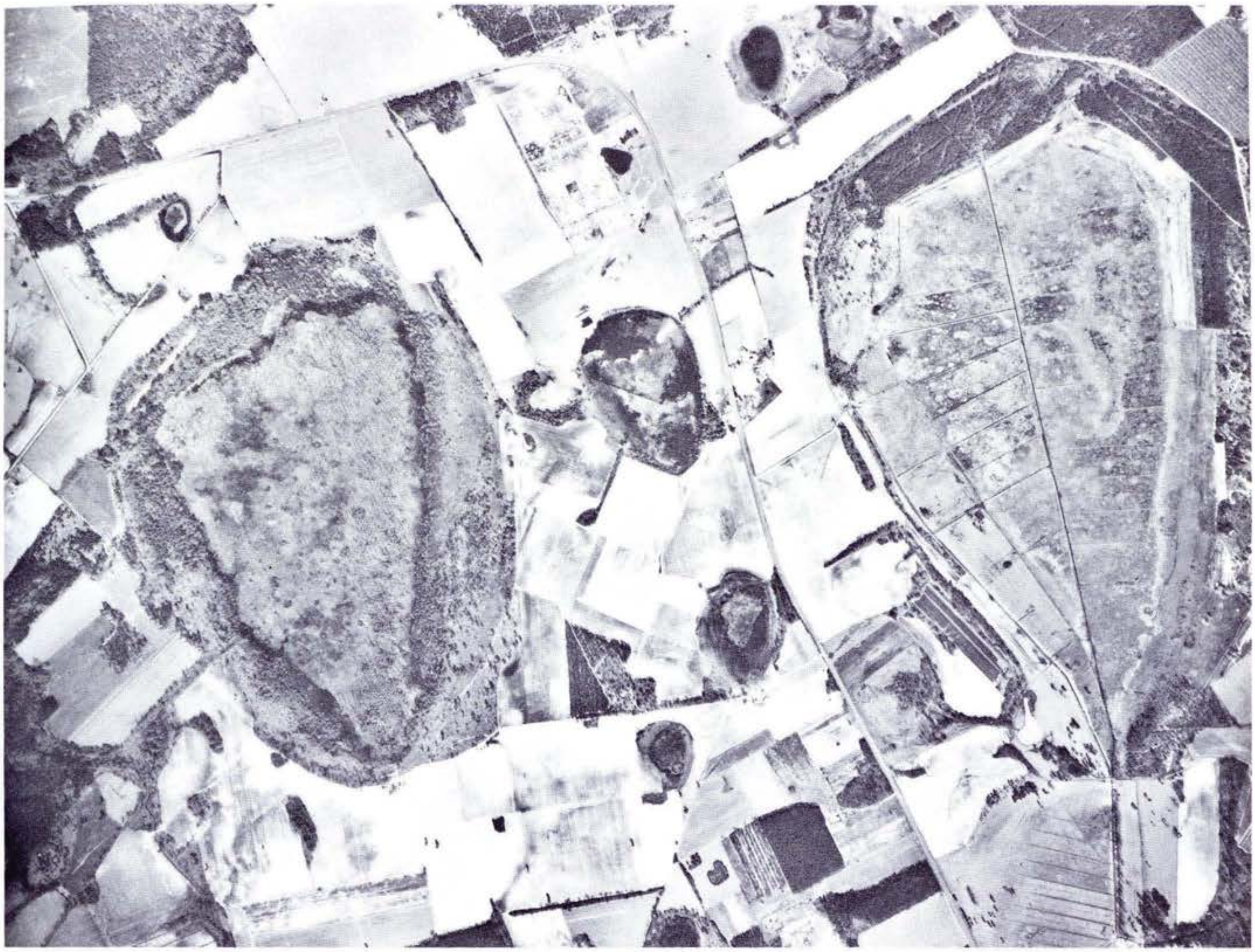

Photo X. Over 1,000 Carolina bays [28] covering 250,000 acres have been identified in Georgia's Coastal Plain. Carolina bays contain a variety of environments, such as cypress, shrub bog and Okefenokee-type vegetation all lumped into a designated wetland environment [28]. Photo courtesy S.M. Pickering, Geologic and Water Resource Division, Georgia Department of Natural Resources.

Some Carolina bays have areas of marsh, others contain shrub bogs, and others, with more or less permanent water have cypress forests. The category "Carolina bay" is somewhat artificial in that these depressions may contain several communities which I describe elsewhere as discrete natural environments.

Generally found in sandy terrain, Carolina bays have an elliptical or tear-drop shape, a NW-SE axis, and have raised sandy rims on the south and east edges. Many contend that they originated from a meteoric shower at a single time. Others, Thom (1967) and Whitehead (1973), believe that they were scooped out by gale force winds from the southwest during the last (Wisconsin) glaciation. Studies involving sedimentary strata, microfossils, and radiocarbon dating have shown North Carolina bays to be at least as old as the most recent Pleistocene glaciation. Wells and Boyce (1953) date them at 250,000 years. All seem to have a blue clay layer which may be due to wind-driven loess in Pleistocene times. Frey (1951 1955) has done extensive work on Carolina bays in the Coastal Plain of North Carolina. J.F Schalles and D.J. Shure (pers. comm.) indicate the presence of an impermeable clay lens beneath bays in Cretaceous sands, and indicate that of six bays studied, low water occurs from October through December with high water levels increasing depth 75% between December and August.

The waters are brown and acid, and tree growth may be slow. Pool *et al* (1972) report that some Carolina bays are not filling in, but are opening up to produce bay lakes within their margins. Generally speaking, Carolina bays are peat-filled depressions from 5 to 30 feet deep, Pool *et al* (1972). Physico-chemical data for six Carolina bays are given: color (ppm) 160-299, average pH about 4.75, and dissolved oxygen (ppm) 5.2-6.7 Johnson (1942) and Sciple (1967) review geology and origin.

### Flora

Kennedy's Pond, a large Carolina bay in Bulloch County was, according to John Bozeman (pers. comm.), formerly heavily forested with cypress and spring-fed. Developers had tried to create open water (by cutting cypress), and lots were sold around the margin. There was a fringe of blackgum (*Nyssa biflora*), a second zone of emergent grass-sedge with *Utricularia purpurea* as one dominant, and a third zone of submerged *Myriophyllum* Another Carolina bay Jones Pond in extreme NW Jenkins County near Big Dukes Bay was examined. The rim of Jones Pond bore a scrubby forest with red cedar black cherry and a few cherry laurel, then a wide zone of loblolly pine and sweet gum with many greenbriers (*Smilax* sp.). Finally towards the interior of the bay there was a moister zone with wax myrtle and red maple as cover and *Dryopteris virginica* as a common fern. Next was a zone dominated by the water willow (*Decodon verticillata*), with some lizard tail (*Saururus*), the bulrush (*Scirpus cyperinus*), and the giant plume grass (*Erianthus gigantea*). Scattered button bush was present; cypress and open water could be seen beyond the grass-rush zone. Characteristically, the pig frog, inhabitant of permanent water was calling.

Photo Y A spring-fed CAROLINA BAY [28], Kennedy's Pond, (Bulloch Co.) looking through a fringe of swamp black gum (*Nyssa biflora*). Much of the cypress in the deeper water was removed in order to "develop" the lake into a leisure community.

On the William Dopson farm (Telfair Co.) is an elliptical pond (Will T Pond) which appears to be a Carolina bay It contains no trees or shrubs, but an almost pure stand of maiden cane with several species of water lilies. The entire pond floor burned in the winter of 1958-59. This particular pond resembles the Okefenokee prairie. Fires periodically destroy peat accumulation in most bays.

Buell (1939, 1946) described the vegetation of peat-filled Carolina bays in North Carolina. He indicates that the buttressed bases of pond cypress become the nuclei for islands, colonized by pioneer shrubs (*Lyonia nitida,* titi, and summersweet clethra), along with a few trees.

Buell states that there is almost no herbaceous aquatic vegetation due to either the fluctuations or the organic opacity Buell (1946) said that sphagnum was present throughout and that pond pine (*Pinus serotina* and greenbrier (*Smilax laurifolia* were universally present. An EVERGREEN SHRUB BOG [33] occupies many peaty bays.

### Fauna

Distribution CP habitat H, drier ones with M and X elements. Appendix VI.

Frey (1951 published a list of the fishes collected from six Carolina bays in North Carolina. The most common fish were: redfin pickerel, chain pickerel, (D) lake chub sucker (D) yellow bullhead, (D) madtom, (*Schilbeodes mollis*), topminnow (*Fundulus dispar*), large mouth black bass, (D) warmouth, (D) blue-spotted sunfish, flier (D) yellow perch, and *Hololepis thermophilus*

No studies known to me have described other components of the Carolina bay fauna. It is probably similar to that of bay swamps and possibly cypress ponds.

Bennett, Gibbons, and Franson (1970) studied the movements of three turtle species, the mud turtle (*Kinosternon subrubrum*), the yellow-belly turtle, and the chicken turtle in Ellenton Bay (10 ha, and up to 2 m deep). One interesting result showed that mud turtles left the bay presumably when it dried up, walked up to 600 meters away and buried themselves 2 to 11 cm deep beneath sand or litter again pointing to the use of terrestrial environments by aquatic species and the importance of maintaining buffer zones of forest around ponds.

The larger Carolina bays, with their varied marsh and canopied habitats, are thus a mosaic of diverse plant and animal communities. In extreme south Georgia, those with permanent water could maintain colonies of round-tailed muskrat. Vertebrate diversity could be comparable to that of Payne's Prairie near Gainesville, Florida (the Great Alachua sink of Bartram) (numbers of species): Fish 17 Amphibians 8, Alligators 1 Turtles 5, Snakes 10, Lizards 4, Birds 66, Mammals 17

## Natural and Cultural Values

Carolina bays, along with cypress and gum ponds, are the major inland wetlands, apart from stream corridors. They provide refuge and watering areas for wildlife, wintering grounds for ducks, and nesting sites for a wide variety of birds and mammals. The relation of these natural reservoirs to the surrounding water table is unknown. Because of their incredible diversity and variety of biotic communities, their scientific and educational value is considerable. Grand Bay (Lowndes-Lanier Co.) is one of the largest bays known. Efforts should be made to preserve a wide spectrum of bay types.

## Man's Impact

Many Carolina bays, because they are shallow have been drained and planted to crops. Highways go through some; Big Dukes Pond has been developed. Only recently has satellite imagery enabled us to inventory the distribution of Carolina bays. Most have been heavily logged of their original timber

# [29] BAY SWAMPS

## Location and Description

This is wet-floored evergreen forest dominated by bay trees. Also called "bayheads," these units are mostly located in the Coastal Plain. They are flat, shallow areas on the heads of branches, in depressions in sandhills, and along the edges of floodplains where there is heavy groundwater seepage from adjacent slopes, often sandhills, Figure 15. The vegetation is predominantly evergreen, usually on a peaty soil which is seldom flooded, yet constantly wet, often with much sphagnum moss. A bayhead can be distinguished from a cypress pond by less standing water and an irregular surface that is often higher than the adjacent terrain (if in flat terrain); roots may be exposed and highly convoluted. The SHRUB BOG [33] is a closely related community.

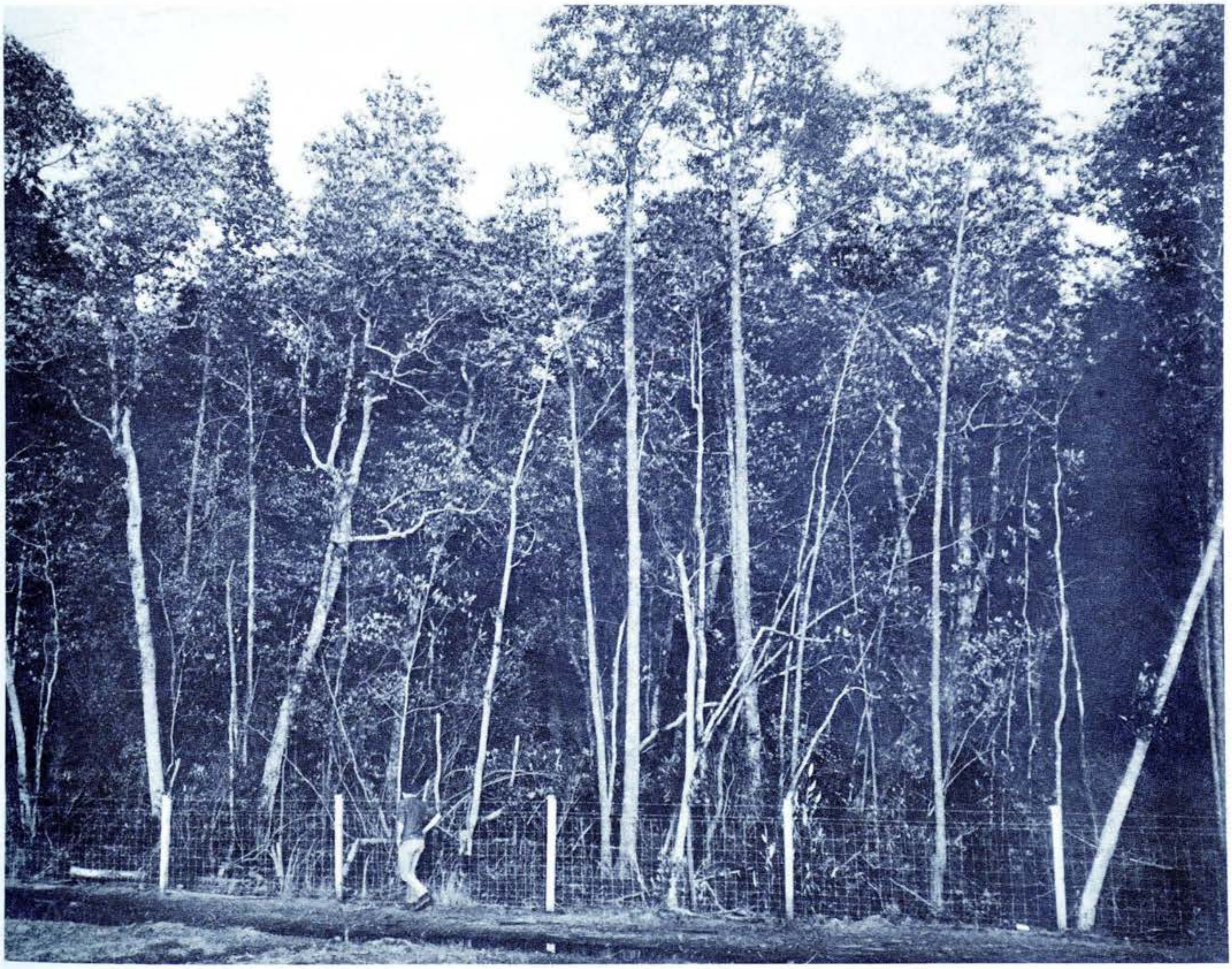

Photo Z. This typical BAY SWAMP [29], dominated by the sweet bay (*Magnolia virginiana*) and loblolly bay (*Gordonia lasianthus*), is located in the Ohoopee sandhills at the junction of I-16 and U.S. 1 in Emanuel County Bay swamps are comparatively rare environments and should be protected.

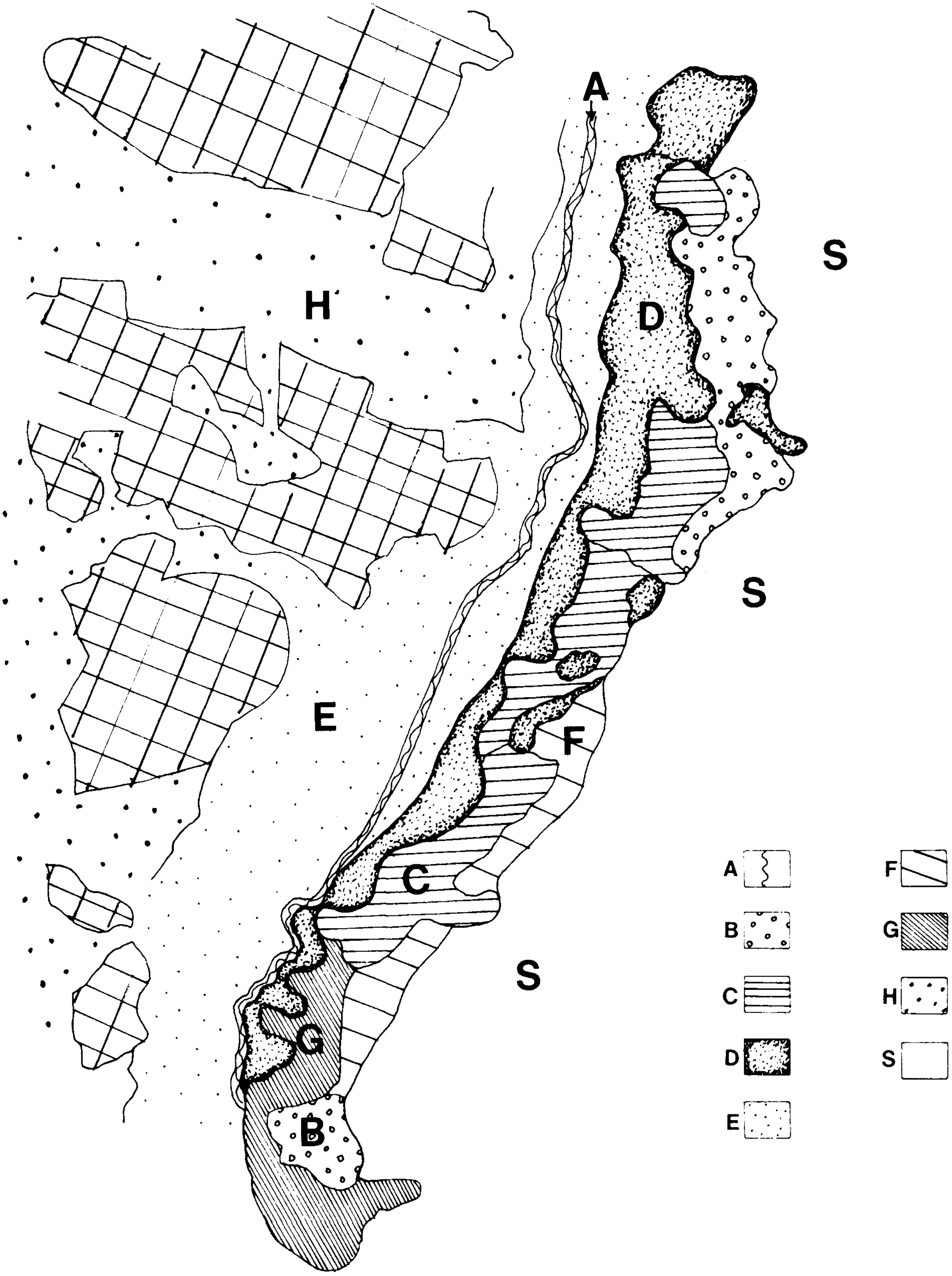


Fig. 15. Seventeen Mile Creek (Coffee County) presents a remarkable array of natural environments, including fine examples of BAY SWAMP and mature evergreen SHRUB BOG. Scale: ⅝ inch = 660 feet. North is at top of page. A. Creek, with cypress and ogeechee lime along banks. B. EVERGREEN SHRUB BOG [32], black titi (*Cliftonia*) dominant. C. BAY SWAMP [29], loblolly bay (*Gordonia*) dominant, sweet bay (*Magnolia virginiana*) sub-dominant. D. BAY SWAMP [29] with loglolly pine as dominant pine, (some slash and pond pine are present throughout C and D). E. CREEK SWAMP [8] - Water oak, black gum, sweet gum, red maple and sweet bay dominant. F. UPLAND BROADLEAF EVERGREEN FOREST [91], or hammock. G. Loblolly pine. H. Heavily logged pine - hardwood, S. Sandhill communities with DWARF OAK FOREST [85] dominant. Note that fields (diagonal squares) are all on the west side of the stream. The less fertile sandhills occur on the eastern side, a characteristic of many Coastal Plain streams.

In the Piedmont sweet bays may occur as subcanopy in alluvial stream swamps west of the Chattahoochee and on a few Ocmulgee headwater tributaries. The closest approximation to a true Piedmont bay swamp was probably approached in the "Villa Rica bogs" area (Carroll Co.). A spring seep hillside bog with peaty surface soil and numerous sweet bays was found in the Hurricane Creek ravine below Highway 5 (Douglas Co., see environment [34] ).

The most outstanding example that I have seen of a mature straight-boled bay swamp is contained within a 200-acre lowland bordering 17-Mile Creek in Coffee County, Figure 15. It is bordered by a bottomland forest along the creek, and on the up-slope by a large SHRUB BOG. The Whitewater Creek locality is in Taylor County, and the examples along it are outstanding for the presence of white cedar. An excellent example easily seen by car is on the east side of U.S. 1, a few yards south of its passage beneath I-16 (Emanuel Co.).

There is usually a surface layer of peat. I have seen bay swamps with nearly seven feet of peat (organic matter 41.0 to 98.0%). Monk indicates that, in many bays, because of fluctuations and oxygenation, there is considerable disintegration of organic matter which is incorporated with the inorganic soil to form what is termed colloquially "muck." Means of calcium, magnesium, milliequivalent of cations, pH, and depth of maximum flooding are lower in bayheads than in streams and river swamps. Bayhead soils are more sterile and more acid (3.5-4.0) than mixed swamps, but in quantities of nutrients Monk (1968) found that they exceeded southern mixed hardwood, cypress head, flatwoods, and sandhills. Table 7 relates bay swamp (bayhead) to the mixed swamp and the cypress pond in ppm of important minerals and moisture.

TABLE 7. A Comparison of Minerals and Moisture in Three Inland Wetlands, after Monk (1968).

| Community | Ca | Mg | K | P | Moisture |
|---|---|---|---|---|---|
| Mixed swamp (river swamp) | 8,131 | 2,958 | 174 | 75 | 37 |
| bayhead | 575 | 1,136 | 122 | 68 | 28 |
| cypress | 185 | 55 | 16 | 1 | 35 |

### Flora

Monk (1966, 1968) recognized the bayhead as a distinct plant community in northern Florida. The bayhead, in contrast to the river swamp (or mixed swamp), is characterized by evergreen species, and usually forms a surface layer of peat. Monk (1966) believed that bayheads were climax communities, and that some may be preceded by pond pine or cypress wetlands. Bay swamps may be analogous to Harper's "sandhill bogs." They are included in Penfound's (1952) "red bay-sweet bay community" under his classification heading of **peaty swamps**, with which he also classifies the evergreen shrub bog (*Ilex-Cyrilla-Zenobia*); his peaty swamps are defined as "oxybic, peat-forming, schlerophyllous woody communities, with surface water only during part of the growing season." Penfound states that peat formation in the *Tamala-Magnolia* community appears to be a prerequisite to the formation of both the white cedar and the evergreen shrub bog swamps. Fire is rare in these environments, usually on an interval of 50 to 150 years, Wharton *et al* (1956). Because of the bay's ability to stump-sprout following fire, the bay swamp has been considered one of Florida's oldest and most stable environments, Clewell (1971).

Monk states that the bay swamp is favored by fire protection but is replaced by white cedar after devastating surface fire. Following shallow peat burns, it may revert to pine swamp and with deep peat burns to cypress-gum swamp. With recurrent fire, the bay swamp, pond pine-slash pine wetlands, and the white cedar swamps may revert to the shrub bog. The bayheads and bay swamps may be related to the pocosins of the Carolinas, characterized by pond pine; *Woodwardia virginica* and sphagnum moss, Tilley (1973). Wells (1967) applies the name pocosin to the great evergreen shrub bogs of eastern North Carolina, such as Angola Bay.

Monk (1966) found 17 evergreen species in North Florida bayheads, 10 of 13 species found only in bayheads were evergreen. Monk indicated that bayheads are dominated by loblolly bay (*Gordonia lasianthus*), sweet bay (*Magnolia virginiana*), and swamp red bay (*Persea palustris*). He indicated that the understory is characterized by wax myrtle, *Leucothoe* and *Lyonia lucida*. Other important shrubs are Virginia Willow, the muscadine, and the ferns *Woodwardia virginica* and *Lorinseria areolata*.

An example of a creekside bay swamp community borders Whitewater Creek where Highway 137 crosses the south fork of the creek in Taylor County. Here in an almost idealized cross section is an overstory of loblolly bay (*Magnolia virginiana*) growing with white cedar (*Chamaecyparis*), with an understory of titi, fetterbush lyonia, fetterbush (*Leucothoe axillaris*), and *Azalea* sp. Immediately adjacent is a steep longleaf pine-turkey oak sandhill. Seepage from the deep sands is so strong that the road-fill forms it into a audible flow. On the opposite (south) side of the highway, the sphagnum beds are readily visible. Pond pines protrude from the bay overstory. At the north fork (the next bridge east) a more mature growth can be seen with larger cedars, although the area has been logged of many mature bay trees. The area of Whitewater and Cedar Creek (boundary Taylor and Schley counties) appears to be the only Georgia locality known for the white cedar. The relationship of the great sandhills here and this unique plant community needs further study. Parts could be called a **white cedar swamp** and classified as a separate environment.

Harper (1906) classifies 17-Mile Creek in Coffee County as a non-alluvial creek swamp. It is the best example of a mature bay forest that I have found, Figure 15. Although the 17-Mile Creek swamp is thoroughly inundated in winter, the high water apparently does not modify by deposition upon or removal of the thick peat substrate. Like some non-alluvial streams, it rises and falls rapidly.

The bay swamp is bordered on the east by extensive sandhills supporting a longleaf pine-turkey oak-wiregrass community. Immediately upslope of the bay forest is a wide zone of **evergreen shrub bog** dominated by black titi (*Cliftonia*) up to 6 inches in diameter. This zone apparently burns on a longer cycle than the zone between it and the outer edge near the sandhill where there are a number of shrubs, such as rusty black haw (*Lyonia ferruginea*), large gallberry (*Ilex coriacea*), fetterbush lyonia, and other shrubs which, because of fire, branch profusely and create an almost impenetrable thicket.

The bay swamp itself is a magnificent forest of mature loblolly bay (*Gordonia*), with varying percentages of sweet bay (*Magnolia virginiana*) and swamp red bay (*Persea*). The two dominant bays have tall straight trunks up to 15 inches DBH. The substrate is peat with many small depressions, filled with water or sphagnum moss. The bay tree roots are nearly exposed and are highly contorted.

The bay swamp of Lake Louise, Photo A1 south of Valdosta (see [35] LIMESINKS) is best classified here, although I am uncertain if it is a fluctuating water level ecosystem. The bay swamp border is crossed by a boardwalk built by Valdosta State staff, for whom the sink and environs provide a unique outdoor laboratory The peat layer is thick and more or less constantly wet. The dominant trees are loblolly bay red bay sweet bay swamp blackgum, and pond pine. Among the shrubs, the maleberry (*Lyonia ligustrina* here attains tree proportions. Other shrubs are wild olive, *Viburnum nudum, V cassinoides,* and *Ilex coriacea.* There are no cypress and no ogeechee lime.

Photo A1 A BAY SWAMP [29], with close affinity to an **Evergreen Shrub Bog** at Lake Louise (Lowndes Co.), occurs where the peat-forming, wet soil (note boardwalk) supports dense evergreen shrubs, overtopped with small sweet and red bays and pond pine (*Pinus serotina*).

The Virginia chain fern and cinnamon ferns are common so are the *Habenaria* orchids, yellow-eyed grasses (*Xyris*), and spider lilies. This environment has an affinity with the *shrub bog*

### Fauna

The fauna is CP habitat some H, but largely M. Appendix VI. Faunal records are scarce. The fauna should not be markedly different from that of branch and creek swamps. Study is essential. See Outten's (1969, 1973) collections at Lake Louise under *limesinks*

### Natural and Cultural Values

This is one of those rare and unusual environments which needs urgent inventory and protection. These areas have high educational and scientific value—recreational value is limited, although canoeing and trails are possible. Both 17-Mile Creek and Whitewater Creek are probably canoeable, and should be intriguing canoe trails. The Whitewater Creek varient of this environment, with its white cedars, is a scientific rarity Whitewater is reputed to be one of our most beautiful streams. Bay swamps act as small reservoirs, with the peat retaining large amounts of water Bay swamps might be better adapted at handling excess nutrients than cypress ponds, but may be more limited in handling excess water Wharton *et al* (1976). Some bays in north Florida support small sphagnum moss industries.

### Man's Impact

Logging will destroy this environment and already is doing so along Whitewater Creek, and at 17-Mile Creek. The bay trees may be cut for pulpwood, and landowners seldom recognize the value or rarity of mature bay swamp forest. Channelization or drainage would be equally devastating. Several truckloads of the magnificent bays along 17-Mile Creek have been sold to help pay taxes on the total holding of the owners. Tax relief is essential.

## [30] BOG SWAMP

### Location and Description

The Okefenokee is placed here because it is a huge, acid (4.2 pH), peat-filled bay-lake. It has two principal drains, the St. Marys and the Suwannee River. It is somewhat similar to the Florida Everglades in that it has sheet flow of water, hardly noticeable but nevertheless present.

According to U.S.G.S. quadrangles, the north end (123 feet M.S.L.) is three feet heigher than the camp Cornelia Canal. The SW coner at Billy's Like is 114 feet. There is thus a 9 foot head between King's Canal and the swamps at the sill dam below Billy's Lake. Water flow is roughly counter-clockwise (Fred Parrish, pers. comm.). The water currents divide at places and some currents apparently even flow northward. The sill which was built to stabilize water levels is 4-½ miles long, with a maximum elevation of 118 feet (above sea level). It has gates for run-off at slightly lower elevations. The average depth of the swamp to sand bottom is said to be about 10 feet. Summer surface water temperatures may reach as high as 37°C. The Okefenokee covers 412,000 acres of which 332,000 acres of swamp and 9,000 acres of peripheral uplands are included in the Okefenokee National Wildlife refuge.

Like many Carolina bays, Okefenokee is a mosaic of many habitats. It is possibly one of the best known natural areas in Georgia, largely due to the Cornell expeditions in the early part of this century. Prominent naturalists, such as the Wrights, S.C. Bishop, Francis Harper and others, participated in what was the first concerted biological reconnaissance in Georgia. Their numerous publications (Wright and Harper, 1913; Wright and Bishop, 1915; Wright, Funkhouser, and Bishop, 1915; Harper, F., 1927; and Wright and Wright, 1932) give us a reasonably thorough inventory of this resource, at least qualitatively.

A 12 foot canal dredged by the J.H. King family revealed cypress stumps, many of them charred, as deep as the dragline went. Hurt (1967) determined that pH varied between 4.2 (April-June) and 5.6 (February-March). Peat is 14 feet thick in Grand and Chase prairies, laid down at the rate of one inch every 53 years, G.S.A. (1974). Okefenokee supplies very acid water to the Suwannee River, with dissolved organic carbon up to 50 ppm, the loss to Okefenokee peat deposits being about 50 $g/m^2/yr$.

### Flora

The following is a synopsis of the major Okefenokee environments based upon the work and classification of Wright and Wright (1915), and Harper (1927).

### Island Habitats

**Pine Barrens**. Estimated to cover 80-90% of Floyd's, Bugaboo, Chesser's, Billy's, Honey and Black Jack islands. Four fifths are considered equivalent to Harper's "intermediate pine barrens" and one fifth his "dry pine barrens." There are some "oak ridges." Authors note the absence of saw palmetto and huckleberries (*Vaccinium* and *Gaylussacia*). The drier areas are distinguished by oaks with persimmon, chinkquapin, wiregrass, and bracken fern. Floyd's Island supports about four square miles of unique "sand scrub" (*Quercus chapmani, Q. geminata,* and *Q. myrtifolia*).

**Hardwood Hammock.** Limited to parts of the island—most Indian mounds were here—the dominant trees were live, water and laurel oak, southern magnolia, with wild olive, saw palmetto, "Poorgrub" (*Xolisma ferruginia*), and sparkleberry.

### Bog Habitats

**Cypress bay.** (Cypress forest) The presence of much peat distinguishes this from the average cypress pond. Cypress forest occupies all terrain that does not include gum or bay forest, sphagnum bog, prairie, island or open water.

It is considered that the sphagnum bogs and cypress forest comprise more than half of the entire swamp acreage. Tussocks often form about the cypress bases. The co-dominant trees are black gum, white bay, dahoon holly, loblolly bay, red bay, and red maple; the dominant shrubs (local names in quotes) are "hoorah bush" (*Lyonia nitida*), sweet bells leucothoe, "hehuckleberry" (*Lyonia phillyreifolia*), titi, "lather leaf" (*Clethra alnifolia*), huckleberry (*Vaccinium* sp.), and Virginia willow (*Itea*). The dominant grass-type plants are maidencane, *Carex glaucescens,* and *Dulichium arundinaceum.* Dominant herbs are sphagnum moss, "never wet" (*Orontium aquaticum*), virginia chain fern, and royal fern.

**Sphagnum bog.** These are usually located between the cypress bays and the prairies, sometimes called strands, i.e., Billy's Island Strand. They are also found around Honey, Black Jack and Floyd's Islands. Some examples are one mile in diameter. A few trees, slash pine, cypress, the three bays, and black gum grow scattered here, reminiscent of the **bay swamp**. The hoorah bush and the large gallberry (*Ilex coriacea*) are the major shrubs. The sphagnum mat supports herbs and ferns, such as *Anchistea virginica,* virginia chain fern, pitcher plants, woolgrass (*Eriophorum virginicum*), and the sundews (*Drosera* sp.). It might be added that, according to Wright and Wright (1932), "The Okefenokee Swamp, except for its islands, open 'prairies,' and water courses, is just one immense sphagnum bog or morass."

### Prairies

Prairies cover about 60,000 acres, Hurt (1967). These are simply shallow "marsh-ponds," lacking trees. They are distinctive Okefenokee habitats. Varying from one to three feet deep, they are traversed by alligator trails and boat "runs" which often follow alligator trails. The bottom is a brownish peat, and the outboard motor in these water trails ahead will stir up so much peat that it will clog the water intakes of motors behind. "Gator holes" are from three to eight feet deep and up to 30 feet in diameter. Here and there may be tree clumps, called prairie "heads" or "houses," where travellers often camp—they are drier than cypress bays. Between the islands and the prairie is generally a zone of maiden cane (*Panicum hemitomum*). The prairies are covered with white water lilies, floating hearts, spatterdock, "Wampee" (*Peltandra virginica*), hardhead (*Xyris* sp.), or orchids, such as *Calopogon pulchellus* and *Habenaria repens*, "firegrass" (*Drosera longifolia*), "colts-foot" (*Brasenia schreberi*), bladderworts (*Utricularia fibrosa* and *U. juncea*), the water plantains (*Sagittaria graminea* and *S. lancifolia*), and "button grass" (*Eriocaulon compressum*).

The total area of prairies is estimated by Harper (1972) at 140 square miles. They are situated chiefly in the eastern part, and are located where the underlying sand is farthest below the water level.

**Watercourses and Lakes.** There is comparatively limited open water, largely narrow prairie runs, often with a perceptible current. Lakes scarcely exceed ¼ mile diameter and are generally less than six feet deep. The lakes among the cypress bays differ from those in the prairies, varying from two to five miles in length and 25 to 100 yards in width. There is a gentle current in them, and they are among the few natural lakes in Georgia.

### Fauna

The fauna is CP, with habitats H, and X elements (a very little SX) on the islands within the swamp, Appendix VI. The following mammals are given in order of abundance for each habitat:

**Pine Barrens on Islands**—cotton rat, cotton mouse, evening bat (*Nycticeius humeralis*), seminole bat, pipistrelle bat, cottontail, red bat, flying squirrel, least shrew.

**Hardwood Hammock**—cotton mouse, cotton rat, seminole bat, gray squirrel, marsh rabbit, mole, flying squirrel, raccoon, big-eared bat, golden mouse.

**Cypress Bay**—cotton mouse, evening bat, seminole bat, wood rat, rice rat, gray squirrel, golden mouse, pipistrelle, big brown bat, raccoon, marsh rabbit.

**Sphagnum Bog**—Other than the marsh rabbit, little else is recorded for this habitat.

### Prairies

The only record of benthic fauna that I have found is by Hurt (1967). She found the most common invertebrates to be five species of oligochaete worms, five species of Arachnida, spiders, and mites, etc.; Cladocera and Copepods; the water beetle, *Dineutus* sp. (very abundant); chironomid fly larva (principally *Pentaneura* sp.); mayflies of the family Caenidae; water bugs (*Ranatra buenoi*) (very abundant); *Rhamphocorixa* sp., *Merragata* sp., *Mesovelia* sp., and *Pelocoris* sp. (moderately abundant); the caddis fly *Oxyethira* sp.; and the dragonfly *Erythemis* sp.

According to Fred Parrish (pers. comm.), the Okefenokee aquatic ecosystem is more productive than heretofore known. There is apparently a detritus-bacteria-plankton cycle based upon the proximity of the peat to the photosynthetic surface zone. Apparently, diatoms and filamentous algae are extremely common. Although Hurt did not report it common, Parrish indicates that the amphipod *Gammarus* is extremely abundant in certain areas, as is the shrimp, *Palaemonetes* sp. He indicates that the only mollusc he had found is a tiny, very abundant limpet (*Laevipex sp.*) attached to almost every subsurface substrate.

I have collected the vertebrate fauna of the prairies more intensively than any other portion of the Okefenokee, taking a rotenone sample of fish from the same 'gator hole for seven years (1963, 1966-1970, 1973), with the kind support of John King, senior and junior and, later, the U.S. Fish and Wildlife Service.

In the following list, the most abundant fish are indicated (A), and those that are common (C) in the prairie runs and 'gator holes. (Most of the larger fish, especially bass, escaped during the sampling process. We took only one sizeable bass in seven years): (A) yellow bullhead, golden shiner, (A) starhead top-mimmow, (A) ocellated killifish, (A) pirate perch, (A) mosquito fish, brook silverside, (C) banded pygmy sunfish, (C) flier, (A) blue-spotted sunfish, blackbanded sunfish (rare), (A) bluegill, banded sunfish, pumpkin seed, (C) warmouth, black crappie (rare), (C) black bass, swamp darter, (C) bowfin, (C) redfin pickerel, (C) chain pickerel, (C) lake chubsucker.

A sweep of the dip net in the prairies will likely yield the three most common species: starhead topminnow, mosquitofish, and ocellated killifish. These make good aquarium species.

In the prairies, the most abundant small amphibian is the dwarf salamander (*Manculus*). The dominant large salamanders are the great siren and the two-toed amphiuma. The pig, bronze and the cricket frog appear to be the most common frogs in the prairie. The green tree frog appears in grassy and brushy areas along canals and islands.

The most common reptiles are the Florida banded water snake (*Natrix sipedon pictiventris*), the ribbon snake, the cottonmouth, the Florida soft-shell turtle (*Trionyx ferox*), and the alligator. We have, oddly, taken the 5-lined skink (*Eumeces inexpectatus*) on small cypress in the middle of prairie areas.

The Red-winged Blackbird is the most common bird overall. The following are considered common species by the Fish and Wildlife Service (Refuge leaflet 181-R3, July 1969): Pied-Billed Grebe, Anhinga, Great Blue Heron, Little Blue Heron, Cattle Egret, Common Egret, Black-crowned Night Heron, White Ibis, Wood Ibis, Mallard, Black Duck, Green-winged Teal, Wood Duck, Ringnecked Duck, Hooded Merganser, Turkey Vulture, Black Vulture, Yellow-shafted Flicker, Pileated Woodpecker, Red-bellied Woodpecker, Downy Woodpecker, Western Kingbird, Crested Flycatcher, Wood Pewee, Barn Swallow, Fish Crow, Blue Jay, Tufted Titmouse, Brown-headed Nuthatch, Carolina Wren, Mockingbird, Catbird, Brown Thrasher, Bluebird, Red-shouldered Hawk, Sparrow Hawk, Sandhill Crane, American Coot, Barred Owl, Chuckwills Widow, Night Hawk, Chimney Swift, Ruby-crowned Kinglet, Loggerhead Shrike, White-eyed Vireo, Prothonotary Warbler, Parula Warbler, Yellow-throated Warbler, Pine Warbler, Palm Warbler, Red-winged Blackbird, Common Grackle, Cardinal, Towhee, Bachman's Sparrow, White-throated Sparrow, Swamp Sparrow, and Song Sparrow.

Hebard (1941) records the last specimen of the Ivory-billed Woodpecker killed on Craven Island in March, 1912, but states that there are reliable records on Minnie Lake islands as late as 1924. He also observed the bird on the Camden-Charlton County line four times in 1935 and 1936.

The most common mammals of the prairie are the rice rat and Allen's water rat or round-tailed muskrat (*Neofiber alleni*), which builds dome-shaped grass houses on the prairie, as well as feeding platforms. They are miniature muskrats—there are no true muskrats in the southern Coastal Plain. Harper (1972) records the historical evidence of beaver in the Okefenokee and Trail Ridge area, but apparently the animals were extirpated by man.

Around the swamp edge on the islands, along the spoil bank of canals and on the prairie heads, one finds the rather rare Florida wood rat (*Neotoma floridana*), an attractive, docile wild rodent which assembles piles of sticks and food objects up to several bushel baskets full by logs or stumps. For years they nested beneath the floor of an old shack on the east side of King's Canal (now Kingfisher Landing), near the main canal fork. Otters are common along the canal. Oddly, no mink are recorded from the Okefenokee. The swamp was one of the last refuges for the black or Florida wolf (*Canis floridanus*) last recorded in 1908, although there was evidence of wolves until 1918, Harper (1927). The last Florida cougar (*Felis coryi*) was observed about 1916.

The rarest of Okefenokee mammals is the star-nosed mole (*Condylura cristata*). Only two specimens have been recorded from the swamp—one furnished to Francis Harper in 1921 by Lem Griffis and the other taken while seining near Billy's Lake by James D. Satterfield, and now in the Georgia State Vertebrate Collection. The only other Georgia specimen is a 1915 record from Marlow, Effingham County. Either the Okefenokee is a refuge with a disjunct population or the animal ranges down the coast of Georgia and has somehow not been taken in between.

### Natural and Cultural Values

Although the cypress of the Okefenokee has been almost completely logged and none of the majestic mature forest remains, the swamp's primary advantages are its size and undeveloped wild character. Essentially, only the prairies remain unmodified. The major advantage of 300,000 acres is the possibility of remoteness from the sights and sounds of the civilized world. The outboard motor (even less than 10 hp) is still a disruptive influence. The canoe trails and camping platforms provide the possibility of 3 to 7 day trips under semi-wilderness conditions. The recreational and educational advantages are great. I have taken classes there for 12 years. The advantage is in experiencing this environment, not that the life there is remarkable—perhaps only two vertebrates, the round-tailed muskrat and the star-nosed mole, are seldom found elsewhere in Georgia.

### Man's Impact

The canal at Camp Cornelia attests the attempt to drain the Okefenokee into the St. Marys. Camp Cornelia Canal was built in the early 1890's by the Georgia and Suwannee Land and Canal Company. It extends 12 miles to Billy's Bay, west of Chase Prairie. It was excavated originally to be 45 feet wide and six feet deep. This canal was cut through most, but not all, of Trail Ridge (with banks 35 feet high). Intended to drain the swamp, construction ceased when water flowed the wrong way, Hebard (1941). Had they continued cutting down, the swamp might have been drained since the St. Marys lies at a considerably lower elevation. The swamp was purchased in 1901, conveyed to Hebard Lumber Company in 1904, and the timber was leased to the Hebard Cypress Company in 1909. The canal was used in floating logs out, Harper (1927).

Most of the heavy cypress timber was formerly found from the western border to Chase Prairie and from Floyd's Island Prairie to Honey Island. The greater part was cut between 1907 and 1927 by the Hebard Cypress Company, which had a camp on Billy's Island of over 100 men. The company used narrow gauge railroads with piles driven down to mineral soil or laid crosswise on a "floating" bed. The old logging railroad lines are plotted on the new U.S.G.S. quadrangles of the swamp. These maps also indicate the proportion of open prairie and wooded (either gum or cypress) terrain, actually circumscribing four types of communities apparently visible from aerial photographs.

A sub-leasee, the Pine Plume Lumber Company, cut the pine on most of the islands. When logging rights were conveyed to the Hebard Lumber Company on December 31, 1926, all the large stands of cypress had been cut except Dinner Pond and all the virgin pine except on Chesser and Bugaboo islands. All of the Bugaboo and part of the Chesser pine was destroyed by the great fire of April 1932, as was the major part of the great body of gum timber in the northwestern part of the swamp, Hebard (1941).

Most of the larger islands were turpentined and later logged of their virgin pine by 1924. The greater part of the evergreen oak hammocks of Chesser's and Billy's islands were cleared away by 1900, and put under cultivation, along with small portions of Mixon's, Hickory and Floyd's islands. Hogs and cattle roamed the islands of the swamp for 100 years. Railroading and timber cutting began on Floyd's Island about 1923—it had supported a magnificent growth of magnolia and live oak up to this time, Harper (1927). In the early 20's families lived on Chesser's and Billy's islands. For a detailed history of the Okefenokee back to 1900, see John M. Hopkins, **Forty-five years with the Okefenokee Swamp** 1900-1945, Bulletin No. 4, Georgia Society of Naturalists.

A possible long-term disruption of the natural ecological forces at work in the swamp has been the construction of a sill (low dam) at the outlet of the swamp into the Suwannee River. The sill holds water levels above a minimum. Some ecologists feel that this will prevent the periodic peat burns by which fire creates and maintains the open prairies and lakes, thus preventing succession to closed-canopy cypress and gum forest. Game and Fish biologists have determined that undesirable predatory fish, such as the bowfin, go over the sill in spring seeking to spawn, and are prevented from returning to the swamp, building up populations of these fish in the Suwannee River to the detriment of game species, such as bass. Lightning-caused fire has always been a natural process in the Okefenokee. It has been shown that there is more lightning in the vicinity of the Okefenokee than in any other region of Georgia.

The abundant peat and peat moss (sphagnum) has attracted attention as an economic resource. The King Canal was draglined from a barge by John King of Waycross who went into the peat moss business briefly, but found it uneconomical. A large drying shed was built at Kingfisher Landing. The old logging railway parallels this canal, and was used by local peat moss gatherers who piled the sphagnum in john-boats and transported it to high ground on a small flat-bed rail car.

Other efforts to exploit the swamp have consisted of fishing camps, boat rental, alligator poaching, frog gigging (done commercially from airboat), and airboat rides for tourists. Oil rights have been paid by oil companies for many years to certain private owners of the swamp.

### Introduction to Cypress Savannah and Herb (Pitcher Plant) Bogs

Herb or pitcher plant bogs (grass-sedge savannahs) in the Coastal Plain and cypress savannah communities (and possibly pond-pine savannahs) have many floral species with undergound adaptations (corms and other subterranean food storage devices) that allow them to survive fire. These are natural wildflower gardens. The plants do not bloom simultaneously, but stagger their floral displays in sequence throughout the growing season. Because of the twin dangers of fire-control and drainage, these environments are becoming rare and the most highly threatened. Keeping fire out permits shrubs, such as gallberry, and trees, such as Virginia bay and black gum, to move in, eliminating the herbaceous plants. Many authors have remarked on these habitats but, by far, the most intriguing account is by Wells (1967), who also refers to them as the savannah lands. Eastern North Carolina has extensive areas, but much is being purchased by industry and, with massive drainage, being converted to truck gardens. Following drainage in the peaty areas, there is much loss of soil structure by drying and shrinking, fire, and other hazards. the remarkable pitcher plants are also threatened by commercial and amateur diggers who sell them for curiosities. Several other species of insectivorous plants occupy this unique habitat.

## [31] CYPRESS SAVANNAH

### Location and Description

This environment, first recognized as prominent in Georgia by John Bozemen, is thought to be the counterpart of Well's (1967) extensive grass-sedge savannahs of the North Carolina Coastal Plain. It is possible that Georgia has grass-sedge savannahs, but none have been indicated to me. Wells states that they are found as "flat uplands of low relief," essentially a wet grassland with scattered pines. Cypress savannahs are found in the flat Pleistocene (lower Coastal Plain) of Georgia and may be quite similar to Monk's (1968) pond-pine phase. Pond-pine savannah would be similar to cypress savannah, but with less of a hydroperiod. This is relatively common environment throughout the areas of wetter Pleistocene terrain.

### Flora

**Trees:** Pond Cypress.
**Shrubs:** Shrub layer generally absent. Young black gum and red maple may be present.
**Herbs:** Hooded Pitcher Plant (*Sarracenia minor*), orchids (*Habenaria* sp.), lilies (*Lilium* sp.), as well as many grasses and sedges.

### Fauna

Distribution: CP; habitat—Chiefly SH but may be invaded by elements of M and H, especially during periods of high water in spring and early summer. Some amphibians may breed (temporary water breeders) and reptiles, such as the cottonmouth, corn and king snake, may make overland forays through the area. Wading birds may feed in the inundated areas—waterfowl may do so in the winter.

This area burns frequently enough to keep shrubs and hardwood trees out.

### Natural and Cultural Values

These natural wetlands are important in water table maintenance, and are shallow aquifer recharge areas. They provide feeding grounds for wading birds and reptiles, and breeding grounds for amphibians. While not as spectacular as the pitcher plant bogs, this community has a sequence of flowering, including lilies and orchids, that it shares in common with the Tifton Upland. Bozeman (pers. comm.) has stated that this environment is the closest counterpart to the extensive grass-sedge savannahs described by Wells (1967) for the North Carolina Pleistocene.

### Man's Impact

This environment is even more vulnerable than cypress ponds and will be drained and planted to slash pine by the wood-using industries as rapidly as possible, as soon as they have completed conversion of **mesic pine lowland** (pond and slash pine lowlands).

## [32] HERB BOGS (PITCHER PLANT BOGS)

### Location and Description

Herb bogs are found in low swales or depressions in the pine uplands of the Tifton Upland and Tallahassee Hills. They occur as openings in pine forest with stunted, scattered pines, Photo A2. The erect trumpets of the pitcher plants are conspicuous. They are kept moist by seepage. In the sequential blooming of this natural wild flower garden, this community is similar to a miniature version of the grass-sedge savannah, Wells (1967). Similar to the cypress savannah, this environment would be included in Harper's (1906) "moist pine barrens." Because of the presence of the distinctive pitcher plants, these communities are almost universally known as "pitcher plant bogs."

Photo A2. A pitcher plant or HERB BOG [32] (Bulloch Co.) is characterized by pitcher plant "trumpets" extending up through the grasses, sedges, and other plants. A large clump of rose gentian (*Sabatia* occupies the center foreground. The heads of stargrass (*Aletris*), lily, hatpins (*Eriocaulon*), and hardhead (*Xyris*), are visible. In the spring especially there are more beautiful wild flowers here than in any other Coastal Plain environment.

Examples are: West side state road #1 1 mile S of Oak Park (Treutlen Co.); 2.3 miles E of railroad depot E of Lyons (Toombs Co.); 2.1 miles W of Alamo (Wheeler Co.); N side of U.S. 280 at intersection with Ga. 149; intersection of Ben Hill and Irwin Co. at Willacoochee River Ocilla (Irwin Co.); 1.8 miles SE of Alapaha River near Irwin-Berrien Co. line (Tift Co.); approx. 6 miles SW of Statesboro between Lotts and Little Lotts Creek (Bulloch Co.); 8 miles NW of Moultrie, E of Highway 133 (Colquitt Co.) 5 miles NE of Cordele on south side of unnumbered state road (Crisp Co.).

Soil is kept moist by lateral seepage. Surface soil may become dry in the fall (September and October are critical months for bog species of plants and animals). Water gradient extends 100 feet into surrounding upland pine areas. Plummer (1963) compared the soils of the moist and intermediate pine barrens. Soils of the pitcher plant bogs had the following characteristics: surface layers very organic, over-all nutrient levels low (inconsistent with the dense plant cover in the wet season); low in potassium, calcium, and magnesium; uniformly acid; productivity keyed to low mineral supply, with gradual decrease in nutrients from April through September Found on Hyatt, Rains, Plummer Bladen, and Rutledge soils. Soils in a bog on Greenwood plantation had pH of 4.5. In Florida, two types of bogs are recognized, a hillside seepage type and a flatlands type. The water table is at or near the surface in both. There is often, in north Florida, a subsurface impermeable clay layer Because they are usually sandy and lack a peat layer herb bogs become arid and burn on a 3-8 year cycle (sometimes more often), Wharton *et al* (1976).

### Flora

Clewell (1971 recognized herb bogs (which he calls "savannah") on clay-rich alluvial soils indicated by a composite (*Verbescina warei*) and on sandy soils indicated by a rush-featherling (*Pleea tenuifolia*). In panhandle Florida, a woody hypericum (*H. fasciculatum* may form a shrub-like overstory in herb bogs not frequently burned. Wiregrass, beak rushes, panic grasses, and sedges occur as ground cover

**Crisp County Bog**

**Trees** Slash Pine.

**Shrubs** A suppressed growth of wax myrtle, dwarfed blackgum, and gallberry

**Herbs** Meadow beauty (*Rhexia* sp.), seed box (*Ludwigia* sp.), fringed orchids (*Habenaria nivea*), (*H. ciliata*), Barbara's buttons (*Marshallia graminifolium*), club moss (*Lycopodium flabelliforme*), parrot pitcher plant (*Sarracenia psittacina*), trumpet pitcher plant (*Sarracenia flava*).

A small bog at Greenwood Plantation in virgin longleaf pine had a few pitcher plants, but a large assortment of other species:

**Trees** longleaf pine.

**Shrubs** Dwarfed red maple, dwarfed sweet bay

**Herbs** - Grasspink orchid (*Calypogon pulchellus*), rose pogonia (*Pogonia ophioglossoides*), fringed orchids (4-5 spp.), rose orchid (*Cleistes divaricata*), ladies' tresses orchid (*Spiranthes* spp.), sticky tofieldia (*Tofieldia racemosa*), swamp thoroughwort (*Eupatorium pilosum*), hooded pitcher plant (*Sarracenia minor*), pink meadow beauty (*Rhexia alaphanus*), sedge (*Scleria* sp.), yellow-eyed grass (*Xyris* sp.), orange grass (*Ctenium aromaticum*).

A **Bulloch County Bog**, Photo A2, has the following plant dominants:

**Trees** - Slash pine (originally longleaf).

**Shrubs** - None (unless fire kept out).

**Herbs** - Yellow meadow beauty (*Rhexia lutea*), pink meadow beauty, hooded pitcher plant, trumpet pitcher plant, hat pins (*Eriocaulon* spp.), Catesby's lily (*Lillium Catesbei*), sticky tofieldia, yellow-eyed grass, stargrass (*Aletris aurea*), beak rushes (*Rhynchospora*, 6, sp.), wiregrass (*Aristida, Sporobolis*).

A **Colquitt County Bog** had the following flora:

**Trees** - Slash pine.

**Shrubs** - dwarfed sweet bay.

**Herbs** - pink meadow beauty, sticky tofieldia, Barbara's buttons, yellow-eyed grasses (*Xyris ambigua, X. difformis, X. scabrifolia*, more or less restricted to this habitat), Colic root or stargrass (*Aletris aurea, A. lutea, A. obovata*), sabatia (*Sabatia macrophylla*, especially in pitcher plant bogs), *Condrophora nudata* (this sp. in bogs only), trumpet pitcher plant*, hooded pitcher plant, parrot pitcher plant*, slender club moss (*Lycopodium carolinianum*), and featherstem club moss (*L. prostratum*).

It is evident from scanning these lists that some species consistently occur in these bogs. Some, such as the trumpet and parrot pitchers, the yellow-eyed grass (*Xyris scabrifolia*), the meadow beauty (*Sabatia macrophylla*), and rayless goldenrod (*Condrophora nudata*), seem restricted to these bogs. I have never seen the weird, carnivorous dew threads (*Drosera filiformis*) elsewhere.

### Fauna

Crayfish and earthworms are abundant, Plummer (1963). Distribution CP, Habitat - probably SH with intrusion of SX elements periodically, Appendix VI.

### Fire

These bogs are generally fall fire-prone and burn regularly on a 3-8 year cycle. Some bogs are habitually burned by fishermen who "grunt" earthworms there.

### Natural and Cultural Values

The pitcher plants, orchids, and lilies of this community could become botanical rarities. There may be endemic species found here. A fringed orchid, *Platanthera* (*Habenaria*) *integra* which occurs in some bogs, is on the federal endangered species list, Leo T. Barber, Jr. (pers. comm.). The community mineral cycling is dependent on the plant and animal components. Hydrologically, these areas may act as moisture reservoirs. Apart from the lilies, such as *Lillium Catesbei* and the orchids, the presence of the following insect-eating plants: pitcher plants (six species), sundews (four species, one the remarkable filiform variety), and the butterworts, make this a fascinating habitat.

Esthetically, this is one of south Georgia's most beautiful environments. The floral displays (including those of rare lilies and orchids) are both extensive and sequential, from early spring through fall. As an outdoor laboratory, this is a superlative teaching adjunct for school systems at all levels. Apalachicola National Forest officials have begun regularly burning "herb bogs," identifying Clewell's *Pleea* and *Verbescina* types with signs for public education.

### Man's Impact

Only a few scattered examples of this once more widespread environment remain. Major threats are suppression by man of recurrent fire allowing plant succession, ditching and draining for better pasturage, and site preparation for planting pine by industry. Another threat is posed by root diggers (seeking the lilies and orchids) and those who dig the pitcher plants (for sale commercially or for home use by amateurs). Wilbur Duncan (pers. comm.) has estimated that pitcher plant bogs have been reduced to 1/50th of their former abundance in 35 years. Three dealers in Wilmington, N.C., wholesale insectivorous plants, and others have wholesale-retail outlets which are in Maine (1), New York (1), and California (2). These plants rarely live long after their purchase.

## [33] SHRUB BOG

### Location and Description

Largely confined to the Tifton Upland; found commonly in Carolina bays; along the drier edge of bay swamps; or forming a ring around **Cypress Ponds**, but in the latter habitats, species diversity is low. These communities develop on certain downslopes protected from fire, usually at the base of Miocene clay ridges, or sandhills. This environment was defined by Wells (1976) as flat upland with fluctuating water table, and a dense growth of head-high evergreen shrubs of many species. Trees present are in dwarf

* According to Bozeman (pers. comm.) largely confined to this environment.

form. The high diversity type has the aspect of an impenetrable thicket, photo A3, with a few dwarfed bay trees and scattered pines. Inundation is highly transitory but the peat layers retain much moisture. The low diversity type presents a weird picture of black, twisted trunks from 4 to 8 inches in diameter

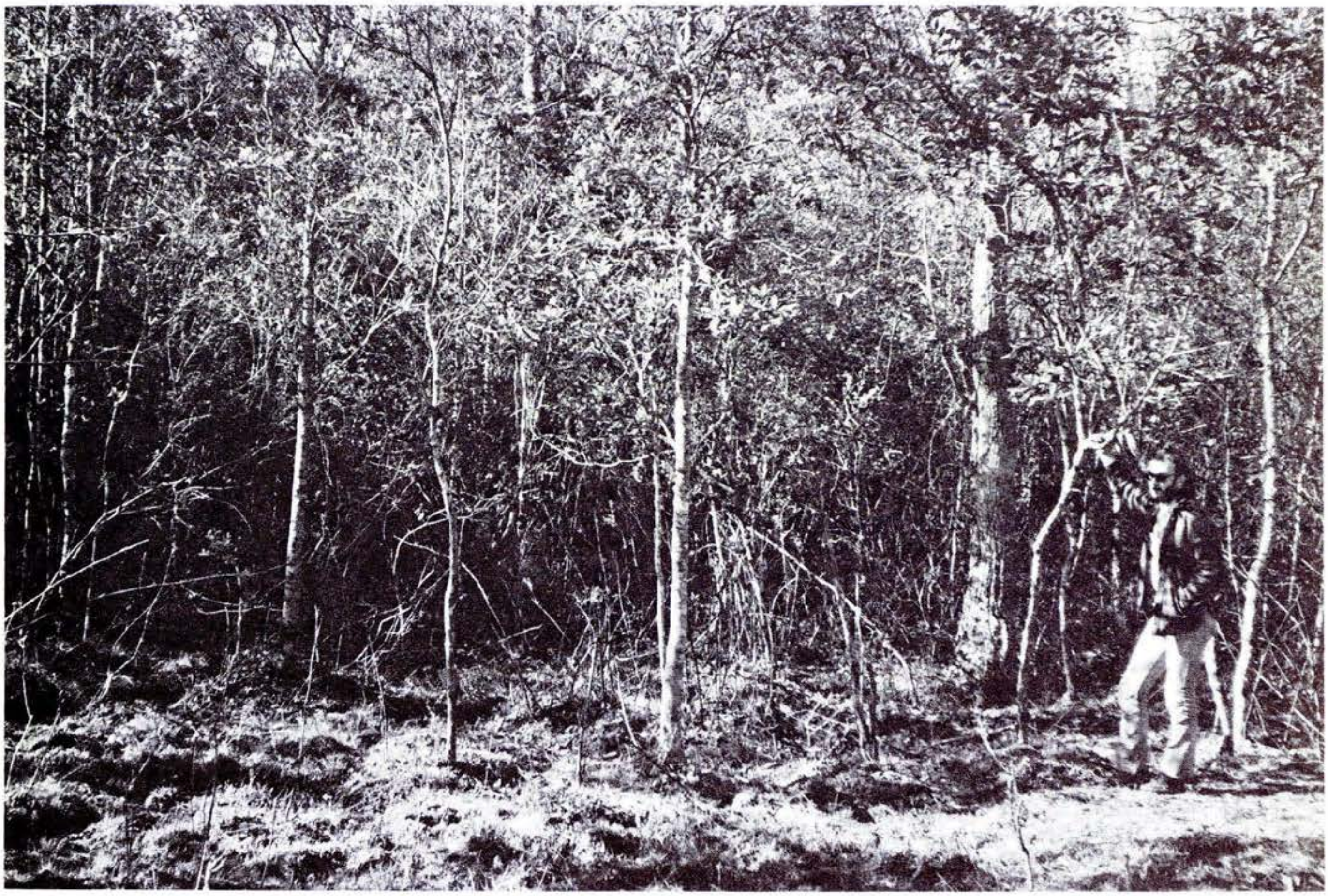

Photo A3. This SHRUB BOG [33] is carpeted with sphagnum moss and is located in the Ohoopee sandhills just east of the Highway 152 bridge in Tattnall County Good examples of this environment are rare. Shrub bogs are closely related to the "pocosin" bogs of the Carolinas, and they are dominated by evergreen shrubs.

Examples are: a small area near lake at Reid Bingham State Park (Cook Co.); I-16 bog, 2.8 miles NW of Ogeechee River (Bryan Co.)· 17-Mile Creek bog (Coffee Co.); Ohoopee bog, 1.4 miles E of Ohoopee River Highway 152, S. side.

Soils are either mineral or peaty (Wells, 1967), usually underlain by non-draining, sticky subsoil. The community is water-logged for long periods during the wet season, and is moderately dry during the dry season. Radford (1974) recognizes a **short shrub** on peat and a **tall shrub** (at bog margins), perhaps on less peaty soil. Monk (1965) notes tendency of soils to be low in calcium, potassium, phosphorus, and moisture equivalent. Plant species must be tolerant of saturated acid soils. A shallow peat layer may accumulate in some, Faircloth (pers. comm.).

#### Flora

**Trees** Pond pine (stunted); dwarfed sweet bay· dwarfed loblolly bay· dwarfed red maple (*Acer rubrum*); dwarfed red bay

**Shrubs** (High diversity shrub bog) (D) Cliftonia or black titi (*Cliftonia monophylla*), (D) titi. Co-dominant shrubs: fetterbush lyonia (*Lyonia ligustrina*), rusty black haw (*Lyonia ferruginea*), odorless wax myrtle (*Myrica inodora*), possum haw (*Viburnum nudum*), cinnamon clethra (*Clethra alnifolia*), American holly (*Ilex americana*), sweet bells (*Leucothoe racemosa*), coast leucothoe (*Leucothoe axillaris*), dwarf laurel (*Kalmia hirsuta*, in openings), huckleberry (*Gaylusacchia* sp.), blueberry (*Vaccinium* sp.), swamp azalea (*Rhododendron viscosum*), Virginia willow, Red chokeberry (*Sorbus arbutifolia*), tag alder (*Alnus serrulata*).

**Herbs** Laurel greenbrier (*Smilax laurifolia*), bracken fern, Virginia chain fern (*Anchistea virginica*), deer tongue (in openings), cinnamon fern.

In the wet ecotone with the upslope pineland, there was pinckneya (*Pinckneya pubens* and saw palmetto. The low diversity type is generally composed of a single species, either black titi (*Cliftonia* or titi.

#### Fauna

The fauna of this environment has not been studied to my knowledge. Distribution CP· the habitat probably has elements os SH, SX, and M, Appendix VI.

### Fire

The high diversity shrub bog is swept by fire irregularly (in dry years). Radford (1974) states that the pocosin shrub bog seldom goes five years without burning. Successional stage following severe fires is to grass-sedge savannah. Fire may die out in the moist litter, or these areas are isolated from fire by water. Thicket aspect is due to shoot growth because fire burns the tops but not the roots and stumps. Some authors feel the **bay swamp** and pond-pine-slash pine areas will revert to this community with recurrent fire. On the other hand, Monk and others indicate that with less fire the shrub bog will succeed to **bay swamp**.

High diversity shrub bogs burn on a 3 to 8 year cycle, while the low diversity types dominated by single species, such as balck titi, burn on a long cycle basis, probably 20-50 years, Wharton *et al* (1976). At 17-Mile Creek there is little evidence that the mature black titi bog is in succession towards bay forest. It appears to be a stable community.

### Remarks

The largest shrub bogs seen by the author total about 100 acres along 17-Mile Creek in Coffee County, positioned between a bay swamp and sandhill terrain where the gradient is low. As one approaches the outer (sandhill) edge of the low diversity shrub bog, dominated by large examples of black titi (*Cliftonia monophylla*), the titi becomes smaller and denser, and the community grades into high diversity bog where fire is more frequent. Where the gradient is steep adjacent to the bay swamp, the shrub bog appears absent—the environment changes abruptly to **upland broadleaf evergreen forest** or hammock.

Another example of this comminity is bisected by I-16 exactly 2.3 miles west of the Ogeechee River (or 2.2 miles west of the railroad bridge). Huge specimens of the black titi or buckwheat tree, six inches in diameter, form a thick subcanopy beneath the pond pines. Other noticeable shrubs are deciduous holly, titi, and fetterbush (*Lyonia*), with dwarfed red and sweet bays. The bog floor is spongy and is downslope from a low grade.

Not many good examples of this interesting habitat can be found, both the frequency of occurrence is low and the size of the habitat is small, approximating the pitcher plant bog in these regards. Faircloth records only five sites in his study area, two in Ben Hill Co., one in Cook, one in Turner, and one in Tift; all are in the Tifton Upland.

Before longleaf pine was logged out and replaced by slash pine, the latter was apparently found naturally only in bog areas, Clewell (pers. comm.). The appearance of some wetland environments is indicated by Figure 16.

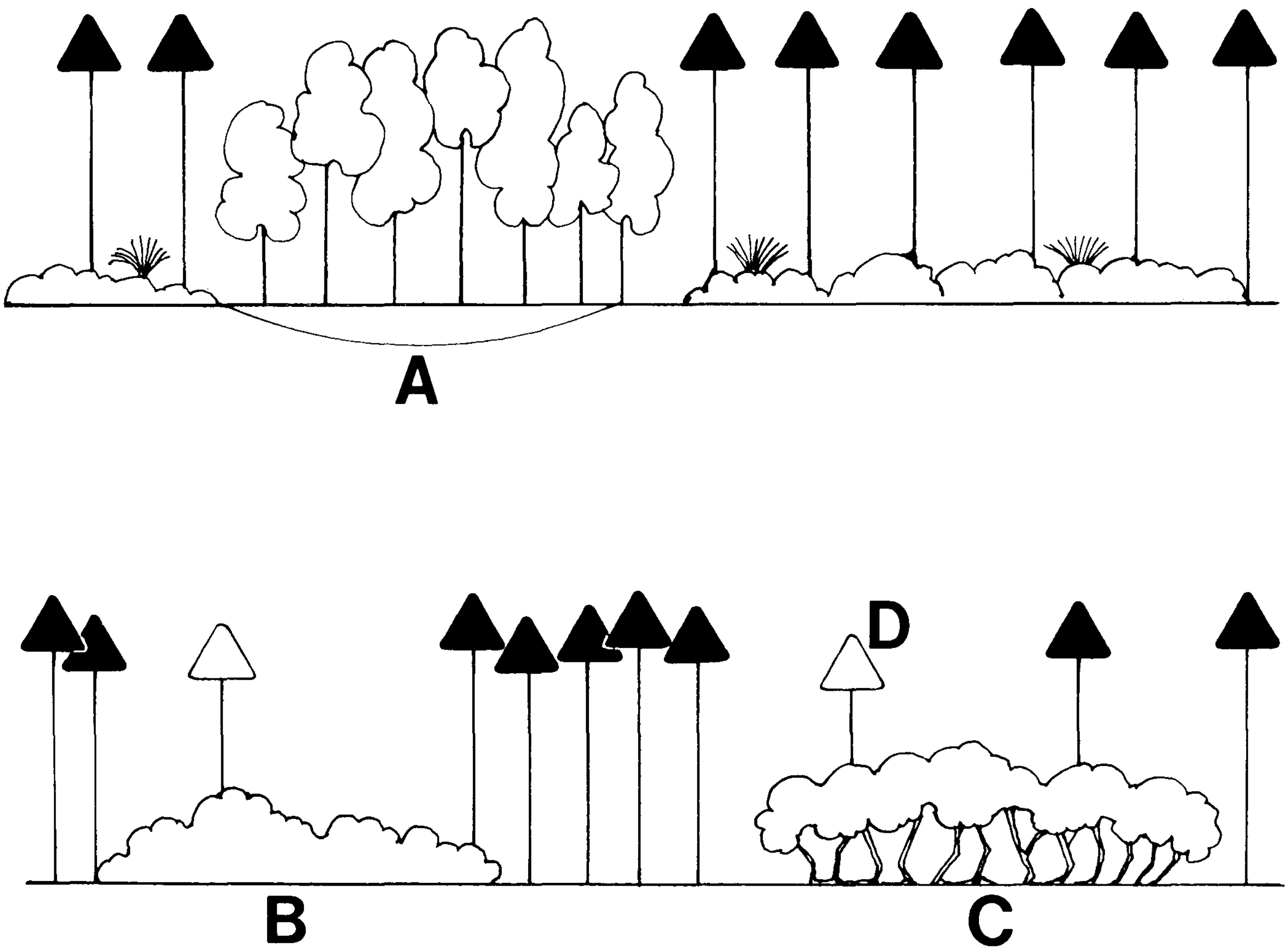


Fig. 16. Appearance of some wetland environments: (A) bay swamp [29] in slash pine flatwoods [94]; (B) shrub bog (high diversity type) [33]; (C) shrub bog (low diversity type [33]; (D) pond pine (*Pinus serotina*) may be present.

## Natural and Cultural Values

While they have values to education and science, the peat layers hold much water and the areas provide cover and food for wildlife. Titi (*Cyrilla*) is a major deer food in the Coastal Plain (up to 65% of diet). Peat layers are also effective buffers against fire encroaching on bay swamps, creek swamps, and shrub bogs. Sometimes shrub bogs lend landscape diversity, There is a bewildering array of shrubs, some medicinally and otherwise important. The low diversity type presents a weird, but fascinating environment which can be walked through with relative ease. These are peat-forming systems and, as such, conserve moisture.

## Man's Impact

(See remarks above)

# [34] MOUNTAIN AND PIEDMONT BOGS; SPRING SEEP

## Location and Description

These are perhaps our rarest mountain and Piedmont environments. Only a few are known. They occur at the heads of valleys where seeps and springs keep the soil more or less constantly wet Some have sphagnum moss (often a foot deep), others a grass-sedge cover or a shrub cover—rarely a tree canopy. Most have a black, organic-rich soil. The "Villa Rica bogs" were over a dense, sticky clay along small streams that may not have flooded their bottomlands annually. The Piedmont spring seep community is well developed in the Brevard Fault Zone, appearing on the side of thin soil ridges, often quartzite-capped.

## Flora

In the mountains, some very rare plant species occur in these bogs. The pitcher plant (*Sarracenia purpurea*) may or may not be present. In the Rabun Bald bog, bog laurel (*Kalmia angustifolia*) and the swamp-pink (*Helonias bullata*) occurred. Cotton grass (*Eriophorum*) is another boreal species which occurs in North Carolina bogs very near the Georgia line. Pitcher plants and bog laurel occur in the Oaky Mountain bog (Habersham Co.). Mountain bogs may have a rhododendron, mountain laurel or alder shrub canopy. A shrub-dominant bog, resembling a Coastal Plain high diversity [33] SHRUB BOG, occurs on Heddon Creek (Rabun Co.) at nearly 2900 feet. Dominant shrubs are black and red chokeberries (*Sorbus melanocarpa* and *S. arbutifolia*), swamp azalea (*Rhododendron viscosum*), maleberry (*Lyonia ligustrina*), and alder. Dwarfed black gum is common, as is *Viburnum cassinoides*. Silky willow (*Salix sericea*) occurs in wetter places, along with royal and cinnamon ferns, turtlehead (*Chelone cuthbertii*) and abundant sphagnum moss. The tiny creek does not appear to flood.

No existing Piedmont bogs have been found. Roland Harper and others described bogs near Villa Rica (Carroll Co.), probably along Bay Springs Creek. These bogs may have contained pitcher plants (probably *Sarracenia rubra*), associated with some Coastal Plain sedges and other species. Bay Spings Creek bog sites (Bruce Boyd property) were bulldozed and converted to pasture in 1954. Present bog remnants nearby contain hardhead (*Xyris* sp.), *Eryngium integrifolium*, boneset (*Eupatorium perfoliatum*), monkey flower (*Mimulus ringens*) and storax (*Styrax americana*).*

Excellent examples of the **Piedmont spring seep community** occur in the Brevard Fault Zone (followed by the Chattahoochee River). The **tree** canopy is mesic hardwood forest dominated by white oak, beech, tulip poplar, unbrella and bigleaf magnolia and, sometimes, sweet bay (hillside bog, Hurricane Creek, Douglas Co.). Shrubs and herbs are more distinctive. **Shrubs** are (D) Virginia willow, (D) *Viburnum nudum* and spicebush. Herbs are: (D) royal fern, (D) cinnamon fern, lady fern, (D) foamflower (*Tiarella cordifolia* var. *collina*), and orchid (*Habenaria clavellata*), (D) soapwort gentian (*Gentiana saponaria*), (D) cowbane (*Oxypolis rigidior*), turtlehead (*Chelone glabra*), (D) climbing hydrangea, jack-in-the-pulpit, and grass of parnassus (*Parnassia asarifolia*). The seep periphery often supports New York Fern and small chain fern (*Woodwardia areolata*).

## Fauna

Little is known of the fauna. Specific species of crayfish may occur. In the mountains, bog-associated boreal vertebrates should occur such as the endangered bog turtle (*Clemmys muhlenbergii*) and bog lemming (*Synaptomys cooperi*). I have taken short-tail shrews and pine voles in runway systems in sphagnum bogs on the Tallalah River floodplain (Towns Co.). Distribution - MT; habitat - largely X but with possible elements of XB - such as the bog lemming. The invertebrate fauna is probably unique.

## Natural and Cultural Values

Obviously, these small, exciting environments are biotic treasures to be preserved at all costs for their scientific and educational value. They often contain rare and endangered species. They provide much needed diversity.

## Man's Impact

Both plants and animals are extremely vulnerable and can be eradicated by collecters, such as bulb-diggers, curiosity-seekers, or over-indulgent professors with their botanical classes. Water levels of a Rabun Mountain bog (Rabun Co.) were dropped by ditching in

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* Reference in Rhodora (Aug. 1957) to bogs 1.3 miles W. Villa Rica; there is 1977 report of Carroll Co. bog with 3 sp. *Habenaria*. Rhodora also lists Coastal Plain species in Douglas Co. bogs: *Eleocharis baldwinii, Bulbostylus ciliatifolia, Rhynchospora filifolia, R. ciliaris* and *R. microcarpa,* Marie Mellinger (pers. comm.).

adjacent fields, thus eliminating the pitcher plants. Most bogs have been completely eliminated by ditch or tile drainage, as on the head of Hick's Creek (Rabun Co.). Fire or the cutting of the shrub overstory would favor herb bog species such as pitcher plants. Most if not all Piedmont bogs were eliminated by bulldozer or drainage between 1945-1960. Because of their extreme rarity pitcher plant bogs should be reported to Department of Natural Resources or Georgia Botanical Society

## [35] LIMESINKS

### Location and Description

Limesinks occur in regions underlain by limestone rock or dolomite. Generally, they are confined to the **Limesink Region** (Dougherty Plain) and **Valdosta Limesink Region**. Some occur in the Tallahassee Hills. Major aquifer recharge of the principal (Ocala) aquifer takes place in these areas. Limesinks also occur along the top of the Pelham escarpment. They come in many shapes and depths, but are generally round; some are shafts with sheer walls. One 12-foot limesink suddenly appeared in front of a tractor plowing a field in Crisp County Ponds in regions where limestone is the basement rock must be suspected of being sinks with their drain holes plugged. The **earth pit** has vertical walls of earth. One in Veteran's Memorial State Park (which has several types), Photo A4, was 10 feet in diameter and about 10 feet deep with absolutely sheer walls, a pit trap in which we found two mud turtles (*Kinosternon*) and a large cooter (*Pseudemys floridana*). Other examples are "the sinks" between Sandersville and Tennille (Washington Co.).

Photo A4. This is a permanent water LIMESINK [35] at Veterans Memorial State Park (Crisp Co.). A wide variety of sinks of all sizes and hydrologic regimes are present here on the edge of the Flint River floodplain (now Lake Blackshear).

According to Stoddard (1955) there are, on Mill Pond Plantation near Thomasville (Thomas Co.), deep gorges through clay hills leading to large and spectacular sinks in the Ward's Creek Watershed. Two miles east is Sinkola Plantation, named for its sink holes. It has two sinks which are 100 feet apart, one containing water 75% of the time, the other dry 99% of the time.

Some sinks, such as Lake Louise at Valdosta, are spingfed, permanent water sinks.

Sinks are formed by the collapse of the roof of underground caverns dissolved out of solid limestone by subsurface streams and seepages. They are of all ages. Those with permanent water may accumulate enormous layers of peat. Watts (1971) found peat layers alternating with silts and clays for a depth of 51 feet (1,570 cm) below water surface (water depth 19.3 ft). An age of > 49,000 B.P was obtained from the sediments lying between 1248-1253 cm.

Many sinks hold water for a while, then go dry Lake Iamonia near Thomasville drained naturally in 1910, 1917 and 1938; then it was artificially plugged and, according to Stoddard (1955), has now deteriorated in productivity It was formerly flooded by 20-foot rises of the Ocklochnee River but this natural mineral delivery system has also been blocked by man. Some limesink lakes remain in meadow a year or more before refilling. Stoddard (ibid) suggests that more sink holes appeared following the heavy rains of 1948 than during a century of normal rainfall.

The majority of sinks have fluctuating water levels and are classified in this category Where sinks are common, the terrain is known as karst topography

Another type of sink near Valdosta, approximately 200 yards in diameter had a connection with the Withlacoochee River This sink remains full of water in winter and spring, but gets low enough in summer to see the limestone rocks around the drain hole. With this amplitude of fluctuation, no aquatic plants can survive. Huge clumps of water elm (*Planera aquatica* were the dominant shoreline vegetation. Mayhaw and *Sebastiana* were common shrubs. The periphery of this sink is quite similar to the bank of a non-alluvial stream.

The "sinks" in Washington County are deep limesinks. In some places, there are caves. Streams in this area disappear underground and reappear—this frequently happens also in the Dougherty Plain. The Alapaha and other streams disappear in the limestone area south of Valdosta. Where I-75 crosses the Alapaha in northern Florida, you can frequently walk down a bone-dry stream bed; the root systems of cypress form fantastic arrays. Sam Pickering indicates that, in the area of Washington County sinks, fossil vertebrate material (whale, shark, manatee) is common.

**Flora**

One Mile Pond in Crisp County (an old limesink) is a shallow, permanent cypress pond with white water lily (*Nymphaea odorata* and butterwort (*Utricularia radiata*). There were scattered button bush and two dominant pond grasses, *Scirpus eriophorum* and *Sacciolepis striata*.

Lake Louise, a permanent water sink, has a surface area of four hectares (160 feet above MSL). It is a peat-filled sink (see geology above) and has a **bay swamp** on one side, a predominantly evergreen forest contrasting with the deciduous forests surrounding most other sinks.

Photo A5. This LIMESINK [35] in the Valdosta Limesink Region (Lowndes Co.) is a shallow pond dominated by white water lilies (*Nymphaea odorata*) with butterwort (*Utricularia radiata*), and a few isolated swamp black gum.

### Fauna

The fauna is CP, habitat H, varyingly depauperate, Appendix VI. The fauna of limesinks is poorly known. The Withlacoochee Sink (see *flora* above) is connected at high water to the river. Fishermen seine it at low water. Masses of hundreds of large black Ranid tadpoles cruise the shore of this sink. Such environments are ideal for some permanent water breeders with one year cycles. Another limesink on Highway 221 is a stable water level sink, and belongs in the same category as spring-fed sinks. This sink had a four foot layer of recent peat, lilies, and a zone of sedges, water willow, and button bush around the edge. Some sinks and sink lakes have their fish fauna restored by high water from adjacent rivers.

Between 1968 and 1973, Outten (1969, 1973) collected at Lake Louise and obtained the following vertebrates: mosquitofish (*Gambusia affinis holbrooki*), least killifish (*Heterandria formosa*), warmouth, bluegill (*Lepomis machrochirus purpurescens*), spotted sunfish, largemouth bass, black crappie, scalyhead darter (*Etheostoma fusiforme*), mole salamander, newt (*Notophalmus viridescens louisianensis*), cricket frog (*Acris gryllus dorsalis*), green treefrog, spring peeper (*Hyla crucifer bartramiana*), barking frog, river frog, leopard frog (*Rana pipiens sphenocephala*), and green anole.

### Natural and Cultural Values

The limesinks, because of their variety and type, are a diverse and valuable resource. Many apparently funnel water to recharge underground aquifers. Others collect rainwater and act as reservoirs or ponds, creating the landscape diversity necessary for a spectrum of plant and animal food chains in an otherwise monotonous terrain, largely agricultural, since limestone soils are markedly fertile and usually flat. Sinks are generally readily visible from the air and can be thus inventoried. They may be confused with Carolina Bays, but the latter have an oriented longitudinal axis and occur in non-sink country (i.e., Tifton Upland, Pleistocene sea floor). Where sinks occur, the bulk of stream drainage is underground—these streams later emerging as artesian wells or springs. Some sinks, such as Waterfall Sink and others, especially on the Pelham escarpment, connect to extensive underground caverns and are regularly "caved" by youth groups. Non-fluctuating water level sinks can maintain fish populations, and are used by a variety of wildlife. Fluctuating water level sinks are sought by some animals (toads, some tree frogs, and many salamanders) for breeding, since they cannot breed in sinks with permanent water (largely due to predation). Sinks make excellent outdoor laboratories; they undergo algae "blooms" and demonstrate other cyclic manifestations of life—maintaining a surprisingly diverse fauna. Waterfowl and many birds and mammals use them. They are oases in an agricultural world. Larger permanent water limesink lakes are surrounded by a pleasant forest of very old live and laurel oaks.

### Man's Impact

Limesinks can contaminate underground aquifers, since almost all surface run-off goes into them, Sam Pickering (pers. comm.). Agricultural surface run-off is thus a danger. Occasionally, sinks are dynamited to close or open their drainage. Some are used as trash dumps. They are easily polluted, and many occur within the city limits. The shores of the larger sink lakes with permanent water, such as Twin Lakes south of Valdosta, are rapidly being developed for homesites. Very few, if any, large sinks remain undeveloped.

## [36] SAGPONDS

### Location and Description

These are modified limesink ponds occuring in parts of the Great Valley region of NW Georgia. They can have numerous terrain features. Greear (1967) found 53 ponds varying from a few feet in diameter to several acres in extent within about one square mile of Bartow County, Photo A6. Many sagponds are connected by a dendritic pattern of surface drainage during the wet season. There are also upland sinks on Lookout and Pigeon mountains, and some go seasonally dry. Watts (1975) describes the vegetation of an ancient pond on Pigeon Mountain (630 m. elev.) called Pigeon Marsh.

### Geology and Hydrology

Sagponds occur in the Paleozoic region of NW Georgia in zones of Knox dolomite overlain with a great thickness (100-300 ft) of weathered parent material, including angular chert pebbles and boulders. Although there are indications that some of the ponds may date back to the Eocene, William Watts (pers. comm.) states that the ponds are probably formed during the Wisconsin glaciation—postglacial deposition being limited to the top several inches. Ponds have a floor of sapropelic silt (gyttja). A sand aquifer was encountered at 23 m below Little Pelfrey Pond. Greear feels that sagponds are formed by the slump of the thick residuum, due to groundwater percolation having created solution chambers far below in the parent dolomite.

Greear (1967) studied 12 sagponds extensively, and classified his ponds into the **dry sag type** (no sapropel) where surface water disappears within hour after rainfall, **young pond type** (thin sapropel) filling from winter and spring rains; **mature pond type** (sapropel nearly filling slump pit) - nine meters of silt will hold water the year around; and the **extinct pond type** (sapropel completely fills slump pit). Some water levels fall at the traditional time, July - October (Little Pelfrey); some fall later, August - December (C.B. Pond). Greear found that the quicker sagponds drained, the less nitrogen their soils contained; also more nitrogen appeared to be related to the greater production of organic matter in the more permanent ponds; potassium and phosphorus were deficient, calcium was variable, but greatest in the tree and grass zones where it was probably concentrated by leaf fall; pH values varied slightly, ranging from 4.59 in the heath zone of one pond to 5.77 in the *Carex* zone of another. Greear found that soil differences would not account for the various vegetation zones; hydroperiod factors seemed to override climatic and edaphic factors.

Photo A6. A nearly-dry SAG POND[36] in the **Great Valley** (Bartow Co.). Swollen-based swamp black gums are the most common trees, and buttonbush (*Cephalanthus*) is a common shrub (behind figure). Alternate wet and drying cycles make this a fluctuating water level ecosystem.

### Flora

Cyclic variations in water levels were considered by Greear to provide an environment to which some Coastal Plain flora was adapted. The remarkable feature of the sagponds reported by Greear is the presence of 24 species of vascular plants previously reported only from the Coastal Plain, 25 other species usually associated with the Coastal Plain but not previously reported from NW Georgia, and 22 additional species having affinities with Coastal Plain flora. Six plant species have northern affinities. These 24 Coastal Plain plants include a joint grass (*Manisuris rugosa*), several panic grasses, an *Eleocharis* some beaked rushes, several *Carex* one *Xyris* one *Juncus* a blue-eyed grass, laurel oak (largely Coastal Plain), a haw, a sticktite, a pea, gallberry (*Ilex glabra* (in the fetterbush zone of one pond), a rockrose (*Helianthemum*), a violet, fetterbush (*Lyonia lucida*), a *Sabatia* a *Lycopus, Oldenlandia* nine lobelias, and a goldenrod.

The zonation of vegetation of a mature pond is approximately· open water-emergent shrub (button bush); aquatic hardwood (swamp blackgum); grass-sedge-*Smilax walteri* zone; heath zone (fetterbush) pine (loblolly) zone. Zonation of a permanent water sagpond is given in Figure 17

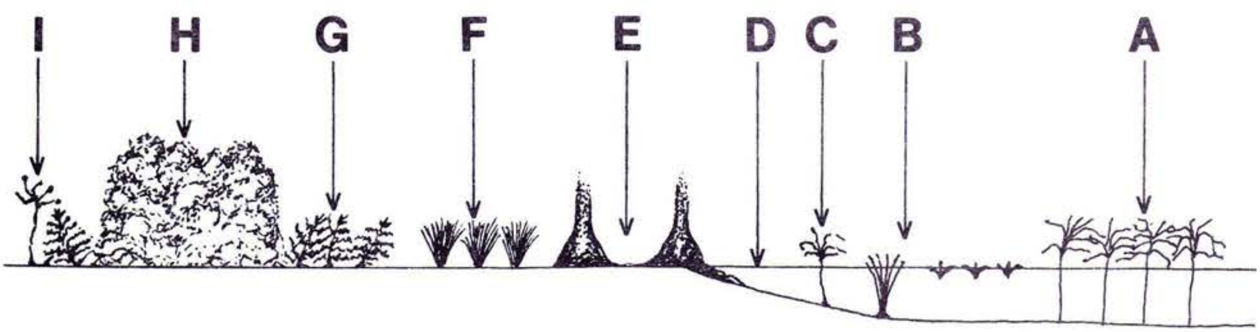



Fig. 17 Profile of one-half of a permanent water sag pond (Quicksand Pond, Bartow Co.). (A) deepwater emergent shrub zone (button bush); (B) open water zone (with the emergent *Glyceria pallida*, and *Potomogeton pulcher* and *Utricularia biflora*); (C) shallow water emergent shrub zone (button bush); (D) open water zone; (E) aquatic hardwood zone (swamp black gum); (F) grass-sedge zone (with *Carex glaucescens, Dulichium arundinaceum, Proserpinaca palustris*); (G) fern zone (*Woodwardia virginica* dominant with *Anchistea virginica* and royal fern); (H) marginal heath zone (fetterbush, *Lyonia lucida* dominant, with red maple and greenbrier *Smilax laurifolia*); (I) outer ecotone with forest (*Rhododendron canescens* as a shrub, bracken fern and the moss, *Polytrichum commune*).

Greear classified his ponds into types (dominants listed):

**Prepond type** - Dogwood and southern red oak.

**Quercus phellos - Erianthus strictus** type - *E. strictus* and *Panicum virgatum,* the dominant herbs.

**Cephalanthus-Nyssa-Lyonia-Acer type.** Most ponds fall in this category, but differ from each other. For example, *Carex glaucescens* represents a developmental change from the basic type, while *Gyceria pallida* in deep water and the fern *Anchistea virginica* and moss *Polytrichum commini* near the margin represent further evolution. The most fully developed Quicksand Pond has *Potamogeton pulcher* in deep water, and *Dulichium arundinaceum* and *Smilax laurifolia* in the marginal vegetaion.

The moisture-loving willow oak is a pond margin species—red maple, fetterbush, and black chokeberry (*Sorbus melanocarpa*) grow around ponds that remain full during the active growing season (April - August). Greear found that fetterbush (*Lyonia lucida*) roots apparently require saturation or near-saturation during part of the growing season. Black gum (*Nyssa biflora*) occurs only in ponds with water through spring and early summer, its buttressed base apparently requiring inundation; he found it unsuccessful with the growing season depth < 25-40 cm. He found the perennial aquatic *Proserpinaca palustria* and the bladderwort (*Utricularia biflora*) to grow where the water fluctuation was 50 cm. He did not find the cat-brier (*Smilax laurifolia*), the gentian (*Gentiana catesbei*), or the sedge (*Dulichium arundinaceum*), where fluctuations were > 60 cm.

### Fauna

The fauna is CV, habitat H for some, invaded peripherally by M and X elements, Appendix VI. The fauna of the sagponds is poorly known. Martien and Benke (1976) found two minute crustaceans (the isopod *Asellus obtusus* and the amphipod *Crangonyx gracilis*) to be the predominant animals on the bottom and in algae mats. Greear indicates the presence of mosquitofish (*Gambusia*) in some ponds. Since some Coosa corridor species range into Georgia, I believe a number of Coastal Plain forms will be found associated with the sagponds. Ray Siewert (pers. comm.) has found some Coastal Plain amphibians, such as the mole salamander, in the sagpond area.

### Natural and Cultural Values

Values are similar to those of sinkholes. Although some sagponds have perched water tables, many act as reservoirs to recharge the highly valuable subsurface aquifers of the Great Valley section.

### Man's Impact

Foresters have sprayed the area and the ponds with 2-4-D and 2-4-5-T and other herbicides in an attempt to kill broadleaf plants. Largely, agriculture and logging practices seem not to have destroyed many of these ponds.

## [37] MARSH PONDS (IN PART)

### Location and Description

Marsh Ponds are largely confined to the Coastal Islands, usually linear ponds lying against the rear dunes (Cumberland) or in between older dunes, sometimes obliterated by dune migration and usually without tree canopies. A few of these ponds should not be classified as fluctuating water level systems, but have relatively stable water levels.

### Flora

The flora is dominated by a variety of grasses, sedges, and emergents. Mud plantain (*Heteranthera*), cattails, and water willow are especially prominent. Water levels fluctuate widely in many ponds. Some have periodic invasion of salt water (every 3-4 years) by spring or storm tides which help keep down freshwater plants. James Richardson (pers. comm.) indicates that ponds, such as Lake Retta and southend ponds on Cumberland Island, are remarkable ecosystems in that they are connected to the marine systems. This limits the freshwater emergent plants, increases the nutrient levels by fluctuating water levels, and leads to algae blooms. These ponds are rich in algae and floating duckweeds. Bozeman (1975) has detailed the vegetation of ponds on Cumberland Island, which he states range from predominantly acid to neutral, with dark stained water. He felt that nearly all were undergoing typical pond succession (submerged aquatic to floating-leaved aquatics to emerged aquatics to shrub marsh to lowland mixed hardwood forest). Bozeman found dominant *submerged plants* to be Milfoil (*Myriophyllum* sp.), pondweed (*Potamogeton* sp.), spike-rush (*Eleocharis* sp.), and bladderwort (*Utricularia*). *Floating aquatics* were predominantly lilies (*Nymphaea odorata, Nuphar luteum, Nymphoides aquatica*), water shield (*Brasenia*), pondweeds (*Potamogeton*), duckweeds (*Spirodela*), frog's bit (*Limnobium spongia*), water fern (*Axolla*), and pond unt (*Nelumbo lutea*). *Emergents* included frog's bit, arrowhead (*Sagittaria graminea*), duck potato (*S. latifolia*), pickerel weed, cattails (both *Typha latifolia* and *T. angustifolia*), lizard tail and knotweeds. Switch cane (*Panicum hemitomon*), sand cordgrass (*Spartina bakeri*), sawgrass (*Cladium jamaicense*), nutgrass (*Cyperus* sp.), beak rushes (*Rynchospora*), sedges, and common rushes (*Juncus effusus*) comprised the emergent grass-type plants.

### Fauna

Fauna is CP distribution, habitat H, Appendix VI. Many of the freshwater ponds that do not dry up with relatively stable water levels, such as Lake Whitney, are not particularly rich in wildlife; the fish fauna is similar to fresh water and dominated by the sunfishes (Centrachids). According to Richardson, this is in direct contrast with Lake Retta, a fluctuating water level ecosystem connected to a marine system with too much salinity for fresh water fish and not enough for salt water fish. This leads to domination by omnivorous and insectivorous euryhaline prey fishes of small size with few fish predators, thus skipping the primary consumer stage. This high biomass of prey species leads to a concentration of predators at the level of secondary consumers and above, such as turtles, herons, alligators, mink, and otter. Accordingly, the wildlife is outstanding.

#### Natural and Cultural Values

Obviously, these two contrasting natural pond systems are scientifically and educationally valuable in mirroring some fundamental ecological precepts, as well as providing wildlife values and scenic diversity.

#### Man's Impact

Destruction of the dunes by feral livestock and vehicles may allow excessive wind movement of sand which has destroyed many of the linear ponds on Cumberland Island. Some interior ponds have been drained on Cumberland by a canal system, and agriculture has been practiced on the peat surface.

2.NATURAL LAKES AND PONDS

## [38] NATURAL LEVEE TYPE

#### Location and Description

This type of pond is seemingly rare, some are small and ephemeral. This type of ponding occurs when relatively heavy deposits of levee sand dam up a small tributary stream. One outstanding example is a four acre lake below Black Shoals on Big Haynes Creek (Rockdale Co.).

#### Flora

Flora usually consists of emergent rushes and sedges, button bush and the like.

#### Fauna

The fauna is largely distribution P, habitat H, Appendix VI. The fish are mostly centrarchids and minnows. The Black Shoals Lake has yielded the brown bullhead and bluegill. There is one semi-natural pond on the Alcovy which, before the beavers built the dam so high, contained huge redbreast sunfish, and still has large black bass. Ducks and herons use these ponds, especially in winter, and beaver, muskrat, and mink are common there. Woodpeckers find the forest of dead trees inviting.

#### Natural and Cultural Values

These ponds are chiefly valuable as overbank sediment traps and duck wintering ponds. (See BEAVERDAM TYPE).

#### Man's Impact

There are numerous shallow lakes along Georgia Piedmont streams, such as Cornish Creek, along the Alcovy north of Highway 78 (Walton Co.) and on the Apalachee and Oconee tributaries, which are due largely to channelization. Here the artificial levee produced by dredging spoil kills the bottomland hardwood forest. Beavers frequently maintain the ponds thus formed - aided by the landfill for bridges which forms a convenient dam. Most of these lakes bear dead gums or other timber, most date back to the 1930s, others are due to more recent channelization efforts.

## [39] BEAVER DAM TYPE

#### Location and Description

In the mountains and the upper portion of the Coastal Plain, but largely in the Piedmont, the beaver is a great pond builder. One only has to fly down the Flint Valley to see the tremendous impact of this animal on Piedmont floodplain ecosystems, Photo A7. Several beaver ponds on the Flint floodplain above the Highway 54 bridge (Fayette Co.) have been studied, a complex system of dams on the Flint and Beaverdam Creek floodplains.

Dams are low and are up ¼ mile in length. Fresh dams are usually sealed along the top with mud. Most possess beaver "lodges" in about 4 to 6 feet of water. Some lodges are used year after year; in other areas, beavers alternate home sites. Along the Flint in Pike County where the river is more incised, beavers simply construct a dam using the natural levee as a base.

Beavers pond smaller branches wherever it is possible. In many floodplains, such as those of Murder Creek (Jasper County), beavers do not build dams, but live in bank dens. They do not attempt to dam the main channels of the larger stream, but invariably choose a small tributary crossing the floodplain but, as on Wolf Creek (Jasper County), beavers sometimes dam a large tributary. In mountain streams, small tributaries, such as Totterypole (Chattooga tributary, Rabun Co.) are dammed, while on the main rivers (Chattooga and Tallulah) beavers live in bank dens.

Beaver ponds often kill the floodplain timber. Beavers may desert a pond. This allows it to revert to a temporary marsh, in some cases going through succession towards bottomland hardwood again. Usually, however, beavers return when alder, willow, and other food saplings are well established, and repair the dam.

Photo A7 This eight-acre BEAVER POND [39], built about 1953, occupies a tributary of the Flint River above Highway 54 in Clayton County The lodge, pictured here, is built in from 4 to 6 feet of water· gum trees in the background are dead. The principal predatory fish are pickerels and bowfin (*Amia calva*); nine species of sunfish are recorded. Musk and painted turtles are abundant.

### Flora

A 34 hectare Flint River pond (with a depth of 1.8 m) was under observation for six years. It has blackwillow and sweet gum around the edges. The dominant sedges seem to be clumps of *Carex rostrata* and *C. stipata,* the rush, *Juncus effusus,* and bulrush, *Scirpus americanus* The arrowheads (*Sagittaria* sp.) are abundant, especially where there is pollution. This pond was built about 1953. Its dam has been dynamited by the owners of a golf course above a number of times, but it is generally always rebuilt. Another pond studied by Willingham (1971), Holiday Pond (10.2 h), had the following emergents: cattail, a sedge (*Carex rostrata*), a rush (*Juncus effusus*), a spike rush (*Eleocharis obtusa*), and an arrowhead (*Sagittaria latifolia*).

### Fauna

The following is a list of fishes collected since 1968 from the vicinity of the Beaver-run pond (Robert Jackson property Fayette Co.): (1 signifies new records for the Flint—identification to be verified.

Bowfin, small mouth buffalo (1); red fin and chain pickerels, creek chubsucker golden shiner (*Notemigonus crysoleucas*), sandbar shiner (*Notropis scepticus* (1), spottail shiner (*Notropis hudsonius* (1), mosquitofish, spotted bass (*Micropterus punctulatus* (1), black crappie, orange-spotted sunfish (*Lepomis humilis* (1), largemouth bass, warmouth, bluegill, spotted sunfish, flier pumpkinseed (*Lepomis gibbosus* (1), Coosa darter (*Etheostoma coosae* (1), and swamp darter (*E. fusiforme*). For a three day period in July 1968, funnel traps were maintained at a dynamited breach in this beaver dam. The list of specimens which tried to escape as the water level fell may give an idea of the quantitative structure of turtle populations, and possibly for certain fishes as well: golden shiner 26; spotted sunfish 19; swamp darter 12; flier 8; creek chubsucker 6; bluegill 6; spotted bass 5; warmouth 3; stinkpot 39; painted turtle 29; snapping turtle 4, yellowbellied turtle 1 Many fish and turtles do not wait until a beaver dam goes dry but get out when water levels begin to drop, so that they will not be trapped.

We have recorded as common amphibia and reptiles: cricket frog, green frog, southern 2-lined salamander (on dam), northern dusky salamander southern toad, king snake (edge), brown water snake, stinkpot turtle, loggerhead musk turtle (*Sternotherus minor*), painted turtle, yellow-bellied turtle, snapping turtle.

Willingham (1971 sampled the turtle population of Holiday Pond (Clayton Co.) with funnel traps baited with chopped fish over a four week period (September October 1970); he caught the following numbers of turtles from this 10.2 hectare beaver pond: snapping turtle (2), yellow-bellied turtle (3), stinkpot (15), painted turtle (29).

The green tree frog, which is largely a permanent water breeder may be able to extend its range northward in beaver ponds. This has occurred along the Flint River I have also recorded the green tree frog and the bird-voiced tree frog from beaver ponds on

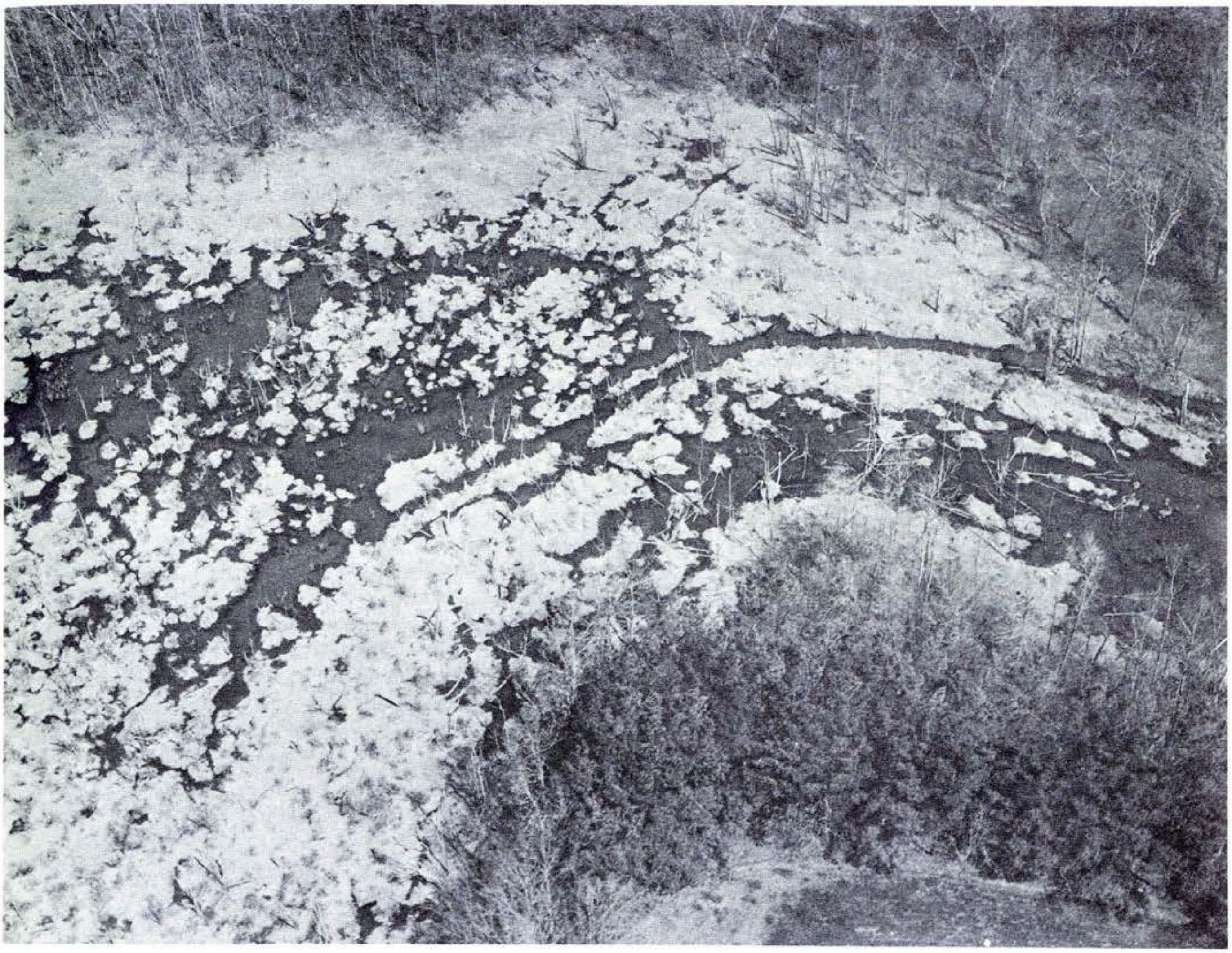


Photo A8. Aerial view of an old BEAVER POND [39] in fresh water marsh stage on a Flint River tributary (Coweta Co.).

Wolf Creek (Jasper Co.). Oddly I have never found a cottonmouth in Flint River beaver ponds, although a population exists on nearby Camp Creek, scarcely a mile away

The most common birds on the ground around the Flint ponds are the King and Virginia rails. The American Bittern and Green Heron are recorded. The Red-winged Blackbird and Purple Grackle are common. The most common spring warblers (mid-April) are the Prothonotary and Myrtle. Three woodpeckers, the Red-bellied, Red-headed and Pileated appear common. On the open water in mid-April, occur Coot, Mallard, Blue-winged Teal, and Wood Duck.

The most common mammals are the beaver muskrat, raccoon, rice rat, and swamp rabbit.

Dudley Ottley (pers. comm.), who has hunted these ponds for years, states that this 3-pond complex is the best duck hunting area he has ever found. He estimated that the upper pond on Beaver-run Creek (the one with aquatic fauna listed above was used by a least 1,000 ducks as a roosting pond. His estimate of species abundance are (in descending order): mallard, wood duck, black duck, green-winged teal, and widgeon.

**Natural and Cultural Values**

Beaver dams destroy a good deal of timber Some wood-using industries which own the Flint River floodplain (Crawford, Taylor Co.) hire trappers to kill the beavers, and prevent ponding and timber damage. Godbee and Price (1975) found all but three Georgia counties had reported beaver damage, estimated at 2,808,998 cords of pulpwood and 1,036,574 thousand board feet of saw timber valued at $66,056,051 Between 1967 and 1975 beaver damage increased 128%, with 287 700 Georgia acres inundated. Benefits (wildlife habitat, erosion control), however were thought to offset damage in 38 counties. Hedlund (1973) stated that 93.3 million cubic feet of timber was damaged by beaver in Alabama, largely (87.6 million cubic feet) sweet gum and tupelo. On the positive side, beaver ponds trap silt and even out habitat diversity by creating open water semi-permanent water marsh and shrub communities, which of course favor certain animals (such as painted turtles, ducks, pickerel, and bowfin), and maintain more diverse food chains. Probably the beaver has been a major modifying force on Georgia floodplains for millenia. On small branches, beavers may actually create miniature floodplains by silt-entrapment. I suspect, on smaller streams in the mountains and Piedmont, that the Indians may have utilized the silt-floored and treeless beaver ponds as corn fields, allowing beavers to reclaim them periodically Beaver ponds are known to be excellent duck hunting areas and are leased along the Flint for this purpose. Mr. Robert Jackson, who owned 800 acres on the Flint, took great pride in his beaver ponds, so much so that when developers upstream did some upstream channeling, his family filed and won a legal suit.

Beaver dams sometimes prevent pollution from reaching the ponds from the floodplain; in other instances beaver ponds may serve as natural oxidation ponds for the treatment of sewage.

**Man's Impact**

Large industry employs professional trappers. Channelization and development pollute or destroy the ponds. Too much pollution can destroy the critical food chains of these ponds, as has happened with the sewage from Clayton County entering some Flint River ponds above the Highway 54 bridge. Roads with landfills greatly encourage beaver to build dams—so do the artificial levees of dredging spoil during channelization. Many individuals attempt to discourage beaver by dynamiting a breach in their dams.

# II. MESIC TO XERIC SYSTEMS

## APPALACHIAN HIGHLANDS

On the surface, all of north Georgia appears mountainous, yet an in depth study shows considerable variation in the types of mountains. Lookout, Sand, Horseleg and Rocky Face mountains in northwest Georgia are certainly mountains, yet they are distinct from the Cohuttas and Blue Ridge to the east. It is difficult to determine where the mountain foothills change into the rolling Piedmont. To further confuse matters, there are indisputable mountains in the Piedmont, such as Pine Mountain with its quartzite rim, the naked granite monolith of Stone Mountain, and the wooded, gneissic slopes of Kennesaw. It also takes a practiced eye to discern when one leaves the Piedmont southward and enters the Coastal Plain. Even though the geological boundary is relatively sharp, the topographic boundary is not and one goes for miles through hills which appear every bit as steep as those in the Piedmont.

The Cohuttas of Fannin, Murray and Gilmer Counties are not part of the Blue Ridge, either physiographically or geologically. They are composed of early Cambrian rocks: slates, quartzites and conglomerates of the Ocoee series and quite different from the biotite schists and gneisses of the more highly metamorphosed sedimentary rocks from which the Blue Ridge is constructed. The Cohuttas are closely related to the Ocoee, Unicoi and Great Smoky Mountains. They are the southern terminus of this mountain chain, while the Blue Ridge might be said to run along the tops of escarpment gorges in Transylvania County, N.C. to Rabun Bald. The Georgia Blue Ridge better could be considered an extension of the Nantahalas into Georgia. These facts make problems for the routing of a "Blue Ridge" parkway into Georgia, for it is physiographically difficult to link Rabun Bald with what we are calling the Georgia "Blue Ridge."

The Cohuttas resemble the Georgia Blue Ridge with their dendritic drainage. Their fauna should be more closely allied to that of the Blue Ridge than to Cumberland Plateau but we have little data. In the Cohuttas we have found, for example, that the black-bellied salamander (*Desmognathus quadramaculatus*) occurs only in streams draining into the Tennessee system. Most Cohutta streams (Jacks, Conasauga) drain into the Alabama system.

Study of a raised relief map (Rome Quadrangle, 1:250,000 series, Hubbard, 2855 Shermer Road, Northbrook, Illinois, 60062) is instructive. The Georgia Blue Ridge can be seen as terminating at the Amicalola-Springer Mountain mass. Southwestward across Highway 52 lies the last large Blue Ridge outlier, the Burnt-Oglethorpe massif.

Southwest of this across Highway 5 is a long, low ridge between Sharp-Top and Oaky Mountain which I call the Oaky Mountain wilderness (although heavily cut-over it is an almost roadless area). Southwest of this, across Highway 140, lies the high isolated ridge of Pine Log Mountain. These various outliers have many plants characteristic of the main Blue Ridge, including several remarkable localities for purple rhododendron, one with hemlock on Bluff Creek (Cherokee County).

Geologically, according to Sam Pickering (pers. comm.), these two outliers are of quite different origin from the Blue Ridge itself, being composed of resistant rocks such as the Weisner quartzite, and are thus similar in their origin to other Piedmont mountains, such as Stone, Kennesaw, and Pine. The rocks composing the Blue Ridge are more or less similar to those of the surrounding Piedmont, hence a different origin must be sought. Oaky and Pine Log mountains are thus considered to be in the Piedmont. Nevertheless, some northern species fround there, such as black birch, sculpin, stoneroller, and seepage salamander, indicate that the fauna is somewhat similar to that of the Blue Ridge. We have not been able to document the presence of high mountain forms, such as the black-bellied salamander and brook trout, in the Pine Log area. A few mountain species (seepage salamander, black birch) are found on high ridges in eastern Alabama, supporting the theory that the Georgia Blue Ridge continues into Alabama via Pine Log and the Talladega Upland, at least from the biotic standpoint.

Another distinct mountain massif, which I call the Rich Mountain wilderness, lies between the Amicalola-Springer Mountain Blue ridge terminus and the Cohuttas to the northwest. These mountains (Rich, Big Bald, Little Bald, Cold, Little Aaron, Turniptown) approach or exceed 4,000 feet in elevation. This large isolated mountain massif is easily bypassed by the casual traveler along Highway 76 (Ellijay to Blue Ridge). This road follows the great Murphy Syncline, the proposed route of the projected Appalachian Highway (400), a route clearly revealed by satellite images. The Murphy Syncline makes a clear division between the Rich Mountain wilderness and the Cohuttas.

West of the Cohutta, Rich and Oaky-Pine Log areas, the Great Valley interrupts the mountain masses. Although often rolling and hilly, the Great Valley possesses some plant and animal communities similar to those in the Coastal Plain. Coastal Plain organisms are exemplified by water hickory, overcup oak, cottonmouth, mole salamander, and barking tree frog.

The Sedimentary Region mountains share biotic similarities with the mountains of the Cohutta-Blue Ridge mass to the east, such as black locust, yellow buckeye, eastern hemlock, black birch, catawba rhododendron, green salamander, and eastern milk snake. On the other hand, there are biotic differences. The Blue Ridge has some forms, such as the black-bellied and seal salamanders, table mountain pine, and Carolina hemlock, that are absent in northwest Georgia. A number of organisms, such as the willow oak, swamp chestnut oak, water oak, shumard oak, sugarberry, winged elm, cave, zigzag and eastern tiger salamanders, mountain chorus frog, gulf softshell turtle, Cumberland pond slider, and map turtle, are absent from the Cohutta-Blue Ridge area. From the trees and terrestrial vertebrates, it appears that there are marked differences between the Blue Ridge Province and the Sedimentary Region.

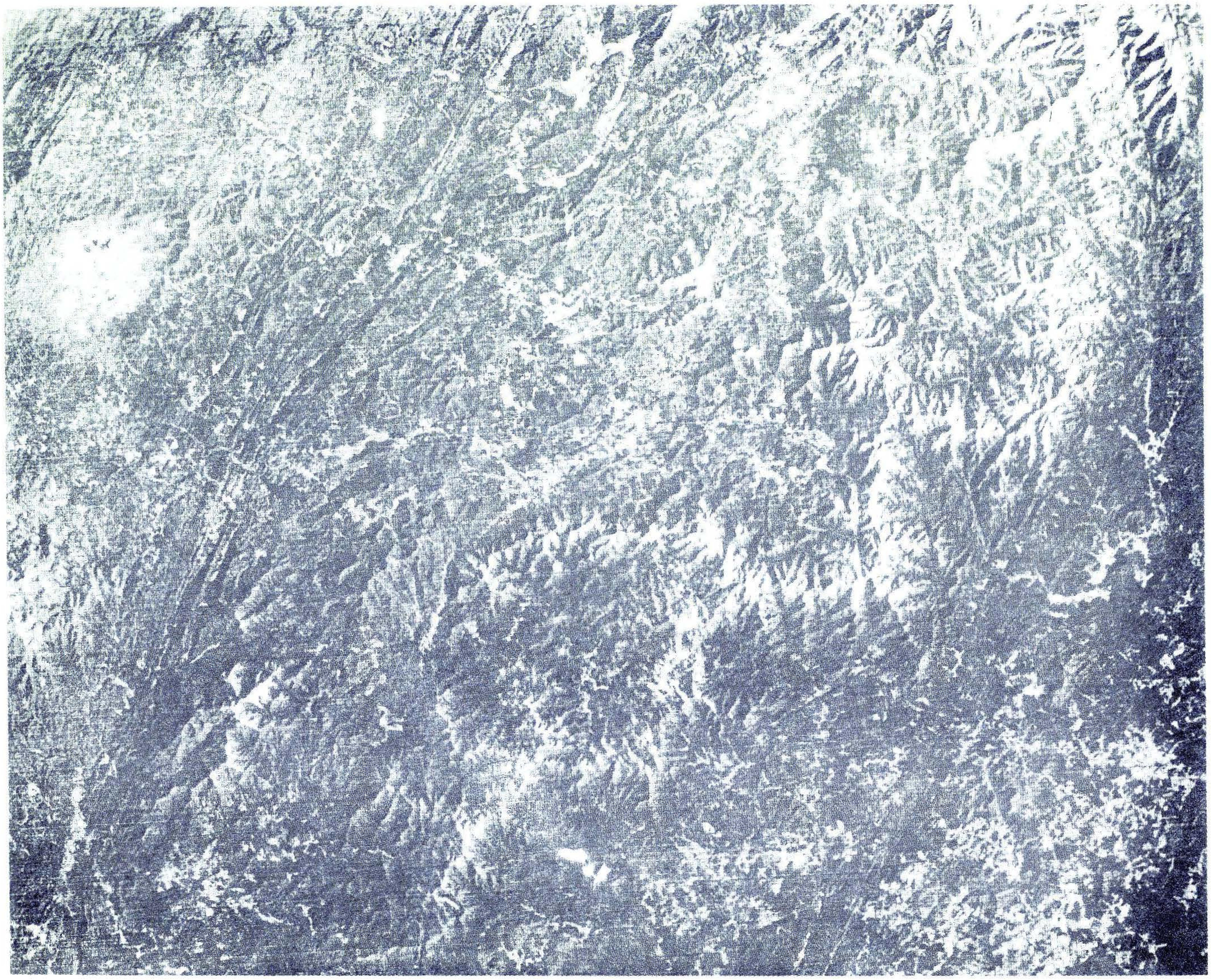
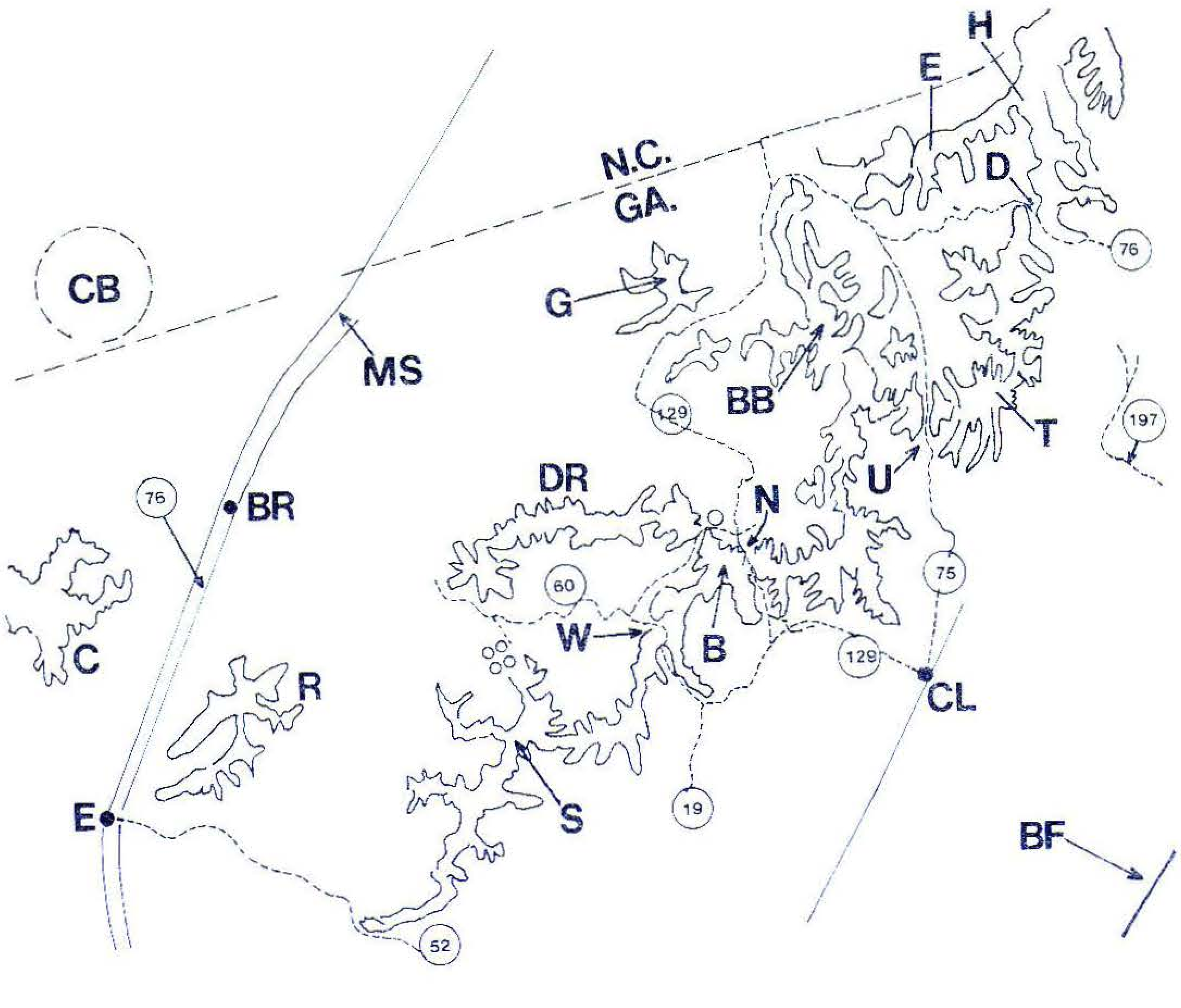


Fig. 18. Landsat Band 5 winter satellite image of the Georgia Blue Ridge, with the main ridges and tops outlined by snow in the winter of 1976. Large patterns on the earth are visible. See sketch below: B Blood Mountain, C Cohutta Mountains, D Dick's Gap, E Eagle Mountain, G Gumlog Mountain, H Hightower Bald, MS Murphy Syncline, N Neel's Gap, T Tray Mountain, U Unicoi Gap, W Woody Gap, BB Brasstown Bald, BR Blue Ridge, DR Duncan Ridge, CB Copperhill Basin (Tennessee), CL Cleveland, BF Brevard Fault. Location of roads, cities, and state line is approximate. Original image courtesy S. Pickering, Geologic and Water Resources Division, Georgia Dept. of Natural Resources.



## II. MESIC TO XERIC SYSTEMS

### SEDIMENTARY REGION

(Cumberland Plateau, Chickamauga Valley, Armuchee Ridges, Great Valley)

1. SURFACE ENVIRONMENTS
   a. BROADLEAF DECIDUOUS FORESTS
      (1) MESIC FORESTS
         [40] BLUFF AND RAVINE FOREST
         [41] FORESTS ON COLLUVIAL FLATS
      (2) SUBMESIC FORESTS
         [42] SUBMESIC RIDGE AND SLOPE FOREST
         [43] FORESTS OF CHICKAMAUGA VALLEY
         [44] DECIDUOUS FOREST OF THE GREAT VALLEY
   b. BROADLEAF DECIDUOUS-NEEDLELEAF EVERGREEN FOREST
      (1) MESIC FORESTS
         [45] RAVINE, GORGE AND COVE FOREST
      (2) SUBMESIC FORESTS
         [46] OAK-PINE FOREST OF THE GREAT VALLEY
      (3) SUBMESIC TO XERIC FORESTS
         [47] ARMUCHEE RIDGE FOREST
   c. NEEDLELEAF EVERGREEN FORESTS
         [48] CEDAR GLADES
         [49] COOSA FLATWOODS
   d. ROCK OUTCROPS
         [50] ROCK OUTCROPS
2. SUBSURFACE ENVIRONMENTS
         [51] CAVES

KEY TO ENVIRONMENTS OF THE SEDIMENTARY REGION

1a Underground caverns, usually in limestone.
[51] CAVES

1b Surface environments (Select 2a or 2b).

2a Bare rock forms ground surface, or it is weathered into blocks, spires, fissures or other weird formations near the edge of flat-topped mountains of the Cumberland Plateau (see physiographic map).
[50] ROCK OUTCROPS

2b Surface with soil and vegetation (Select 3a or 3b).

3a Pines or cedars dominant forest tree, or pines mixed with hardwoods (Select 4a or 4b).

4a Pines or cedars dominant forest tree, often occuring in pure stands (Select 5a or 5b).

5a Forest a stand of red cedar with Christmas tree form, most common in Catoosa County.
[48] CEDAR GLADES

5b Forest a stand of long leaf pine (cones longer than 6 inches, twigs finger-sized and stubby, needles exceeding 10 inches) on higher terraces (flats) of the Coosa Valley. Community now rare or non-existant.
[49] COOSA FLATWOODS

4b Forest a mixture of pines and hardwoods (Select 6a or 6b).

6a Biotic communities in ravines on the top of, or incised into the edge of, flat-topped mountains, primarily Lookout, Pigeon and Sand Mountains. Conifers are likely zoned, with pines on dry cliff ledges and hemlocks on moist talus slopes at cliff bottoms.
[45] RAVINE, GORGE AND COVE FOREST

6b Biotic communities not in gorges or ravines (Select 7a or 7b).

7a Forests on rolling hills and higher terraces (flat areas near the rivers) of the Great Valley (see physiographic map), or occupying intermontane valleys in the Armuchee Ridge area.
[46] OAK-PINE FOREST OF THE GREAT VALLEY

7b Forests on top and sides of the Armuchee Ridges (see physiographic map), such as Horn, Johns, Rocky Face and Taylor's Ridge.
[47] ARMUCHEE RIDGE FOREST

3b Pines or cedars scarce or absent or confined to dry, rocky zones or cliffs. (Select 8a or 8b).

8a Forests on steep, north-facing bluffs, particularly along the Coosa River. Red oak and beech usually present with northern plants in the shrub, and particularly in the herb, zone (most obvious in the spring).
[40] BLUFF AND RAVINE FOREST

8b Forests on "normal" slopes, or on ridges or flat terrain (select 9a or 9b).

9a Forest on flat terrain along watercourses (Select 10a or 10b).

10a Forests on narrow "flats" below springs, or near the heads of streams; usually with steep slopes nearby; no evidence (levees, sand, silt or debris) of overbank flooding. Beech often present.
[41] FORESTS ON COLLUVIAL FLATS

10b Forests on larger stream floodplains; usually with evidence of overbank flooding, or typical bottomland or streamside hardwoods present (swamp chestnut oak, willow oak, silver maple etc.)
[11] COOSA FLOODPLAIN (SEE WETLANDS SECTION)

9b Forests not on flat terrain along watercourses. (Select 11a or 11b).

11a Forests on slopes and ridges of mountains west of the Great Valley (see physiographic map), or in the north-flowing drainage of the Chickamauga Valley. (Select 12a or 12b).

12a Hardwood forests on rather steep talus (boulder colluvium at base of slope) slopes, usually on the western slopes of the Armuchee ridges and Cumberland Plateau "mesas", (Xeric oaks and some cedar and some pine present on dry, high sites, white oak prominent on lowest slopes), or on the broad tops of these latter mountains.
[42] SUBMESIC RIDGE AND SLOPE FOREST

12b Streams drain northward into Tennessee system, terrain flat or rolling, forest (formerly with chestnut) now a mixture of oak species, with hickory.
[43] FORESTS OF CHICKAMAUGA VALLEY

11b Hardwood forests of the Great Valley, usually on flat or gently rolling terrain; an oak-hickory forest dominated by white oak.
[44] DECIDUOUS FOREST OF THE GREAT VALLEY.

## SEDIMENTARY REGION

### CUMBERLAND PLATEAU

### CHICKAMAUGA VALLEY

### ARMUCHEE RIDGES

### GREAT VALLEY

**Introduction**

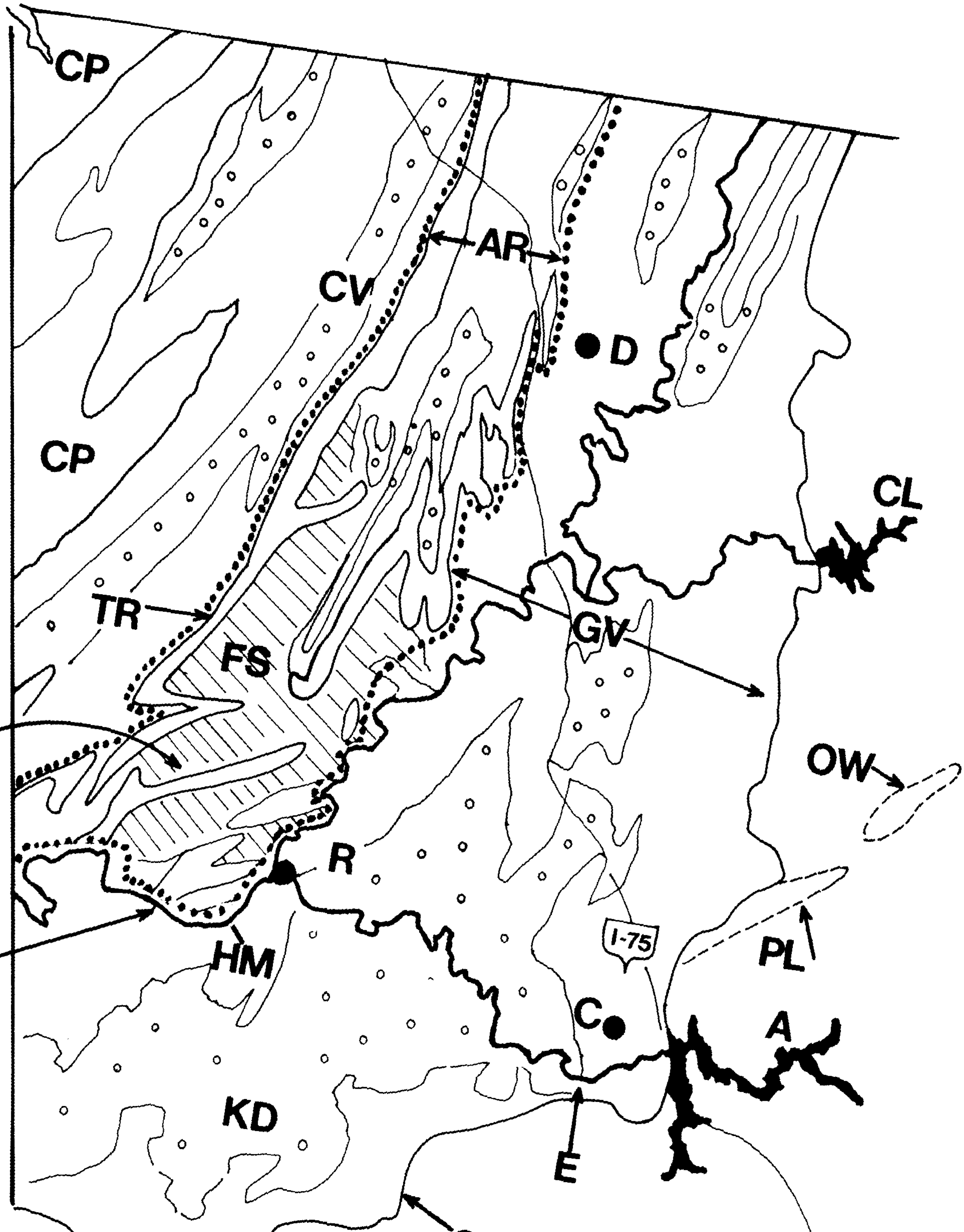
Nowhere in Georgia is the bedrock geology of the land more visible, exciting, or easier to relate to land form than in the Sedimentary Region. Enclosed by the great Cartersville Fault and composed of sedimentary deposits of Paleozoic age, many of the rocks contain the fossils of early life on earth, life that inhabited shallow, inland seas and, at death, was covered by the sediments of these areas. These sediments are now limestones, shales, sandstones, and cherts. Even some coal beds containing fossil plant life are present. Driving across these long, linear ridges and intervening level valleys can be a fascinating lesson in geological history. Natural environments in this sector can often be tied into the bedrock geology with more confidence than in the Blue Ridge or Piedmont provinces. If you anticipate exploring this region, two maps will make your trip infinitely more rewarding; the new geologic map of Georgia obtainable from the State Geologist and the raised relief map (1:250,000), Rome Quadrangle, produced by Hubbard, Northbrook, Illinois 60062.

A brief description of the region can be related to Figure 19. Highway 411 runs along the Cartersville Fault roughly bounding the Great Valley on the east. The Coosa River and tributaries course through the Great Valley. Numerous rolling hills are contained in the Great Valley unit. The Coosa impinges on some of these hills, creating bluff forests. The bulk of Great Valley soils are underlain by two rock groups; the Knox, composed of limestone and dolomites underlying flatter terrain, and the Conasauga, composed of shales, sandstones, and limestones underlying gently rolling hills.

The Great Valley is bounded on the west by the Armuchee Ridges, a series of long, linear hills. The tops of most are Red Mountain sandstone (Silurian age). Downslope on the east side and often forming cliffs are cherts, slates, and shales of Mississippian age. The west flanks may be underlain by limestones (Taylor's Ridge, fig. 20) or siltstones (Rocky Face, Fig. 21), both of with support deciduous forests.

The Armuchee Ridges section is bounded by Taylor's Ridge to the west (fig. 20) and southeastward by an outlier called Horseleg Mountain, almost in the city limits of Rome. The valleys between Horseleg and Taylor's Ridge are underlain with the Floyd shale (with some sandstone and limesone), thus differing from the Great and Chickamauga valleys which are largely floored by limestones and dolomites. The Chickamauga Valley divides the Armuchee Ridges from the Cumberland Plateau, Figure 19. The latter is represented by broad, sheer-sided mountains (Lookout, Pigeon, Sand) with broad plateaus on top, quite unlike anything else in the state. The plateau top is capped by the Castle Rock sandstone. The rimrock is weathered into weird formations and below it are a series of shales and sandstones forming 1,000 foot eastern escarpments. A generalized cross-section is indicated in Figure 22. It can be seen from the way the rock strata are inclined that the present day Lookout and Sand mountains are actually former valleys (synclines), thus earning them the title of "synclinal ridges." The former ridges (anticlines) have eroded and are now lower than the valley floor, Figure 23.

Fig. 19. Map of northwest Georgia (Sedimentary Region) with major environmental features indicated. A Allatoona Lake, E Etowah River, CR Coosa River, CP Cumberland Plateau, CV Chickamauga Valley, AR Armuchee Ridges (between dotted lines), TR Taylor's Ridge, LV Lavender Mountain, HM Horseleg Mountain, GV Great Valley, FS Floyd Shale (diagonal lines) on valley floor, KD Knox Dolomite (open circles) on valley floor, CL Carter's Lake, R Rome, C Cartersville, D Dalton, PL Pine Log Mountain, OW Oaky Mountain wilderness, CF Cartersville Fault.



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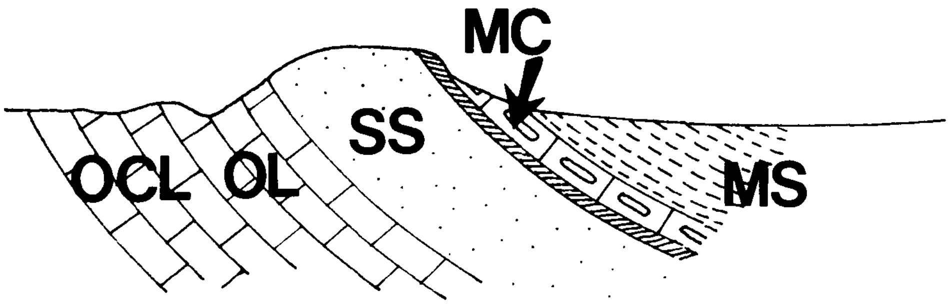



Fig. 20. Diagrammatic cross section of Taylor's Ridge at Summerville (looking north), Bulk of ridge is formed by Silurian sandstone (Red Mountain Formation). Cliffs of the eastern side are formed in chert beds of Silurian (Armuchee Chert) and Mississippian (Fort Payne Chert) age. MS Mississippian Shale (Floyd Shale), MC Mississippian chert, SS Silurian sandstone, OL Ordovician limestones, OCL Ordovician-Cambrian limestones. After Cressler (1974).

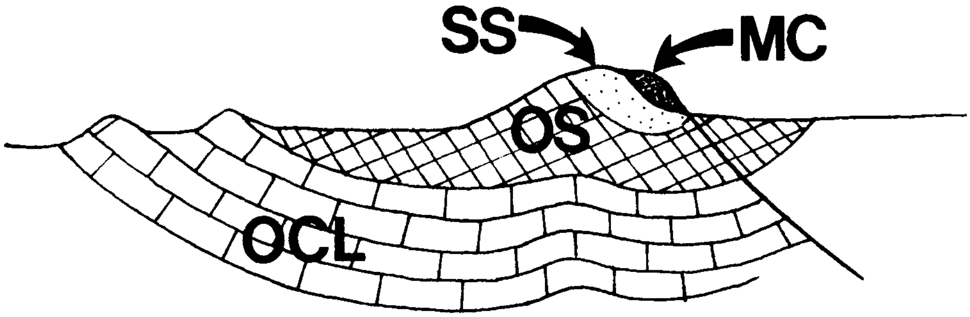



Fig. 21. Diagrammatic cross section of Rocky Face Mountain at Dalton (looking north). Top of the ridge is in Silurian sandstone (Red Mountain Formation), cliffs on the east side are formed by Mississippian cherts, and western slopes by Ordovician siltstones and mudstones (some limestones at the base, some conglomerates at the top). MC Mississipian chert (Fort Payne Chert), SS Silurian sandstones, OS Ordovician siltstones, OCL Ordovician - Cambrian limestones. After Cressler (1974).

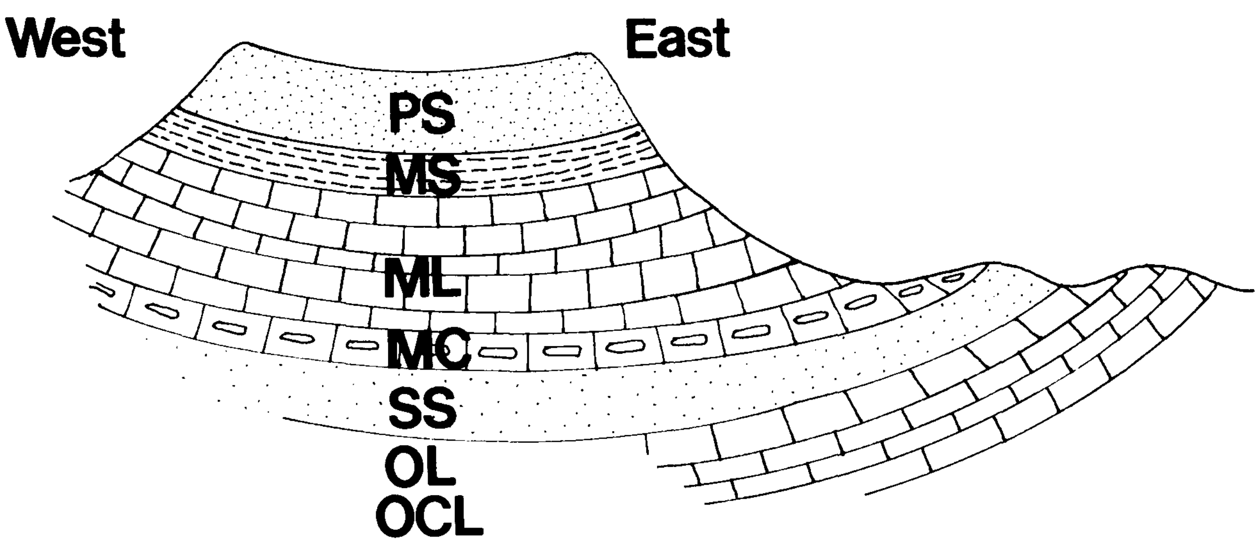



Fig. 22. Diagrammatic cross section of Lookout Mountain and associated ridges (looking north). Adjacent low hills are in Red Mountain Sandstone (SS) and Knox Dolomite (OCL). PS Pennsylvanian sandstones, MS Mississippian shales, ML Mississippian limestones, MC Mississippian chert (Fort Payne chert), SS Silurian sandstones, OL Ordovician limestones, OCL Ordovician - Cambrian limestones. After Cressler (1964) and S. Pickering (pers. comm.).

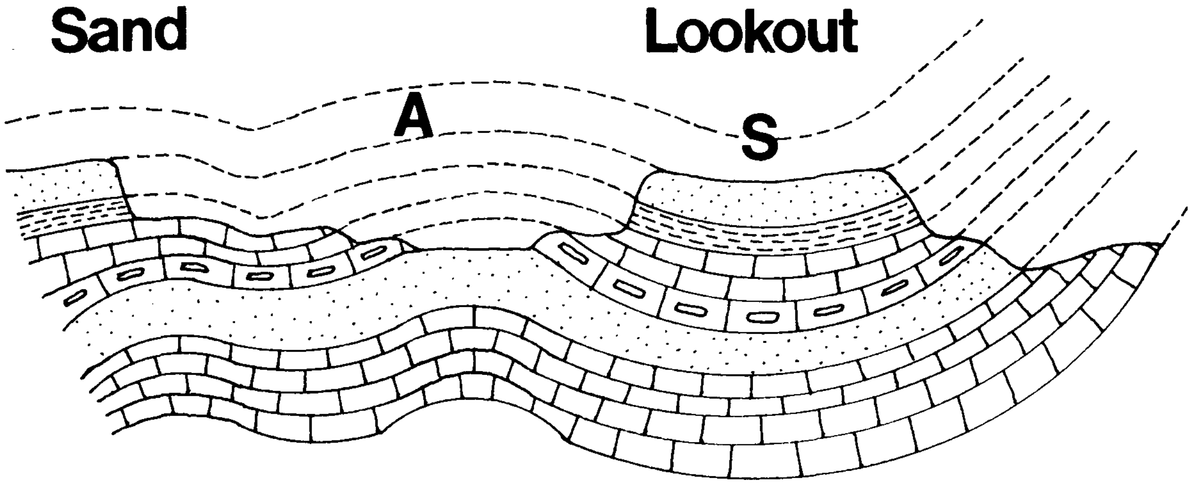



Fig. 23. Diagrammatic cross section of Sand and Lookout mountains depicting the eroded anticlines (A) as valleys and the former synclinal valleys (S) as ridges (looking north). After Sullivan (1942).

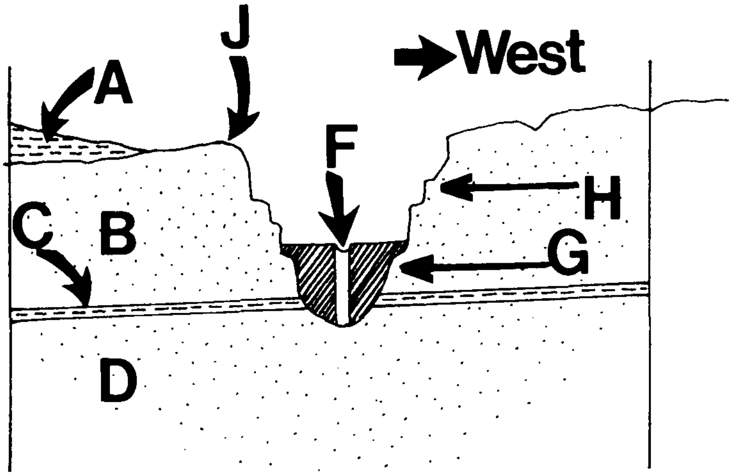
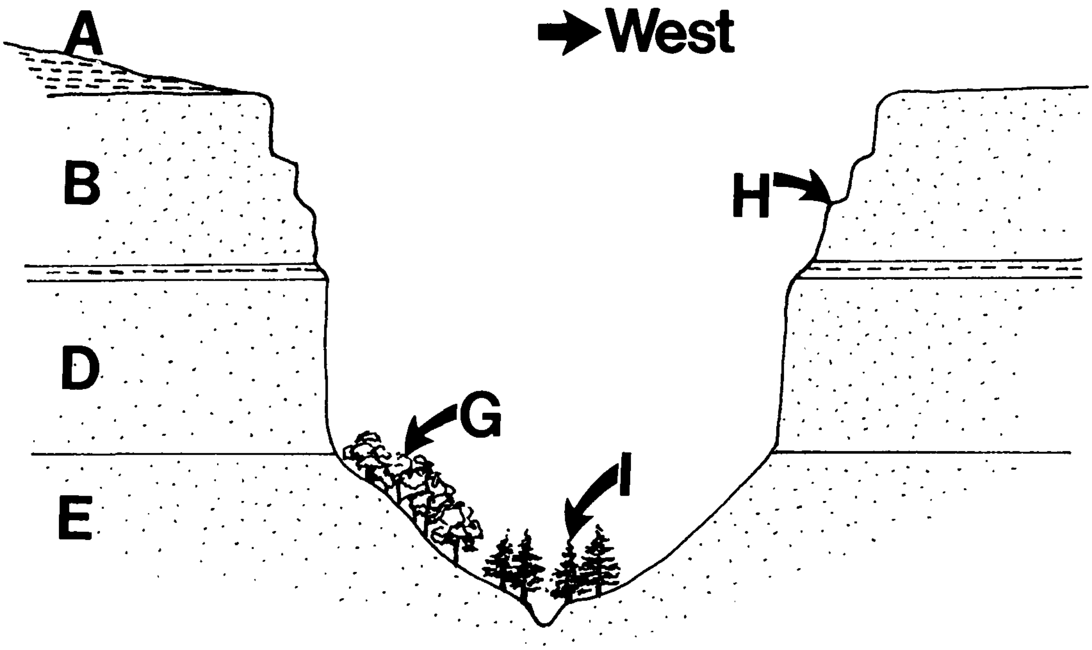



Fig. 24. Cross sections of Cloudland Canyon (Sitton Gulch) relating geology and landform, with some tree types indicated. Profile above is at Cloudland Canyon State Park observation point, lower sketch is a profile about ½ mile downstream (north) from the lookout point. Both profiles are drawn as if the observer were looking south. (A) Vandever Shale, (B) Bonair Sandstone, (C) Whitwell Shale, (D) Lookout Sandstone (Suwannee), (E) Lookout Sandstone (Gizzard), (F) Daniel's Creek Falls, (G) Talus slope with hardwoods, (H) Ledges with pine, (I) Hemlock on lower moist talus slope, (J) Observation point. Gorge depth in lower diagram circa 1,000 feet.



A close look at the strata making up the western edge of Lookout Mountain can be gotten from the overlook at Cloudland Canyon State Park. Figure 24 indicates corss-sections of the gorge, the rocks and main tree types that occur. Daniel's Creek, which forms the canyon directly in front of the overlook, has a beautiful waterfall visible upstream. The stream falls over a sandstone cliff. One can walk behind the falls because of a 12 foot layer of less resistant shale, Figure 24.

Lookout, Pigeon and Sand mountains have been classified by physiographers in the Appalachian Plateau Province, but because of geologic and biologic similarities, I include them with the Ridge and Valley Province. Since it possesses some remarkable Coastal Plain plants and animals, the valley of the Coosa and tributaries is considered a separate area called the Great Valley. The river and its wide floodplain is separately classified in the hydric section as [11] COOSA RIVER, because its appearance and biota more closely resemble those of streams on the Coastal Plain. Harper (1930, 1943) also called the Coosa Valley the Appalachian Valley, and Braun (1950) used the term Great Valley. This valley sweeps down from Tennessee diagonally across northwest Georgia and extends nearly halfway down the state of Alabama. It is a remarkable and little-recognized entity, being botanically and zoologically unique. Braun categorizes it under her "oak-pine forest region" (which also includes the Piedmont) rather than the oak-chestnut region through which it intrudes. Unique limesinks occur in the Great Valley (see [36] SAG PONDS).

Knowledge of the fauna of the Sedimentary Region is so sketchy that it will be treated at the end of the Sedimentary Region section, along with **Values** and **Man's Impact** on the region as a whole.

1. SURFACE ENVIRONMENTS

a. BROADLEAF DECIDUOUS FORESTS

(1) MESIC FORESTS

## [40] BLUFF AND RAVINE FOREST

### Location and Description

These bluffs, according to Braun (1950), are due to post-Harrisburg erosion associated with early Pleistocene glacial cycles. Bluffs along the Coosa are steep. Black Bluff eroded into Conasauga limestone (early Cambrian age) supports a forest with northern affinities much as do some Piedmont bluffs. Jones (1940) described mesic ravines on the Berry School property just north of Rome, in the Great Valley.

### Flora

On Black Bluff the dominant **trees** appeared to be northern red oak and shagbark hickory, with some beech and chestnut oak with hackberry and box elder near the river. The mesophytes, silver bell and paw paw (*Asimina triloba*) also occur. There is an endemic viburnum and mock orange. Wild hydrangea is present along with a host of mountain **herbs** represented by Dutchman's Breeches, white snakeroot (*Eupatorium rugosum*), dwarf ginseng, and toothworth (*Dentaria concatenata*).

A water gap at Lavender Mountain is somewhat similar. The dominant trees were beech, white oak, and black gum; the **shrubs** were wild hydrangea, mountain laurel, azalea (*Rhododendron canescens*), and maple-leafed viburnum. Dominant herbs were foamflower, false Solomon's seal, and birthwort (*Aristolochia serpentaria*). Jones (1940) described a basswood-maple-beech association from ravines of the Berry School property (Floyd Co.) with red maple and tulip poplar, and sugar maple (*Acer barbatum*) as a sub-canopy member. Dominant shrubs were maple leaf viburnum, witch hazel, wild hydrangea, hop hornbeam, sweet shrub, dogwood, and pinxter-flower azalea with mountain laurel in rocky places.

Typical herbs seemed to be Christmas fern, foamflower (*Tiarella cordifolia*), bluets (*Houstonia caerulea*), toothworts (*Dentaria heterophylla* and *D. laciniata*), spring beauty (*Claytonia virginica*), rue anemone (*Anemonella thalictroides*), yellowroot, black cohosh (*Cimicifuga*), wood anemone (*Anemone quinquefolia*), lady fern (*Athyrium asplenioides*), maidenhair fern (*Adiantum pedatum*) and winged beech fern (*Phegopteris hexagonoptera*), galax, coneflower (*Rudbeckia monticola*), boneset (*Eupatorium perfoliatum*), violets (*Viola esculenta* and *V. hastata*), and several sedges (*Carex leptalea, C. debilis, C. lurida*). Some of these, and other plants, were restricted to this environment.

Harper (1943) documented the following trees and shrubs from "ravines": northern red oak, American holly, hop hornbeam, horse-sugar, big leaf magnolia (*Magnolia macrophylla*), and chalk maple (*Acer leucoderme*).

## [41] FORESTS ON COLLUVIAL FLATS

### Location and Description

These forests occur on valley fill deposits along smaller streams and spring-fed branches adjacent to the foot of ridges, such as Rocky Face and Horn Mountain in the Armuchee Ridges, and along the base of Lookout and Pigeon mountains. These environments superficially resemble floodplains, but the major source of soil is colluvium which has moved down from adjacent ridges. The colluvial flat in "The Pocket" (Floyd-Gordon Co.) is interlaced with large spring branches and supports a mesic deciduous hardwood forest.

Photo A10. This forest [41] on a colluvial flat in "The Pocket" (Floyd Gordon counties) supports a mesic forest dominated by white oak and tulip poplar The associated springs and spring runs seldom overflow their banks, hence no floodplain is involved. Other colluvial flats support beech forests. This environment is a pleasant oasis amid drier forests of the Armuchee Ridges.

#### Flora

At "The Pocket" the colluvial flats support a forest of the following **trees**: (D) white oak, (D) yellow poplar yellow buckeye, beech, ash, black cherry black gum, Florida sugar maple, slippery elm, and ironwood. **Shrubs** appeared to be spicebush and azalea. The herb community was not visible (December). An interesting colluvial flat at Gordon Springs (Whitfield Co.) appeared to have originally been a beech-dominated forest. A colluvial flat forest in Chickamauga National Military Park (Catoosa Co.) had willow oak as a dominant, along with sweet gum, hackberry shagbark hickory and a few red cedars.

(2) SUBMESIC FORESTS

## [42] SUBMESIC RIDGE AND SLOPE FOREST

#### Location and Description

This oak-hickory forest occurs on most of the top and talus slopes of the Cumberland Plateau, and on the west slopes of the Armuchee Ridges. The western slopes of Taylor's Ridge are composed of sandstone, siltstone, and limestone, Figure 20, while that of Rocky Face is largely siltstone, Figure 21

The top of Lookout Mountain lies between 1300-1600 feet. Soils on top are classified as Hartsell's fine and very fine sandy loams, USDA (1942). They are considered 5th class soils best suited for forest. The slopes, including the colluvial talus at the bottom, are classed as "rough stony land."

#### Flora

Slope forest **tree** dominants on the eastern slope of Lookout (Highway 48, northeast exposure) were northern red oak, southern red oak, and chestnut oak, with yellow poplar and ash in a moister ravine. Lower the highway goes through an oak-hickory forest with heavily-disturbed cove forests of hickory yellow poplar and black locust. Cedars are visible in rocky areas. The entire eastern rim (Highway 239) commonly has more of the xeric oak species, such as post and blackjack. The west flank of Lookout bears an oak-hickory forest. On these rocky sandstone slopes chestnut oak dominates strongly, while the lower slopes are shared with white oak.

The top of Lookout and Sand mountains supports deciduous hardwood forest, or did so originally The most common pine now seen is shortleaf, although Virginia pine is very prevalent along the plateau edges.

Photo A11 The rocky west face of Lookout Mountain at McCarty Bluff (Highway 157 Dade Co.) is covered with a chestnut oak-dominated forest [42], with white oak increasingly common at lower elevations. Shortleaf and Virginia pines occur along the rimrock.

Watts (1975) cites Mohr who indicates that Lookout Mountain was originally covered with an oak forest comprised principally of white and rock chestnut oaks (*Quercus prinus*). Harper (1943) indicates that the dominant trees were originally shortleaf pine (*Pinus echinata*), post oak, and red oak (*Quercus falcata*) in dry woods, and white oak on richer soils. He also mentions black oak and blackjack oak, white and pignut hickories, and the chestnut (*Castanea dentata*) as characteristic of "dry woods." One site in near-original forest on a gentle slope on the Lookout Plateau supported a mixture of oaks: northern red, chestnut, post and white, along with hickory black gum, and dogwood. The only visible **herbs** in December were spotted wintergreen and alumroot. Another flatter site had white oak and southern red oak dominants, along with hickory and a few post and scarlet oaks. Some shortleaf pines suggested heavy logging and disturbance. Mountain laurel and American holly were widely scattered in the **shrub** layer A north-facing Sand Mountain site had northern red oak and black oak as dominants, with chestnut oak, post oak, scarlet oak, southern red oak, white oak, hickory and sourwood as co-dominants. Dogwood dominated the sub-canopy

Some of the lower western slopes and outliers of the Armuchee Ridges are underlain by limestones and siltstones, either of which appears to support deciduous forests. A near-original northwest-facing cove on Rocky Face (Whitfield Co.) on Ordovician siltstone (fig. 21 had chestnut oak as dominant, along with white oak, northern red oak, and hickory A near-original west-facing slope on a lower limestone ridge (see fig. 21) just west of Rocky Face was examined in detail. **Trees** were: (D) white oak (bottom half of slope), (D) chestnut oak (top half), Florida maple, mockernut hickory northern red oak, sourwood, hop hornbeam, dogwood and near the moist base of the slope, beech, shagbark hickory and yellow buckeye. The dominant **shrub** was hazelnut. Dominant **herbs** (December) were Christmas fern, brown-stemmed spleenwort (*Asplenium platyneuron*), round-lobed hepatica, wild ginger and striped wintergreen.

## [43] FOREST OF THE CHICKAMAUGA VALLEY

### Location and Description

The Chickamauga Valley lies between the Armuchee Ridges (specifically Taylor's Ridge) and the eastern escarpment of the Cumberland Plateau. The valley is unique in that its northern portion (including McLemore Cove) drains northward into the Tennessee River while the southern portion is drained southward by the Chatooga watershed into the Alabama system. The terrain is flat or rolling, underlain by Knox dolomite, and the Chickamauga limestones and shales, siltstones, and sandstones of the Rome Formation. There are large springs, such as Cave Springs (Catoosa Co.), issuing from the limestone. The forests are oak-hickory

Photo A12. This oak-hickory forest [43] (winter aspect) in Chickamauga National Military Park (Catoosa Co.) is dominated by four submesic oak species (post, southern red, scarlet, and black).

#### Flora

Lipps (1966) found historical evidence that chestnut was once the dominant tree on soils overlying the Knox formation. A hardwood forest on Brotherton Road, Chickamauga National Military Park, contained trees over 110 years of age and had a forest dominated by a mixture of black oak, post oak, southern red oak, scarlet oak, with mockernut hickory as co-dominant. There was almost a total absence of white oak. Few shrubs were present. White oaks seem to be the dominant tree on similar soils in the Great Valley

## [44] DECIDUOUS FOREST OF THE GREAT VALLEY

#### Location and Description

Forests on flat terrain were underlain by limestones and dolomites (a magnesium-rich limestone) and on gently rolling hills surfaced by Conasauga, Fullerton and Sequoia soil groups now "primarily in cultivation, roads, and urban development," Lipps (1966). Conasauga and Capshaw soils appear particularly suitable to deciduous hardwoods.

About half of the Great Valley soils are in the Montevallo-Klinesville-Rarden Association, USDA (1965a). They are shallow, well-drained acid soils of rolling, hilly shale ridges where the depth to shale is 8-20 inches. The other common soil is the Christian-Clarksville-Fullerton Association underlain by cherty limestone or sandstone. Montevallo soils are the most extensive in Gordon County. Most of the above soils support hardwoods. The Klinesville, derived from acid, red shales, has areas dominated by Virginia and shortleaf pine.

#### Flora

The normal forest of the valley floor of the Great Valley according to Braun (1950), is an oak-hickory forest dominated by white oak. Remnants can be seen here and there. Lipps (1966) studied old survey reports and reconstructed original vegetation partterns. She found indications that chestnut was formerly restricted to the Knox (and to some extent the Rome formations of the valley floor She feels that the higher terraces along the Coosa (Dewey soil group) supported forests of elm, ash, tulip poplar sweet gum, ironwood, and black cherry and that lower sites (Stendal soil group) with white oak, tulip poplar sweet gum, ironwood, elm, ash, walnut, sugar maple, and sycamore represented bottomlands occupied by the Cherokees.

Old survey records consulted by Plummer (1975) suggested an oak-dominated forest (45-55%) with 2 or 3 times more post oaks than other species in Gordon County Apparently in eastern Gordon County where shallow soils (Montevallo-Klinesville-Rarden) derived from acid shales dominated, there was more red oak and black gum; with deeper soils to the west, black oaks and red oaks shared dominance.

b. BROADLEAF DECIDUOUS-NEEDLELEAF EVERGREEN FORESTS

(1) MESIC FORESTS

## [45] RAVINE, GORGE AND COVE FOREST

### Location and Description

Streams originating on top of Lookout, Pigeon and Sand mountains may form gorges or ravines either on top or in the precipitous escarpment walls. Although steep gorge walls may be xeric environments, the lower talus slopes and along streams may be mesic. Shallow ravines are cut into the Lookout Plateau by Daniel's and Bear creeks, the two principal tributaries of Sitton Creek which have formed Cloudland Canyon, or Sitton Gulch, as it was formerly called. Smaller ravines occur as smaller streams drop off the side of these plateaus. One of Georgia's largest and least known gorges is the Cole City Gorge of Nickajack Creek, the mouth of which opens into Tennessee in the extreme northwest corner of the state. It is reached only by old logging roads.

Photo A13. Cloudland Cayon is a gorge eroded in the west side of Lookout Mountain (Dade Co.). Its perpendicular sandstone cliffs have ledges where shortleaf and Virginia pines obtain a precarious foothold. Moist talus slopes and ravines [45] support mesic forest with hemlock near streams. Oddly catawba rhododendron (*Rhododendron catawbiense*) occurs here in the ecological niche filled by rosebay rhododendron in the Blue Ridge.

These gorges have nearly perpendicular cliffs of sandstone, Figure 24. On ledges and at the bottom where talus and colluvium collect, they are vegetated. Less steep ravines are more or less thickly vegetated with either a deciduous hardwood or a hardwood-hemlock forest.

### Flora

The top of the escarpment and the ledges in the cliffs are often clothed with Virginia and shortleaf pines. Black birch occurs, surprisingly An oak-hickory forest covers the talus slope at the bottom of Cloudland Canyon. Hemlock grows near the stream itself and is remarkably common in the shallow ravines of Bear Creek (Highway 157) and Daniel's Creek (Highway 143). Here the shrub understory is mountain laurel and, surprisingly dense thickets of catawba rhododendron, a species usually confined to high, rocky mountain tops circa 5,000 feet in the Blue Ridge Province, although it occurs in the Cohuttas on Fort Mountain circa 2,500 feet. Around Cloudland Canyon's rim are catawba rhododendron, mountain laurel, and bush honeysuckle (*Diervilla sessilifolia*). In a small ravine on the west slope of Lookout occurs mock orange (*Philadelphus hirsutus*) and marginal wood fern, and on cliff-edge rocks mountain spleenwort (*Asplenium montanum*) and the rare lobed spleenwort (*A. pinnitifidum*).

(2) SUBMESIC FORESTS

## [46] OAK-PINE FOREST OF THE GREAT VALLEY

### Location and Description

This forest is found on the rolling hills and higher terraces in the valleys of the Great Valley and Armuchee Ridge areas, underlain by soils of the Conasauga, Fullerton and Sequoia groups.

### Flora

The percentage and distribution of natural forests containing pine are uncertain. Lipps (1966) cited historical data showing that the Indians had large areas under cultivation in the Great Valley. Plummer (1975), working from old survey records in Gordon County, indicated an oak-pine-hickory ratio of 50:18:8. Distribution of oak-pine may have originally been confined largely to ridge outcrops of the Conasauga and Floyd shales. Since 1832, logging, mining, and agriculture have so modified the Great Valley that existing samples of near-original forest are extemely rare.

Jones (1940) described plant communities of the Berry School property of Floyd County. His work attests the variety of environments in the Coosa Valley. He described in detail two upland forest associations. His most extensive was "upland woods"; a "redgum-oak association," the other an "oak-hickory association," on slopes.

In his upland woods (mature type) the dominant **trees** were white oak, loblolly pine, red oak (*Q. rubra*), post oak, sweet gum, and mockernut hickory (*Carya alba*). **Shrubs** were two haws (*spathulate* and parsley), deciduous holly (*Ilex deciduous*), narrowleaf crabapple (*Malus augustifolia*), low blueberry (*Vaccinium vacillans*), dewberry (*Rubus* spp.), roses (*Rosa setigera* and *R. carolina*), and poison oak. Jones listed the dominant **herbs** of the mature forest as rue anemone (*Anemonella thalictroides*), veined hawkweed (*Hieracium venosum*), golden aster (*Chrysopsis mariana*), bladdersedge (*Carex* sp.), panic grass (*Panicum* sp.), and white-top aster (*Seriocarpus asteroides*). Jones indicated that his oak-hickory slope forest graded into his upland woods at the foot of low mountains in the Coosa Valley. The oak-hickory association had the following **tree** dominants: rock chestnut oak, pignut (*Carya glabra*), black oak, red maple, and Virginia pine (*Pinus virginiana*). Major **shrubs** were dogwood, sparkleberry, sassafras, pinxter-flower, and low blueberry (*Vaccinium vacillans*). Dominant **herbs** were trailing arbutus (*Epigaea repens*), trumpet honeysuckle (*Lonicera sempervirens*), everlasting (*Antennaria plantaginifolia*), bluets, wild ginger (*Hexastylus arifolia*), and the bladdersedge (*Carex varia*). He recorded a number of other plants restricted to this drier association, including woolgrass (*Erianthus contortus*), little bluestem (*Andropogon scoparius*), broomgrass (*A. ternarius*), erect dayflower (*Commelina erecta*), false indigo (*Baptisia elliptica* and *B. Le Contei*), black locust, beaked pea (*Rhychosia erecta*), sourwood, and showy fleabane (*Erigeron pulchellus*).

Greear (1967) quotes Harshberger's 1911 comments on some flats of the Coosa Valley which he stated were covered with a low forest of dwarfed blackjack oak and loblolly pine, with hawthorns (*Crataegus spathulata* and *C. marshallii*).

(3) SUBMESIC TO XERIC FORESTS

## [47] ARMUCHEE RIDGE FOREST

### Location and Description

Submesic forest is seemingly confined to the Armuchee Ridges and underlain by shales, cherts, and sandstones of Devonian-Mississippian age, or on soils on Silurian sandstones. The best known example is on Horseleg Mountain, an Armuchee Ridge outlier just southeast of Rome. Turkey Mountain (Floyd Co.) is probably similar. Most of Taylor's Ridge and the top of Rocky Face, Horn and John's mountains are composed of the Red Mountain sandstone formation of Silurian age and probably support variants of this forest.

The most xeric forest seems to be located on ridges fromed by the Red Mountain sandstones of Silurian age which yield shallow soils principally in the Apison, Tellico and Allen types. Lavender Mountain is an example which supports a unique flora. Horn Mountain (Gordon Co.) is capped with the Gilpin-Dekalb-Bodine-Steekee Association of soils, USDA (1965a). The Gilpin soil is a stony silt loam over shale located 15-30 inches below surface. Dekalb soils are sandy and sandy clay loams over weathered sandstone about 24 inches deep. Both soils support hardwoods. The Gilpin-Dekalb Stony Complex that caps Horn Mountain has 25-60% slopes and rock outcrops occupy 5-25% of the surface. The slopes of Horn Mountain are covered with Allen stony fine sand loam on 25-60% slopes. This soil consists of sandy or clay loams over shales or limestones lying 24-48 inches below. Sandstone and shale-derived soils are often strongly acid — those from limestones neutral to basic.

### Flora

While parts or Horseleg and Lavender mountains support forests with considerable pine, most of the Armuchee Ridges northward appear to support a deciduous hardwood forest. The xeric top and cliff edges of Rocky Face bear some Virginia and shortleaf pine and the top of Horn Mountain near "The Pocket" bears a forest of chestnut oak and shortleaf pine, with post oak and Virginia pine present. The slopes of Rocky Face and other Armuchee Ridges appear submesic, with the dominant trees being chestnut oak, southern red oak, post oak, black oak, and white oak, and hickory. Some coves provide interesting botany. The base of Rocky Face's eastern slope has an east-facing valley with mountain laurel and perhaps the lowest station for catawba rhododendron in Georgia. Galax is common in the understory.

Lipps (1966) studied in detail a 100-acre remnant of submesic forest on the northern end of Horseleg Mountain. She found that almost all correlations of soil and site related to per cent slope and position of slope (north or south-facing, etc.). On steep slopes she found that organic matter and clay were borne away and lost to the A and B horizons. She found as slope increased the A horizon becomes sandier and the B thinner with more gravel, a lower pH, lower water storage, and base exchange capacity Total soil depth also decreased with % slope increase. Her findings make a potent case against clearcutting on steep slopes—soil changes within the first three years before canopy return could be permanent. It would appear that the building of the A and B horizons by the forest ecosystem on steep mountain slopes is very slow, with perhaps a delicately balanced system of gain and loss.

Photo A14. This ravine in the near-original Marshall Forest at Rome (Floyd Co.) supports a moist oak-hickory forest with large loblolly pines. Uphill from the ravine, environmental variables such as slope and moisture cause the forest to change to chestnut oak dominance, then to various types of pine-oak forests [47].

Since Marshall Forest is a near-original remnant, Lipps' findings warrant inclusion in some detail—we have so few studies of this nature available. Lipps discerned three categories of forest types within Marshall Forest. One, her "mixed forest comminity " could be considered under mesic forests. All, however have pines and even the most mesic has some chestnut oak, so inclusion in a submesic category seems warranted. Here again we recognize a problem—the very bottom of the ravine called "Flower Glen" is mesic but one has to rise but a few feet up the side of the ravine to encounter dry-tolerant species, such as chestnut oak. This prevents categorizing nature in neat packages—environmental variables, such as moisture and slope, result in gradients reflected by the biotic community. (See also Lipps and DeSelm, 1969).

Lipps' (1966) "mixed forest community" had as **tree** dominants mockernut hickory, chestnut oak, tulip poplar shagbark hickory, sourwood, and 3.9% of large pines (usually loblolly). Co-dominants were black, white and red oaks. Four **shrubs** and vines were the most common sweet shrub, common greenbrier muscadine, and maple-leafed viburnum. Other common shrubs (over 60% freq.): wild hydrangea, Virginia creeper pinxter-flower poison oak. *Vaccinium stamineum* and sparkleberry. Other shrubs of interest were the fringe tree, mock orange (*Philadelphus*), cutleaf blackberry (*Rubus lacinatus*), and rusty blackhaw virburnum (*Viburnum rufidulum*).

The dominant **herbs** of particular interest are the mesophytes—some with distinct northern affinities: bellflower (*Campanula americana*), Indian pipe (*Monotropa uniflora*), black cohosh (*Cimicifuga racemosa*), toothwort (*Dentaria heterophylla*), hepatica (*Hepatica acutiloba*), bloodroot (*Sanguinaria canadensis*), featherbells (*Stenanthium gramineum*), maidenhair fern (*Adiatum pedatum*), rue anemone (*Anemonella thalictroides*), and lady fern (*Athyrium asplenioides*).

Lipps' second category "chestnut oak forest community " usually occupied a north-facing slope (averaging 33%), with the shallowest soil profile (22 in.), and surface rock up to 95%. The canopy dominant was chestnut oak. The dominant **shrubs** were sparkleberry (*Vaccinium vacillans*), pinxter-flower (*Rhododendron nudiflorum*), maple-leafed viburnum, and sweet shrub. Chinquapin and witch hazel also occurred. The muscadine was a common vine. The dominant **herbs** were *Stenanthium gramineum,* iris (*Iris verna*), wild ginger (*Hexastylis ruthii*), spotted wintergreen (*Chimaphila maculatum*), *Coreopsis major* wild potato (*Dioscorea quaternata*), flowering spurge (*Euphorbia corollata*), bedstraw (*Galium circaezans*), Indian physic (*Gillenia stipulata*), hawkweed

(*Hieracium paniculata*), bluets (*Houstonia caerulea*), Solomon's seal (*Polygonatum biflorum*), bracken fern (*Pteridium aquilinum*), and *Tephrosia virginiana*.

Lipps cites a study of a similar stand on Lavender Mountain where white oak shares dominance with chestnut oak. The Marshall Forest stand is similar but not identical to chestnut oak communities on the Cumberland Plateau.

Lipps' third category, "pine-oak forest community" of the Marshall Forest, occupies most all the uplands except the north-facing slopes. Canopy dominants were shortleaf pine and black oak. **Shrubs and vines** with over 50% occurrence in study plots were sparkleberry, muscadine, greenbrier (*Smilax rotundifolium*), deerberry (*Vaccinium stamineum*), *V. vacillans*, and poison oak. Dominant **herbs** were *Coreopsis major, Tephrosia virginiana,* spotted wintergreen, spurge (*Euphorbia corollata*), skydrop aster (*Aster patens*), panic grass (*Panicum microcarpon*), goldstar grass (*Hypoxis hirsuta*), *Oxalis stricta, Panicum asheii,* Solomon's seal (*Polygonatum biflorum*), and the Christmas fern.

Lipps ascertained three divisions in her pine-oak forest: (1) a lower slope with shortleaf pine, southern red oak and dogwood, (2) a midslope with shortleaf pine; mixed oak species and sand hickory, and (3) an upper slope where loblolly exceeded shortleaf, with mockernut hickory and chestnut oak.

Lipps discusses the occurrence of pine in Marshall Forest at length. She cites Braun who stated that "except on proper soils and drier sites," pine are temporary. Lipps indicates that Marshall Forest does indeed have "poorer soils and drier sites." Except for the lower slope, she feels that pines are permanent on most of the uplands.

The presence of old pines up to 225 years in the mixed forest and the absence of younger pine trees is intriguing. Lipps feels that the presence of these old pines indicates that the forest is original since the first Caucasians settled in the Rome area in 1832. However, she did not increment-bore the hardwoods which look rather younger. There appear to be no records of logging known to the owners.

One of the important results of Lipps' study is the documentation and discussion of the occurrence of pines in hardwood forests. It has been a common tendency to ascribe secondary succession to be in progress when one finds old pines growing here and there among hardwoods in the Georgia Piedmont. Often one may indeed be witnessing the penultimate state in forest succession from field to hardwood canopy. Lipps, however, presents a convincing argument for natural catastrophe, such as gaps created by ice storms (which she documents as severe in 1902, 1908, 1932, 1935, 1960) or wind blowdowns (1908, 1913, 1921, 1932, 1948, 1955). She indicated a 30 year periodicity for severe ice storms. She feels that pine invaded fire-caused openings in the chestnut oak community in the 1930's also. She suggested a canopy gap in hardwood forests might, in addition, be caused by such pests as the hickory twig-girdler (*Oncideres cingulata*). The highest percent of pines was lost to the pine-oak comminity; here their reproduction and ages are regular, whereas in the moister communities (mixed forest) they survive sporadically and grow to greater age. Lipps concludes that shortleaf pines (*Pinus echinata*) are present and survive as a sub-climax because of catastrophe; she could not state whether fire or storm was the primary catastrophic cause.

The longleaf pine and xeric oak forest of Lavender Mountain may be unique. This linear ridge just west of Rome supports a forest of longleaf and Virginia pine with blackjack and a few chestnut oak. The forest is arid and quite different from those on the sandstone formation that is on the eastern rim of Lookout and Pigeon mountains. Jones refers to Andrews' (1917) study of the longleaf pine community of Lavender Mountain. The north slope of Lavender consisted of a ground cover of coarse grasses, with the fern *Pteris acquilina* and the legume *Tephrosia virginica* presenting an aspect that was "closely similar to that of the great pine region of the south Atlantic Coastal Plain." The typical wiregrass of the Coastal Plain is replaced on Lavender Mountain by the grasses *Andropogon furcatus, A. virginicus,* and *A. scoparius*, mixed with a few sedges, such as *Scleria triglomerata* and *Cyperus retrofactus*.

Lipps records the fact that 50% of the longleaf pine on Lavender Mountain was destroyed by the ice storm of 1960. This, then, is one important factor making Floyd County the northernmost terminus of the range of the longleaf pine. Along the eastern edge of the Armuchee Ridges farther north, shortleaf and Virginia pines, rather than longleaf, are co-dominant with the hardwoods.

Harper (1943) indicated that the sandstone and chert hills in Alabama's Coosa (Great) Valley originally bore longleaf pine forests.

c. NEEDLELEAF EVERGREEN FOREST

## [48] CEDAR GLADES

### Location and Description

These interesting environments dominated by red cedar presently occur on low, flat, north-south trending limestone ridges (and occasionally on slopes) in the Chickamauga Valley. The soil is thin and rocky. Younger glades appear like a Christmas tree farm, older forests less so. There are frequent open places with a ground cover of grasses and herbs. Some cedar glades are protected within the boundaries of Chickamauga National Military Park (Catoosa Co.).

### Flora

The red cedar is the dominant **tree**. The former extent of this community is not known. Lipps (1966) indicates that pure stands of red cedar grew on rocky areas of Colbert soils (upland soils in Karst topography)—she did not specify a locality. Cedars do occur elsewhere, such as in McLemore cove and on the slopes of Lookout Mountain. Slightly deeper soils favor a hardwood or pine overstory, sometimes with a cedar understory. No **shrubs** were observed. In open areas the dominant **herbs** (December) were a prairie mimosa (*Desmanthes illinoiensis*), a prairie clover (*Petalostemon gattingeri*), a coralberry (*Symphoricarpus*), an onion (*Albium cernuum*) and several grasses, some clumping as does *Andropogon*. Some of the plants are allied to those of midwestern prairies. Georgia's Catoosa County glades are considered disjunct from the main environment which occupies up to 6% of the Central Basin of Middle Tennessee, Quarterman and Caudle (1968), who consider the following herbs dominant (abundant) in Georgia: a lily

*Nothoscordum bivalve,* an amaryllus *Agave virginica,* a pink (*Arenaria patula*), a mustard (*Leavenworthia exigua* endemic); the legumes (*Petalostemon gattingeri* endemic) and (*Psoralea subacaulis* endemic), a St. John's wort (*Hypericum dolabriforme,* endemic), a cactus (*Opuntia rafinesquii*), a mint (*Isanthus brachiatus*), a beard-tongue (*Penstemon tenuiflorus*), a ruellia (*Ruellia humilis*) and a buttonweed (*Diodea teres*).

Photo A15. CEDAR GLADES [48] occur on flat, rocky limestone ledges in the Chickamauga Valley of Catoosa County. At least four herbs are found nowhere else. Georgia's cedar glades are disjunct outliers of an environment more common to Tennessee's Central Basin. The dominant red cedar is a "calciphile" or calcium-loving tree.

## [49] COOSA FLATWOODS

### Location and Description

Apparently these pine forests occurred on higher sandy and gravelly terraces adjacent to the floodplain of the Coosa River Although the hydrologic regime of the Coosa River is not identical to Coastal Plain streams, it is, like most streams heading in the mountains, subject to occasional heavy inundations which carry heavy bedloads of sand and gravel; it is thought that in Pleistocene and post-Pleistocene times, stream flow was much heavier Now many terraces are isolated and not subject to periodic flooding. Apparently, no example of this environment remains. It must have been startlingly similar to Coastal Plain flatwoods ([94] MESIC LOWLAND PINE FOREST).

### Flora

Redmond (1975) mentions a "Coosa flatwoods" on the Conasauga formation, and indicates that the Weiss Reservoir inundated many longleaf pine forests. (This reservoir barely invades Georgia.) He states that in Alabama's Coosa Valley the Holston-McQueen-Chewacla soils are morphologically similar to some soils of Alabama's Coastal Plain. Harper (1943) discusses extensive areas of longleaf pine flatwoods on the sandy or gravelly valley floor of Cherokee and Etowah counties (Ala.) where such Coastal Plain environments as pitcher plant bogs were present, as well as annual fires!

Greear (1967) quotes Mohr who stated that " heavy forests of longleaf pine cover the lower hills towards the Coosa River through adjacent Cherokee County and for a short distance beyond the Alabama and Georgia state line "

d. ROCK OUTCROPS

## [50] ROCK OUTCROPS

### Location and Description

Outcrops are of limestone in the Great Valley or of sandstone along the eastern rim of Lookout, Pigeon and Sand mountains. The "rock city" type of weathering in sandstone leaves many large rocks weighing several tons balanced and isolated on the surface, Photo A16. Often the horizontal surfaces will weather into weird, round protrusions. Arboreal vegetation is stunted and bonsaied almost to the shrub stage. A good example lies just east of Highway 239 about three miles north of the community of Lookout. The type of weathering has led to the use of the term "Rock Castle sandstone" that is applied to the caprock of the Cumberland Plateau. This sandstone, of Pennsylvanian age, is not present at the gorge rim of Cloudland Canyon.

Dry forests containing a high percentage of pines are located along and adjacent to the plateau rims, especially along the eastern edges where the Castle Rock sandstone forms the rimrock. As moisture increases downslope away from the plateau rim towards the center of the plateau, these forests grade into the submesic deciduous forests characteristic of the plateau surface.

Photo A16. Sandstone rock [50] and picturesque dwarfed pine-dominant forest occupies the rim of Lookout Mountain (Walker Co.). Some of the sandstone is weathered into rock spires and pedestal (teetering) rocks. Mountain laurel is common on the bluff and catawba rhododendron occurs.

### Flora

In one example, just back from the rim edge in reasonably shallow soils, chestnut oaks, hickory, and old Virginia pines dominated the canopy with sparkleberry and devil's walking stick as common shrubs. Harper (1943) spoke of Virginia pine and chestnut oak in "rocky places."

Just east (downslope) of the sandstone rim was a typical submesic deciduous slope forest of chestnut oak and hickory (*Carya alba, C. glabra*). A blueberry and mountain laurel were dominant shrubs. Small post oaks were present along with maple leaf viburnum, witch hazel, and hazel nut as prominent shrubs. False Solomon's seal was a common herb.

The most xeric example is represented by a mixture of pines and hardwoods. On the eastern rim of Lookout Mountain in a "rock city" type (Highway 239) of environment, the dominant canopy **trees** appear to be dwarfed shortleaf and Virginia pines, Photo A16. Stunted horse sugar serviceberry sourwood and persimmon grew almost as shrubs; yellow jasmine provided common ground cover Some small pignut hickories, red maples, and chestnut oaks were present in dwarfed subcanopy or shrub stage.

As on Piedmont granite outcrops where there is a strong surface seepage, we find a curious combination of xeric and moisture-loving plants. Red and black chokeberry and mountain laurel represent the dominant **shrubs**. There is an occasional clump of catawba rhododendron. Yellow jasmine and grapevines appear as dominant ground cover Some **herbs** characteristic of granite outcrops occur such as the lily sunnybells (*Schoenolirion croceum*) and the stone crop *Sedum* (*Diamorpha smallii* Steve Bowling (pers. comm.).

Watts (1975), apparently describing the rim-rock of Pigeon Mountain, states that the "natural habitat for pine is the cliff edge, where Virginia pine is the most common. It is associated with beaked hazlenut (*Corylus cornuta*), mountain laurel, and other ericaceous plants." He analogizes it to Braun's (1950) "pine-heath."

Jones (1940) indicates the presence in the Great Valley of limestone outcrops bearing a fern flora distinct from sandstone outcrops. On limestone outcrops he found the hairy lipfern (*Cheilanthes lanosa*), ebony spleenwort (*Asplenium platyneuron*), and purple cliff brake (*Pellaea atropurpurea*), while on sandstone he found wooly lipfern (*Cheilanthes tomentosa*), mountain spleenwort (*Asplenium montanum*), and Bradley spleenwort (*Asplenium Bradleyi*).

2. SUBSURFACE ENVIRONMENTS

## [51] CAVES

### Location and Description

Extensive caves occur in the Cumberland Plateau of Dade County. An example is Case Cavern in the bottom of Cloudland Canyon. Here the principal surface rock is limestone of Mississippian age. For notes on cave **Fauna** and **Man's Impact**, see section at rear of Sedimentary Region.

**Fauna of the Sedimentary Region.** The famous Ladd Quarry in Knox dolomite (Bartow Co.) has yielded a fascinating Pleistocene fauna (see introduction, Blue Ridge Province and Ray, 1967). Few studies have been made of the modern fauna. The abundance and variety of molluscs in the Coosa and tributaries is mentioned elsewhere.

Some reptiles and amphibians are (Conant, 1975) confined to the Sedimentary Region: zig-zig salamander (*Plethodon dorsalis dorsalis*), northern spring salamander (*Gyrinophilus porphyriticus porphyriticus*), northern two-lined salamander (*Eurycea bislineata bislineata*), long-tailed salamander (*E. longicauda longicauda*), cave salamander (*E. lucifuga*), Tennessee cave salamander (*Gyrinophilus palleucus*), cottonmouth (*Agkistrodon piscivorous leucostoma*), black kingsnake (*Lampropeltis getulus niger*), striped-neck musk turtle (*Stenotherus minor peltifer*), map turtle (*Graptemys geographica*), midland painted turtle (*Chrysemys picta marginata*), Cumberland pond slider (*Chrysemys scripta troosti*), mountain chorus frog (*Pseudacris brachyphona*), and the Gulf coast soft shell (*Trionyx muticus*). The six with double (binomial) names are true species, those with trinomial names are merely varieties or subspecies.

The green salamander (*Aneides*) occurs in rock crevices in gorge walls in the Cumberland Plateau much as it does in Tallulah Gorge. Associated with the twilight zone of caves are the interesting prehensile-tailed cave salamander and the Tennessee cave salamander listed above. Cave crickets are a part of this cavemouth fauna. Deeper in many caves is a troglodite fauna of blind, pigmentless animals, including the southern cavefish (*Typlichthys subterraneus*), some blind crayfish, and other invertebrates. Many caves have colonies of colonial bats of genera such as *Myotis* and *Pipistrellus*, which hibernate in these equithermal retreats.

Although they have not been investigated, the hemlock-heath ravines could possibly yield boreal mammals, such as the red-backed vole.

### Fauna of the Great Valley

The herpetofauna of the Great Valley is becoming known. Conant (1958) records the barking tree frog from this area in Georgia. A recent study of Alabama's Coosa Valley by Redmond (1975) supports the contention that the Great Valley represents a broad pathway for Coastal Plain elements to invade or survive in NW Georgia, attesting the faunal uniqueness of this region. Redmond found the following Coastal Plain vertebrates in the Great Valley relatively near the Georgia line: oak toad, green tree frog (Cherokee Co.), squirrel tree frog (Etowah Co.), mud salamander (*Pseudotrition montanus flavissimus*), red-tailed skink (*Eumeces egregius*), chicken turtle (*Dierochelys*) (Shelby Co.), and map turtle (*Graptemys geographica*) (Coosa Co.). The pine woods tree frog (*Hyla femoralis*), gopher frog (*Rana areolata*), and the southern hognose snake (*Heterodon simus*), along with the chicken turtle, squirrel tree frog, and oak toad, extend north of the Alabama Coastal Plain only in the Coosa Valley. In some (gopher frog, pine woods tree frog, coral snake) the populations are disjunct, indicating to Redmond that they were once more widespread. Those, such as the oak toad, with ranges still continuous with the Alabama Coastal Plain, suggest to Redmond a recent northward dispersal. Some animals (green tree frog, barking tree frog) with isolated populations elsewhere above the fall line Redmond considers once more widespread and now able to survive locally in suitable habitats. We have collected a number of cottonmouths from oxbow lakes at Forster's Bend of the Coosa River.

For the small vertebrate fauna of the sagpond area of the Great Valley, (see [36] SAGPONDS, HYDRIC section). Golley (1962) records the presence of the cotton mouse (*Peromyscus gossypinus*), primarily a Coastal Plain mammal, in the Great Valley, whereas in the Blue Ridge, Cohuttas, and Piedmont the dominant form is the white footed mouse (*P. leucopus*) at similar elevations.

**Natural and Cultural Values of the Sedimentary Region.** Bluffs along the Coosa, such as Black Bluff, should be preserved for their outstanding mesic and northern flora. Some of the colluvial flat forests, especially along spring runs, are ideal park and recreation sites, seldom, if ever, flooding. The oak-hickory slope and ridge forests provide much game food and cover. Fortunately, erosion of steep slopes is not nearly so serious here as in the Blue Ridge Province. The forests do serve to protect the recharge capacity of local aquifers that provide well water and supply the springs and streams of the area. Obviously, near-original remnants of forest environments should be preserved wherever found. Unique ravines, such as Cloudland Canyon, offer valuable recreational and esthetic experience. The hemlock-rhododendron community along Daniel and Bear branches is scarce and the stunted forest of naturally bonsaied trees along the eastern rims of the Cumberland Plateau are spectacular and should be preserved from abuse, such as trash dumping and shrub digging.

In places where the highway is close to the rimrock, such as McCarty Bluff (Dade Co.) on the western rim of Lookout, hang gliding take-off points are heavily used. The forest with long-leafed pines on Lavender Mountain is biologically unique and should be protected. It is remarkable that the cottonmouth snake, normally a resident of sluggish Coastal Plain streams, occurs in the Lavender Mountain area in rocky torrents, as it does in parts of northern Alabama. The cedar glades are obviously exotic environments. No samples of the Coosa flatwoods are known to exist. Various caving groups have long sought protection for the outstanding caverns of this region, many of which have been heavily abused.

The Great Valley has hardly been recognized as a separate ecological entity. We are just beginning to realize that it is a wide and important corridor running through Alabama from the Coastal Plain, most obvious when one looks at Harper's (1943) map of Alabama. Apparently, the flora and fauna are closely related to the Coastal Plain. Few natural samples of ecosystems exist. The unique **sagponds** numbering up to 95/mi$^2$ are certainly important in this regard.

This region is an educational trip in physical and historical geology. It affords exciting vistas from the rimrocks. There are several gorges or "gulfs," some relatively unknown, and there are many waterfalls. Pigeon Mountain, with both caves and rimrock formations, is being acquired by the state under the Heritage Trust program. A number of archaeological sites, such as the one at Cave Springs and the important archaic and protohistoric sites at Foster's Bend (Floyd Co.), are being studied. Ladd's Quarry is now one of the most famous Pleistocene fossil localities in the world. The region, especially along the Cartersville Fault, has been heavily mineralized. The major aluminum ore, bauxite, was first discovered in North America at the Hermitage Mine in 1878. Coal and high energy shales are present in the area in limited quantities.

### Man's Impact on the Sedimentary Region

Lipps (1966) records the impact of Cherokee agriculture with some exact acreages in cultivation. Since the advent of Caucasian man about 1832 agriculture has eliminated most of the original forest of the flat and rolling terrain, both in the valleys and on the plateaus. Harper (1943) commented that the poor soil on Sand, Lookout and Pigeon mountains was easily tilled, hence large areas were cultivated. Lipps documents a drastic reduction in post and red oaks after 1832. Forests that remained after agricultural clearing were either logged, or cut to provide charcoal by several large companies.

The impact of fire on these environments is difficult to assess. Since the Cherokees relinquished all claim to northwest Georgia in 1835, there is a history of fire. Early records (USDA, 1911, 1942) indicate that a large proportion of the forests of John and Horn mountains were killed by fire and the forested slopes of Lookout and Sand apparently burned regularly.

Large acreages were cut to produce charcoal. Charcoal was used for smelting iron mined from Lookout Mountain. Harper (1943) indicates that in 1913 all of the charcoal iron furnaces of Alabama were located in the Coosa Valley. He also states that the turpentine industry operated in Talladega County for a few years. In addition to logging damage, the higher terrain dries out rapidly and, apparently, fires were repeatedly set to burn the woods in the fall until as late as 1936, Lipps (1966). Jones (1940) states that the most extensive logging was between 1866 and 1870. He was able to study some second or third growth forests. Most of his trees were 90 years old with a median age of 73 years. The oldest tree found was a 221 year old black oak which was cut in 1939. Jones calculated that loblolly pine constituted (in 1940) about two-thirds of the stems of cutover forest on rolling uplands in the Great Valley.

Mining has also had a considerable impact on parts of this area. The first bauxite was mined by open pit beginning in 1878 in Bartow County. Other minerals, such as barite (ore of barium) and ocher, have been strip-mined from the eastern Great Valley for many years. Some cement is produced from outcrops in or near the Great Valley. Coal has been mined on the Cumberland Plateau. Some shales, such as the Chattanooga shale, are highly carbonaceous and can almost burn as coal does. With continuation of an energy shortage, coal mining in the area may resume.

The rimrock areas of the Cumberland Plateau are subject to abuse. There is an unsightly garbage dump off the edge of the cliff along Highway 239 several miles north of the Lookout community. Hang-gliding enthusiasts have built a cement take-off platform at McCarty Bluff on Highway 157. Some caves have been heavily abused by dumping, the breaking of stalactites and stalagmites, and grafitti.

## METAMORPHIC REGION

## BLUE RIDGE PROVINCE

This physiographic category includes the rounded, eroded crystalline rock masses of the Blue Ridge and Cohuttas with dendritic drainage patterns, contrasting with the linear steepsided elevations of the Ridge and Valley Province with its trellis drainage.

The term "Southern Appalachians" is used by Braun (1950) to cover the non-sedimentary portion of the Appalachians. The Appalachians are very old, portions having undergone erosion for 400 million years. The core of the range has had five or six miles of rock removed from it. Hack (1969) reviews the evidence of cyclic erosion resulting in peneplains described by various authors. He believes that a more acceptable theory is the "equilibrium concept" in which the present landscape "developed by continuous down-wasting of the topographic surface for many thousands of feet," which is a way of saying that the present land forms are the result of the slope, dips, and degrees of erodability of the rocks underlying them. His corollary assumption is that the forests are likewise adjusted to the present environment both locally and regionally, and that "simple classification of forest into broad regional types gives a false picture of the true nature of the environment." In his research Hack found that available soil moisture was the most important factor controlling plant distribution, "resulting in a remarkable relationship between species of forest trees and physical environmental factors." He endorses the concept that plant associations are accidental conglomerations of individual plants that arrived in the area and were able to survive there rather than the traditional view that highly organized plant associations are best explained in terms of successional changes in the complex organism of the forest itself. It is perhaps best not to take either side of this argument. Research into the nature of the complex interrelationships of plant and animal biocenoses will help us think about these problems.

Since the southern Appalachians have been a mountain mass for hundreds of millions of years, this area is considered to harbor one of the oldest aggregations of plants, and perhaps animals, in North America. According to Little (1970), many plant genera in the southern Appalachians are relicts from the Arcto-Tertiary flora, "the fossil plants of northern or Arctic regions in late Mesozoic and early

Cenozoic eras." During this time the Arcto-Tertiary forests covered much of Eurasia and North America, being broken into areas of concentration or refugia, the richest representation being in China and Japan, the second largest in the Southern Appalachians.

Before discussing the nature of our present forest, a word needs to be said about climate. Past climates may have been quite different, and may have aided the survival of the Arcto-Tertiary biota in the higher mountains. Hack (1969) cites the occurrence of spruce pollen in present Appalachian bogs and in Carolina bays. During the Wisconsin glacial maximum (20,000 years BP) spruce and pine apparently occurred in Dismal Swamp and at Singletary Lake in SE North Carolina, Whitehead (1967).

Benninghoff and Stevenson (1967) and Watts (Greear, 1967) found that pollen from Ladd's Quarry and the sagponds of Bartow County (carbon 14: 20,100 $\pm$ 240 BP) indicated a forest of northern pines with some spruce between 22,000 — 13,000 BP. These were the now boreal jack pine (*Pinus banksiana*) and spruce (*Picea rubens/mariana*), presently growing some 700 miles north. Ray (1967) found fossil evidence of spruce grouse (*Canachites canadensis*) and wood turtle (*Clemmys insculpta*) at the Ladd quarry.

Hack (1969) summarizes other data which suggest that northern hardwood forest was much more extensive and may even have covered large parts of the Coastal Plain. He cites evidence of fossil dunes in South Carolina sandhills that may be Pleistocene in age. Hack discusses the "block fields" of ice-fractured rock (see [53] BOULDERFIELDS) we now find on the north slope of Brasstown Bald and the north face of Hightower Bald, now overgrown with northern hardwoods. Evidence indicates a rather rapid warm-up about 9,000 years ago, with more rainfall, erosion, and silt in the Appalachians, Hack (1969).

Hubbard (1971) states that "In the southern Appalachians there is little question that broadleaf forests would have been displaced by spruce/fir/forest from all but the lowest elevations, probably retreating largely into the Coastal Plain south of the Carolinas . . . " The so-called Braunian hypotheses that the ice sheets had little effect on the flora and fauna to the south is rejected by Hubbard and other authors on the basis of the fossil evidence. Radford (1974) apparently also rejects the idea that Pleistocene glaciers did not change vegetation zones in the Southeast. He restates the findings that there was a full glacial forest in southern North Carolina with red pine and 7% spruce, with some fir and two species of *Lycopodium*. He feels that the late glacial (15, 000 — 10,000 BP) age supported a beech-hemlock forest in its earlier years, and that from 10,000 BP on it was oak-hickory forest. He thought that a mixed mesophytic forest spread over the Piedmont but later retreated, leaving relict communities here and there on north-facing bluffs.

Braun classifies both the Blue Ridge and the Ridge and Valley Province as part of the "oak-chestnut forest region." In the 1930's the chestnut was destroyed by an Eurasian fungus (*Endotheca parasitica*) introduced on lumber into New York City. The spores spread southward by wind, the feet of woodpeckers, and other vectors. The "chestnut blight" removed an estimated one quarter to one half of all forest stems from millions of acres of forest slopes, Brooks (1971). Chestnuts grew rapidly and produced a huge nut crop. Their spiny pericarp protected the nuts from some animals, thus providing the food for a wide variety of wildlife. Its fallen logs in a situation neither too moist nor too dry endure for many years and provide food and shelter for many animals. Even today sound chestnut logs are still being removed from Appalachian forests. The effect of the loss of the chestnut on wildlife must have been profound. (See comments on the chestnut in Piedmont, **xeric broadleaf deciduous forests**.) Today, chestnuts are still sprouting from the stumps and, at higher elevations, producing small crops of nuts. A "new" habitat, called the "chestnut sprout association," was described by Maurice Brooks (1971) and Eugene Odum. This growth modified many shrub and transgressive communities of the southern Appalachians; in some areas or regions — breeding birds switched nesting sites to these new "thickets." The chestnut is recognized as a component of the xerophytic mountain forest by some, Hubbard (1971). Tucker (1973) considered that it "occupied the moist slopes of moderate elevation." In Georgia's Cooper Creek (Union Co.) Scenic Area the best chestnut grew on moist and gentle slopes (NE face), along with large poplars and white oak. In my experience it is found mostly on rich, well-drained soils, usually with *Carya ovalis* and large tulip poplar as co-dominants, similar to the situation at Cooper Creek.

Tucker (1973) summarized the changes that followed the death of the chestnut in mountain areas. At high elevation sites at Highlands and in the Great Smokies northern red oak was the primary site inheritor, followed by chestnut oak and white oak. At lower elevations black oak becomes the most important canopy member, followed by chestnut oak and white oak. Research at Coweeta found dramatic increases in basal area for black oak (from 9.57 to 17.94 sq. ft.) between 1934 - 1953, following death of the chestnut. There are also indications that since the death of the chestnut, forest conditions are accelerating in the mesic direction, leading to an invasion of hemlock into the lower elevations of the slope community. Tucker indicates that it is too early for an equilibrium to have been established in slope communities once occupied by chestnut. This should be kept in mind during our classification and discussion of mountain forest.

Successional forests are not treated in the following classification. Pure pine forests in the mountains are almost always the result of human modification, although rocky ridges may support a natural pine-dominant canopy. Some stands of Virginia pine or shortleaf may be due to natural catastrophe. Very steep slopes were pastured or put into orchards by the early settlers. These are usually distinguished now by dense stands of tulip poplar or tulip poplar-black locust. If a seed source is available upslope, a white pine forest may result under mesic conditions in some areas. Under drier or rocky conditions, apparently either Virginia or shortleaf pine forms the successional stage in most of northern Georgia. Heavy logging may modify slope forest so that white pine invades.

The Metamorphic Region of the Appalachians is immensely old. The detritus of millions of years of erosive weathering has contributed sands as far away as peninsular Florida. In our Blue Ridge subtle differences in rock type account for the heights of different peaks. For example, the micas in schists resist weathering more than the feldspars making up harder rocks. Rocks which weather in place produce a crumbled residual material called "saprolite," which may become soil when acted upon by the biotic community. In steep terrain one often finds valleys filled with soil of a different origin. Called "colluvium," this soil forms a layer over the residual soils. In road cuts the divinding line is often clear, the overlying colluvial soil frequently contains rocks and boulders carried down with it from the valley walls. Colluvial soil accumulates downslope by the action of landslides, sheet wash, and ice tumble. The latter phenomenon is based on the fact that ice crystals push a rock out perpendicular to the slope surface, yet on melting the rock falls by gravity downslope, not back to its original resting place. Also we must not forget the 1,000 year deluge, whose enormous erosive power makes dramatic changes overnight. Since the Pleistocene we may have had 20 such events, R. Hatcher (pers. comm.). Thus many stream valleys are filled with colluvium and may be called "colluvial flats," readily identifiable on topographic quadrangles as flat areas enclosed by steep ridges.

In the mountains we also find deep, black (melanized) soils either of residual or colluvial origin. These soils are considered podzols (soils forming under cold, acid conditions). Where the water table is high, they may be called "ground water podzols." Due to cold, acidity, or water, bacterial decomposition is retarded and organic material fails to be oxidized, thus accumulating and causing the black color. Such soils may be seen forming beneath rhododendron or other heath plants at higher elevations. Black podzolic soils on gently-rounded ridges, such as found in the Rich Mountain wilderness, may be relict soils formed under a now-vanished conifer forest during the Pleistocene, R. Curry (pers. comm.). Careful attention to rock type may reveal subtle differencs in the plant (and perhaps the animal) communities, particularly in the mountains and Piedmont. According to A.E. Radford (pers. comm.), soils derived from hornblende gneiss have plants that are distinct from those on adjacent soils derived from biotite gneisses and schists. On the Scaley Ridge cliffs, for example, a few miles north of the Georgia line (Clay Co., N.C.), the herbs are exemplified by *Trillium grandiflorum*, meadow parsnip (*Thaspium* sp.), a mustard (*Arabis* sp.), and pipevine (*Aristolochia macrophylla*). The "ecosystematic" approach developed by Radford takes into account all of the environmental factors operating to control a plant community and is the next and ultimate step in precisely defining natural environments.

Classification of mountain soils is complex. An early survey, USDA (1954), indicates that ridge soils in the Brasstown Bald area (Towns Co.) are Porters-Balfour stony loam or Porters stony loam. The very narrow backbone of Hightower Bald ridge was called either "rough stony land" or Porters stony loam. A later survey (USDA, 1972) places the highest ridges of Dawson, Lumpkin and White counties in the Edneyville-Porters-Ashe Association, with the lower slopes in the Hayesville-Fannin-Edneyville Association (broken ridgetops and irregular hillsides) or the Tallapoosa-Musella Association (cobbly soils on ridgetop, foothills and low mountains). A typical low mountain area (south slope) is the Jones Creek watershed. Jones Creek is an Etowah tributary (Lumpkin Co.). Here, narrow bottoms (in corn or hay) are classed as Toccoa soils and are surfaced with brown sandy loams. Much of the slope forests occur on the Tallapoosa Series, having sandy loam soils with weathered saprolite below 18 inches and up to 20 feet deep. The remainder of the Jones Creek slope forests, especially on S and E-facing slopes, are Edneyville soils — loams and clay loams overlying bedrock 38 inches below. The most extensive soil, however, in the Jones' Creek area, is the Hayesville sandy loam with the A and B horizons extending to 42 inches and the bedrock deeper than six feet. This strongly acid soil occupies most of the rounded ridgetops.

In the Rich and Cohutta mountains and in the Tallulah watershed, the Tusquitee stony loam is formed in colluvium in narrow coves, USDA (1954, 1973), and probably underlies environments [60] and, possible [53]. Most higher slope forests and some rounded ridge forests, such as the [57] OAK-CHESTNUT-HICKORY forests, would appear to grow on Porters stony loam (USDA, 1954) or on Ashe-Edneyville stony loam (USDA, 1973). These soils are derived from gneiss, granite or schist which lies from 24 to 52 inches below the surface. This latter soil group includes the deep, black soils similar to the Porter Series (USDA, 1973) and covering rounded ridges, such as Little Aaron Mountain (Gilmer Co.), and filling deep coves supporting both environments [52] and [55]. Earlier research (USDA, 1928) called this soil Porters loam and stated that it was developed from colluvial material in coves with northern exposure and on "the tops of smoother mountains." It was sometimes cleared by mountaineers for pasture and hog range and, rarely, to grow potatoes.

## II. MESIC TO XERIC SYSTEMS (CONTINUED)

### BLUE RIDGE PROVINCE

(Blue Ridge and Cohutta Sectors)

1. BROADLEAF DECIDUOUS FORESTS
   a. MESIC FORESTS
      - [52] BROADLEAF DECIDUOUS COVE FOREST
      - [53] BOULDERFIELDS
   b. SUBMESIC FORESTS
      (1) RIDGE FORESTS
      - [54] OAK RIDGE FOREST
      - [55] CHESTNUT RIDGE FOREST
      - [56] CHESTNUT OAK RIDGE FOREST

      (2) SLOPE FORESTS
      - [57] OAK-CHESTNUT-HICKORY FOREST

      (3) SUMMIT FOREST
      - [58] SHRUB BALD
   c. XERIC FORESTS
      - [59] BROADLEAF DECIDUOUS RIDGE FOREST
2. BROADLEAF DECIDUOUS-NEEDLELEAF EVERGREEN FORESTS
   a. MESIC FORESTS
      - [60] BROADLEAF DECIDUOUS-HEMLOCK FOREST
   b. SUBMESIC FORESTS
      - [61] BROADLEAF DECIDUOUS-WHITE PINE FOREST
   c. XERIC FORESTS
      - [62] BROADLEAF DECIDUOUS-PINE RIDGE FOREST
3. ROCK OUTCROPS
   - [63] CLIFFS AND GORGE WALLS

KEY TO BLUE RIDGE PROVINCE UPLAND (MESIC TO XERIC) ENVIRONMENTS

1a Exposed rock in cliffs or gorges.
[63] CLIFFS AND GORGE WALLS
1b Little or no bedrock visible (Select 2a or 2b).
2a Plant community shrub-dominated, trees if present stunted; found on the tops of highest peaks.
[58] SHRUB BALD
2b Plant community tree-dominated, on terrain other than highest tops (Select 3a or 3b).
3a Forests predominantly hardwood, few or no pines, hemlocks or cedars (Select 4a or 4b).
4a Biotic communities occuping north-facing coves at high elevations (Select 5a or 5b).
5a Ground surface a jumble of moss-covered boulders, usually above 3500 - 4000 feet; no soil visible; water sub-surface; usually at heads of north-facing coves; yellow birch often dominant tree.
[53] BOULDERFIELDS
5b North-facing coves usually above 3500 feet. Buckeye, basswood, black birch and tulip poplar likely; limited shrub zone; herbaceous community extremely rich.
[52] BROADLEAF DECIDUOUS COVE FOREST
4b Hardwood forests of ridges or slopes (Select 6a or 6b).
6a Ridge forests (Select 7a or 7b).
7a Ridge forests at high elevations, usually above 3500 feet (Select 8a or 8b).
8a .High ridges (such as along the Appalachian Trail) dominated by short-trunked and gnarled northern red oak, or , sometimes, white oak.
[54] OAK RIDGE FOREST
8b Ridge now or formerly chestnut-dominated (snags, stumps or sprouts visible); ridges are generally rounded and with deep, rich soil.
[55] CHESTNUT RIDGE FOREST
7b. Ridge forests at lower elevations, usually below 3500 feet, with species other than in 8a or 8b, but if occuring above 3500 feet, ridge usually very rocky or with thin soil. (Select 9a or 9b).
9a Ridge forests with rocky, thin soil dominated by chestnut oak.
[56] CHESTNUT OAK RIDGE FOREST
9b Dry ridge forest at low elevations either dominated by a single oak species (such as blackjack), or more usually with a mixture of as many as 6 different oak species.
[59] BROADLEAF DECIDUOUS RIDGE FOREST
6b Slope forests. Dominant forest on slopes of Blue Ridge. Forested with a combination of oak, hickory and, formerly, chestnut; shrub layer diverse, often with localized patches of mountain laurel, rhododendron, blueberries or other heaths. Grades and blends into most environments listed above.
[57] OAK-CHESTNUT-HICKORY FOREST
3b Forests of hardwoods mixed with pine or hemlock (Select 10a or 10b).
10a Dry ridge forests lying usually between 2000-3500 feet and characterized by the presence of pitch pine.
[62] BROADLEAF DECIDUOUS-PINE RIDGE FOREST
10b Slope or cove forests (Select 11a or 11b).
11a Forests containing hemlock, usually in the lower parts of coves, in streamside zones or, sometimes, in nearly pure stands on colluvial or alluvial "flats" along mountain streams.
[60] BROADLEAF DECIDUOUS-HEMLOCK FOREST
11b Forests containing white pine, usually on slopes and deep-soiled ridges at moderate elevations (1500-3000 feet). Rarely forming pure stands, but may do so following disturbance of the original forest.
[61] BROADLEAF DECIDUOUS-WHITE PINE FOREST

BLUE RIDGE PROVINCE

(BLUE RIDGE AND COHUTTA SECTORS)

1. BROADLEAF DECIDUOUS FORESTS

a. MESIC FORESTS

## [52] BROADLEAF DECIDUOUS COVE FOREST

### Location and Description

Moist, cool, north-facing mountain coves serve as refuges for a once widespread vegetation that has apparently existed since the Tertiary. Generally there is a deep, black humus-darkened soil. The upper end of such coves may bear a "northern hardwood" vegetation type — the lower end may be dominated by hemlock, see [61] BROADLEAF DECIDUOUS-HEMLOCK FOREST. If the upper end is a jumble of moss-covered rocks, I classify it as [53] BOULDERFIELDS.

The trees are distinctive, with numerous moisture-loving species. Shrubs are not conspicuous — it is the richness of the herbaceous layer adapted to the friable, mull soil that is striking.

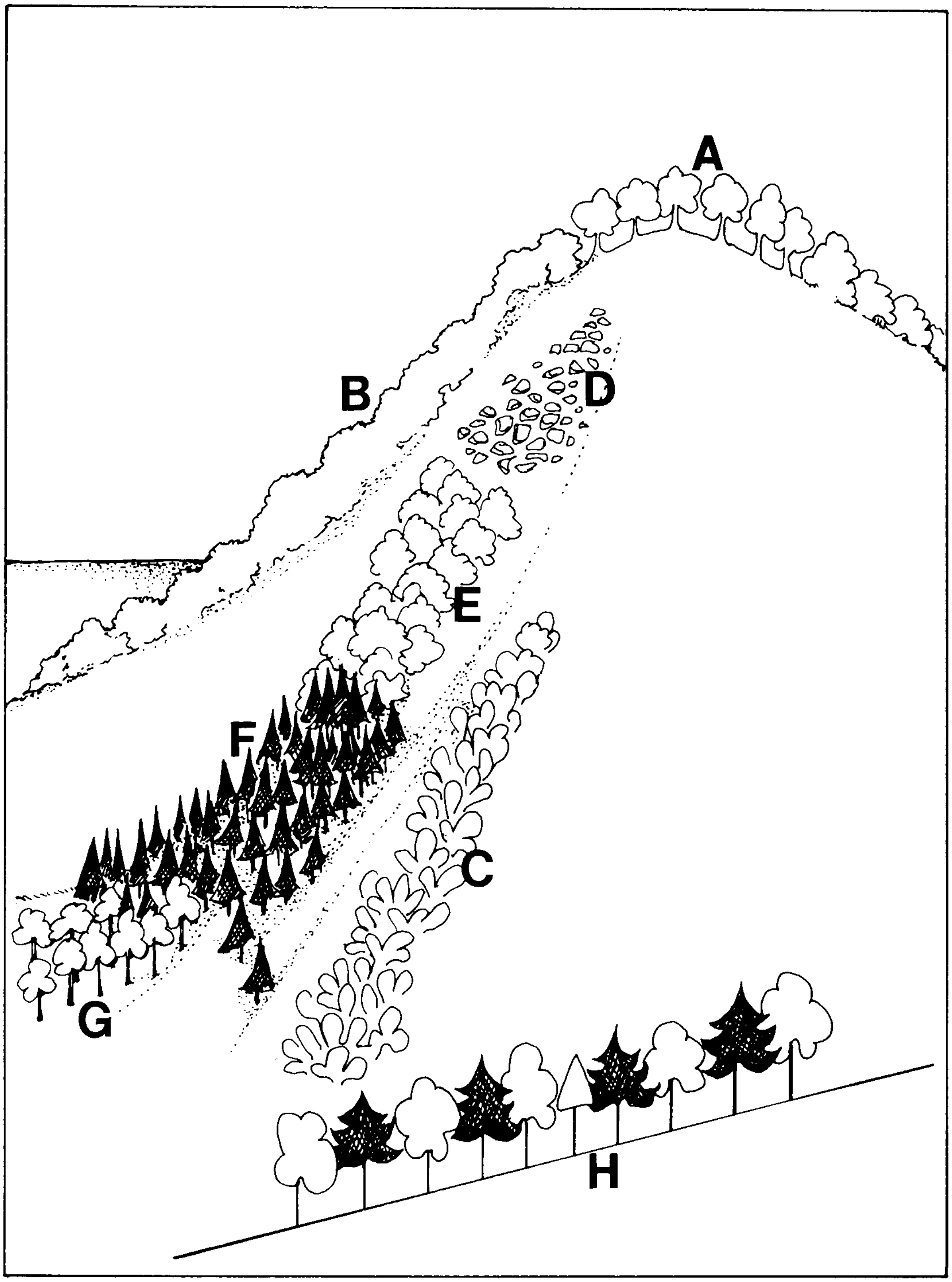



Fig. 25. Some Blue Ridge Province environments, indicating topographic location: (A) oak ridge forest [54]; (B) oak-chestnut-hickory slope forest [57]; (C) chestnut oak ridge forest [56]; (D) boulderfields [53]; (E) broadleaf deciduous cove forest [52]; (F) broadleaf deciduous-hemlock forest [60]; (G) colluvial flats with birch at high elevations; (H) broadleaf deciduous-pine ridge forest [62] (pitch pine ridge at lower elevations). North is at extreme lower left.

A virgin area of this type is the upper north face of Brasstown Bald (Union Co.). Other examples are numerous, usually at elevations over 3,000 feet: the heads of coves on the north face of Hightower Bald (Towns Co.), Till Ridge Cove (Rabun Co.), Sosebee Cove (Union Co.), Devil's Den (Fannin Co.), Wolf Pen Gap Cove (Gilmer Co.).

This forest corresponds to Kuchler's (1964) "mixed mesophytic forest" (except that it lacks hemlock), to Braun's "mixed mesophytic cove forest," and to Cain's (1943) "buckeye alliance." Cooper and Hardin (1970) recognized two divisions of mixed mesophytic forest in Blue Ridge escarpment gorges: cove and slope segregates. Braun (1950) viewed the mixed mesophytic cove forests as very similar (except for the addition of silver bell, *Halesia monticola*) to the forests occupying the Cumberland Plateau. This community may occupy colluvial flats (see introduction, Mountain Province) resembling miniature floodplains, but of a different origin. Removal of original timber from colluvial flats at higher elevations will invite a thick stand of black birch or yellow poplar.

Photo A17 The upper ends of mountain cove forests [52], if north-facing, often bear stands of yellow birch, here shown in winter aspect in the Cohuttas of Fannin County.

## FLORA

**Trees** — Several authors have worried over the distinction between "northern hardwoods" and typical "cove hardwoods." Whittaker (1956) defined northern hardwoods as a high altitude (3,500 4,500') segregate of cove hardwoods. Braun (1950), outside the Great Smokies, considered that the cove and northern hardwoods were distinct. She indicated that the "northern" canopy dominants were sugar maple, yellow birch, beech, and buckeye.

It is too difficult, in my opinion, to discern in Georgia a cove of "northern" hardwoods as distinct from the more common cove forest community, although the upper ends of many of our coves contain trees, such as yellow birch, striped and mountain maples, which I consider diagnostic of a northern forest community in Georgia.

The dominant trees in this community are buckeye, basswood (*Tilia heterophylla*), tulip poplar sugar maple (only close to the N.C. line), silver bell, and, formerly in some coves, chestnut. If the coves reach beyond 3,000 feet the upper ends are often dominated by trees of distinctly northern affinities, such as yellow birch, sometimes mixed with beech. Buckeye and silver bell are distinctly southern genera, Braun (1950). Further down in the coves other southern species may occur such as the umbrella, bigleaf, and Fraser's magnolias. Other common trees are northern red oak, wild cherry, white ash, red maple, and bitternut hickory.

The Devil's Den site has as dominants beech, buckeye, basswood, striped maple, yellow and black birch. The upper portions of Sosebee Cove have as dominant trees, buckeye (some very old examples), tulip poplar basswood, black birch, striped and mountain maples, and serviceberry. It is also a station for one of our rarest trees, the yellowwood (*Cladrastis*). Sosebee Cove has been heavily modified by logging, altering the floristics. Yellow birch is nearly absent, although black birch is very abundant. The north face of Brasstown is dominated by yellow birch with beech and black birch as co-dominants and, lower down, yellow buckeye.

The north-facing Loggy Branch Cove (Hightower Bald) forest (mostly above 3,200 ft. elevation) has as dominants sugar maple, black birch, tulip poplar and as a co-dominant the rare yellowwood. Yellow birch appears higher in the cove and some buckeye and black cherry are present. At high elevations a forest of yellow birch is being invaded by buckeye (probably following heavy logging). In high mountain areas either yellow or black birch may be a successional invader following heavy logging of the original forest, such as has occurred in most of these rich coves. Loggy Branch Cove has the largest number of the rare yellowwood trees known to exist and reproduce in Georgia, J. Dan Pittillo (pers. comm.). Under or near the Hightower Gap is perhaps the only Georgia example of a "*Beech Gap*" — a stand of beech-buckeye which is a common and distinctive minor habitat in the higher Appalachians of North Carolina. Till Ridge Cove supports a forest of sugar maple, basswood (*Tilia heterophylla*), northern red oak, mountain maple, and sweet birch, Marie Mellinger (pers. comm.).

Loy Davenport (pers. comm.), who logged the original timber in the Rich Mountain area (NE Gilmer Co.), recalls that northern red oak and tulip poplar were the dominant hardwoods in Ramp Gap and Wolf Pen Gap coves. In the latter, subcanopy silver bells were left, now grown into giants up to 75 inches circumference. In many coves black birch has come in as a successional species down to 3,000 feet. In Sosebee Cove, removal of the original red oak, tulip poplar, and basswood has left a forest dominated by old giant buckeyes and young poplars.

Pure red oak stands on deep, rich, black soils Braun (1950) considers as part of the "northern hardwood" forest. I discuss such stands as [54] OAK RIDGE FOREST.

**Shrubs and Vines.** The spice bush (*Lindera benzoin*) is common in these coves. Rosebay rhododendron is perhaps the most common shrub. Radford (1974) lists several northern hardwood communities. One from Haywood County, North Carolina at 5,220 feet has a yellow-birch-beech forest with *Cornus alternifolia, Ilex ambigua, Vaccinium erythrocarpum,* and *Vibrunum alnifolium* as shrubs. Braun indicated that in the northern hardwoods the following dominant "shrubs" appeared: hobblebush (*Viburnum alnifolium*), striped maple (*Acer pennsylvanicum*), mountain maple (*Acer spicatum*), and azalea.

**Herbs.** The herbs marked with an asterisk below are the ones which are more or less diagnostic for this environment: false lily of the valley (*Maianthemum canadense*)*, false hellebore (*Veratrum parviflorum*)*, American false hellebore (*V. viride*), tasselrue (*Trautvetteria caroliniensis*)*, spring beauty (*Claytonia caroliniana*)*, wild monkshood (*Aconitum uncinatum*), golden seal (*Hydrastis canadensis*), ramp (*Allium tricoccum*)*, trout lily (*Erythronum americanum*)*, mandarin (*Disporum* sp.)*, nodding trilliums (*Trillium cernuum* and *vaseyi*), 3-birds orchid (*Triphora trianthophora*), twayblade orchid (*Liparis lilifolia*), ladies' slippers (*Cypripedium calceolus*), kidney-leafed twayblade (*Listera smalli*) growing beneath dense rhododendron, umbrella leaf (*Diphylleia cymosa*)*, toothwort (*Dentaria diphylla*)*, squirrel corn (*Dicentra canadensis*)*, dutchman's breeches (*Dicentra cucullaria*)*, and ginseng (*Panax quinquefolia*). Some of these, like *Listera* and golden seal, are quite rare. Other common herbs are black snakeroot (*Eupatorium rugosum*), blue cohosh (*Caulophyllum thalictroides*), wood nettle (*Laportia canadensis*), foamflower (*Tiarella cordifolia*), water leaf (*Hydrophyllum canadense*)*, and honewort (*Cryptotaenia canadensis*).

The most common ferns in Sosebee Cove are Goldie's fern (*Dryopteris goldiana*), marginal wood fern (*Dryopteris marginalis*), intermediate wood fern (*Dryopteris intermedia*), and silvery spleenwort (*Athyrium thelypterioides*).

In wet areas we find monkey flower (*Minulus*), skullcap (*Scutellaria serrata*), and turtleheads (*Chelone* sp.).

Braun lists for her northern hardwoods the following dominant herbs (in part): False lily of the valley, oxalis (*Oxalis acetosella*), enchanter's nightshade (*Circaea alpina*), creeping bluet (*Houstonia serpyllifolia*), trout lily, spring beauty, and fringed phacelia (*Phacelia fimbriata*). The loggy branch cove, discovered by Wilbur Duncan, and perhaps our finest example of this environment, was dominated (April 27) by blue cohosh (*Caulophyllum*), goat's beard (*Aruncus*), two toothworts (*Dentaria diphylla* and *D. laciniata*), squirrel corn, dutchman's breeches, umbrella leaf, *Anemone quinquefolia*, and trout lily (especially), bellwort (*Uvularia*), false hellebore, bloodroot, buttercup, stinging nettle, various trilliums, and the rare Indian plantain (*Cacalia muhlenbergii*). The most common ferns appeared to be bladder fern, *Cystopteris protusa*, and silvery spleenwort (*Atherium thelypterioides*).

The pH of these rich coves is often circumneutral, unlike the more acid soil of the oak and conifer-dominated slopes. This allows the proliferation of trilliums and other plants which are known to prefer circumneutral soils. *Galax,* partridgeberry, rattlesnake plantain, and other acid-loving plants may be absent.

Section on mesic forest **Fauna, Values** and **Impact** follows [53] BOULDERFIELDS.

## [53] BOULDERFIELDS

On the high north face of Brasstown Bald, in the upper Sosebee Cove, in coves on the north face of Hightower Bald, in the head of Devil's Den (Fannin Co.), and on high, north faces in the Rich Mountain area (Gilmer Co.), are communities with a distinct geologic substrate — fields of angular rock or blocks of rock with little visible soil. These large angular boulders are apparently split out by the action of ice in Pleistocene or post-Pleistocene times. The areas, usually north-facing, may date back at least 10,000 years when rock spalling was replaced by erosion and grinding, although their exact age is uncertain. Hack's (1969) discussion of ice-fractured rock fields is cited in the introduction to this section. Boulderfields may represent a type of rubble colluvium or talus. They are more abundant in mountain ranges further north, such as in the Balsams (N.C.), and are often moss-covered and exceedingly beautiful environments. At altitudes above 4,000 feet, forest growing on them can almost be considered a cloud forest. It is very wet and cold, and trees are festooned with lichens ("old man's beard"). Water flows beneath the boulder fields and often can be heard through the rocks several feet below the surface.

### Flora

Boulderfields are generally always associated with the BROADLEAF DECIDUOUS COVE FOREST. Another suitable name is "moss gardens." There are several block fields on the north face of Hightower Bald at higher elevations (greater than 3,500 feet). There, three plants stand out as diagnostics of the habitat; strawberry vine (*Euonymus obovatus*), flowering raspberry (*Rubus odoratus*), and a gooseberry (*Ribes cynosbati*). Two evergreen ferns live there, the intermediate and marginal wood ferns *Dryopteris intermedia* and *D. marginalis*. Further study of these unique "mini-environments" would be rewarding.

Radford (1974) lists vegetation from a boulder field at 4,500 feet in Pendleton County, West Virginia, and states that yellow birch is characteristic of the thin-soiled block fields, with beech occuring where soil builds up in crevices.

Photo A18. Old yellow birch often occupies the upper ends of north-facing coves [52] here on Brasstown Bald (Towns Co.), growing in a BOULDERFIELD [53] with rosebay rhododendron as the dominant shrub and with a northern herbaceous flora. These old, gnarled trees are often festooned with "old man's beard," a lichen (*Usnea*) and are the closest thing we have to a cloud forest.

**Fauna of Mesic Forests.** See notes on invertebrate fauna under **Fauna of Submesic Forests.**

The aquatic vertebrates of the cove streams are reviewed in the HYDRIC section, [5] MOUNTAIN RIVER. In the small branches the Desmognathine salamanders, both in species and individuals, are abundant, dominated by the seal (*Desmognathus monticola*), black-bellied (*D. quadramaculatus*) and Blue Ridge Mountain (*D. ochrophaeus*) forms. The large purple salamander (*Gyrinophilus*) seems to be an indicator of the high northern cove stream fauna, being quite common in Sosebee Cove and in Brasstown Bald seeps. In the forests the slimy salamander is common. At higher elevations one finds a similar form, *Plethodon jordani,* especially on Rabun Bald and *perhaps* on Brasstown Bald, though not so mapped by Highton (1971). The only reptiles we have recorded from these environments are the box turtle and ringneck snake. I am sure that the garter snake occurs. Rodent-eating snakes are not found often in spite of high rodent densities. In some areas the timber rattlesnake is common where deep dens (rock cliffs) are nearby.

Although the south face of Brasstown Bald is quite another environment, I list here the birds named by Hubbard (1971) as breeding (or probably breeding) on Brasstown Bald (4,784 ft.), cited by Burleigh (1958): Golden Eagle, Yellow-bellied Sapsucker Least Flycatcher Raven, Winter Wren, Veery, Solitary Vireo, Golden-winged Warbler Black-throated Blue Warbler Blackburnian Warbler Chestnut-sided Warbler Canada Warbler, Rose-breasted Grosbeak, and Slate-colored Junco.

For seven years (1966-1970, 1972, 1973) we have trapped (or observed signs of) mammals at Sosebee Cove (Union Co.). The mammals are: (D) short-tailed shrew, smoky shrew (*Sorex fumeus*), (D) northern deer mouse (*Peromyscus maniculatus*), northern jumping mouse (*Zapus insignis*), (D) eastern chipmunk, woodchuck, deer and black bear Traplines on the north face of Brasstown have yielded little except northern deer mice and an occasional short-tailed shrew. Such block fields are a potential habitat for the rock shrew (*Sorex dispar*), but we have not taken it in Georgia. Closer to Brasstown's top we have taken a color mutant of the northern deer mouse (with a reddish belly instead of white) and golden mice in the dense rhododendron thickets near the summit. Collecting in coves in Fannin County and elsewhere has failed to add to the Sosebee Cove list.

Several other small mammals encroach into Georgia in this general environment close to the North Carolina line at the Rabun Bald and down the steep valley slope of Beech Creek (Towns, Rabun Co.) in the Tallulah River watershed. These additional species are the masked shrew (*Sorex cinereus*) and the pygmy shrew (*Microsorex hoyi*) reported by Wharton (1968a), and the red-backed vole (*Clethrionomys gapperi*) reported by Wharton and White (1967), all elements of the Boreal Forest (XB). I have (Wharton, 1968b) previously reported on the red squirrel which occurs in these coves as far south as the Brasstown Bald area. Tom French (pers. comm.) has taken the red-backed vole on the Hightower Bald Ledge. Such boreal mammals probably extend well down into Georgia along the high leads of the Blue Ridge.

There is a species of mammal that is found only in boulderfields farther north (in N.C.), the rock shrew (*Sorex dispar*), a Pleistocene disjunct. Other faunal elements are scarcely known.

**Natural and Cultural Values of Mesic Forests**

The deciduous cove forests and boulderfields are so scarce and beautiful as to warrant immediate inventory and protection. They are botanical paradises. Esthetically, they are often spectacular and exotic, especially the higher portions of the coves, such as the north face of Brasstown Bald. As educational outdoor laboratories they are unexcelled in mountain regions. The forests are true Arcto-Tertiary relicts, or living museums of an extremely old association of plants and animals.

**Man's Impact on Mesic Forests.** Logging is the greatest danger, especially clearcutting or regeneration cutting. These forests grow timber well because of their richness and moisture. Bulb diggers are a grave threat. Most of the yellow ladies' slippers have already been removed from Sosebee Cove (the pink one occurs in more acid soils). Small areas such as this are too vulnerable. Logging brings roads. Natural areas gated off and controlled (such as the north face of Brasstown) can work in places, in this case patrolmen are always nearby to control motorized access. Elsewhere, the answer to preservation lies in protecting large areas containing a number of these environments in back or wild country or special management categories. Laws against plant exploitation are urgently needed.

b. SUBMESIC FORESTS

I use Radford's (1974) classification of "submesic" to include the major forests of the Mountain Province. This is Kuchler's (1964) "Appalachian oak forest." These forests are not as moist as the mesic coves. As in all these divisions there is seldom a clear-cut boundary between this environment and the moist, rich coves. A north slope with rich soil at sufficient altitude will harbor some of the plants and some of the trees of the mesic cove. Variations in slope, compass exposure, and moisture complicate boundaries of mountain slope forests. Usually, however, as one tops out on a ridge, soils get thinner and drier and the chestnut oak begins to dominate the canopy. Limited knowledge of the soil and moisture requirements makes it difficult to state the precise requirements of white oaks, red oaks, and black oaks. **Fauna, Values** and **Impact** concerning the submesic forest will be treated at the end of the **submesic forest** section.

(1) RIDGE FORESTS

## [54] OAK RIDGE FOREST

**Location and Description**

From the Nantahala Mountains southward along the crest of the Georgia Blue Ridge, we do not find either a spruce-fir conifer forest or a northern forest of birch and beech, but rather stands of usually a single species of oak. These oaks are often stunted and gnarled by wind and altitude. Sometimes a 12 inch tree may be 100 years old. This forest occurs along the Appalachian Trail. It may resemble an orchard, and is frequently carpeted with bunch grasses or ferns and is a picturesque and beautiful environment. The twisted and wind-pruned oaks often have very short trunks, especially above 4,000 feet. Because there was very little marketable timber there, this environment was spared from the earlier logging that devastated much of the mountain slope and cove forests, so that today we have virgin oak timber along much of the higher ridges in Georgia.

**Flora.**

**Trees.** The dominant tree is northern red oak (*Quercus borealis*). Chestnut formerly occurred on the moister, northern face of the ridges and mixed with the red oak in places. White oak encroaches on the drier, southern face of ridges. Along the crest of high ridges in the Cohuttas (Bald, Potato Patch, Cowpen mountains) white oak is the dominant ridge forest species. On Flat Top, which appears to have the richest soil, both species occur together. In the Rich Mountain wilderness (Gilmer Co.) the top of Little Bald with its deep, rich soil bears principally red oak, while nearby the top of Big Bald with its thinner, poorer soil is dominated by white oak.

**Shrubs.** Radford (pers. comm.) recognizes several variants of the oak ridge environment which may occur on upper slopes as well, especially on the north face. : **Red oak-sedge**, with the grass-like sedge (*Carex pennsylvanica*); **red oak-deciduous heath**, with an understory of tall blueberry (usually *Vaccinium constablei*); **red oak-evergreen heath,** with a rosebay or catawba rhododendron understory; and **red oak-deciduous shrub**, with a beaked hazlenut shrub layer. In the Cohutta we have **red oak-herb**, and on the west face of Standing Indian just north of the Georgia line, a **red oak-deciduous heath**, with an azalea understory. Though much rarer, white oak replaces red oak in certain areas, such as the Cohuttas. A deciduous holly (*Ilex montana*) may be locally common, as well as witch hazel. Catawba rhododendron may occur above 5,000 feet and rosebay rhododendron at lower elevations. Radford (1974), in a high locality (5,620 feet) in North Carolina, found *Vaccinium constablaei,* a hawthorn (*Crataegus flabellata*), and flowering raspberry. Under the stunted red oak canopy of Hightower Bald (Towns Co.) we found shrubs, such as hawthorn, hazelnut and flowering raspberry, in dense patches on the ridge crest.

**Herbs.** The herb strata is not lush, except on deep, rich soils such as found on Rich Mountain (Gilmer Co.). Here the dominants are white snakeroot (*Eupatorium rugosum*), a high-altitude goldenrod (*Solidago curtisii*), and hay-scented fern. On Bald Mountain in the Cohuttas the herbs are similar except that New York fern is the dominant fern. Bunch grasses , if present, are generally either hair grass (*Deschampsia flexuosa*) (often on balds also) or the oatgrass (*Danthonia spicata*). A sedge (*Carex pennsylvanica*) commonly forms a beautiful carpet in moister areas (it is also common under beech) and at high altitudes. Radford (1974) provides a list of herbs for Pisgah ledge (Haywood Co., N.C.) at 5,000 feet where some chestnut apparently shared dominance with red oak (topsoil pH 4.5 to 5.0): *Aster lateriflorus, A. undulatus, Campanula divaricata, Gentiana clausa, Hieracium paniculatum, Houstonia purpurea, Phlox maculata, Pontentilla simplex, Rudbeckia laciniata,* three species of goldenrods, fly poison (*Amianthium*), *Angelica triquinata, Stenanthium gramineum, Viola canadensis, Carex virescens, Galax aphylla, Heuchera villosa, Clintonia borealis, Aster acuminatus, Eupatorium rugosum,* and *Dioscorea villosa*. Section on submesic forest **Fauna, Values** and **Impact** follows [58] SHRUB BALD.

Photo A19. On high ridges of the Cohuttas (Fannin Co.) OAK RIDGE FOREST [54] is dominated by white oak. In most of the Blue Ridge, northern red oak (*Quercus borealis*) forms the ridge top dominant. In either case, the trunks are short and limbs are gnarled. The lack of much lumber in trees at this elevation saved strips of virgin forest along the highest ridge crests of Georgia's Blue Ridge.

## [55] CHESTNUT RIDGE FOREST

### Location and Description

Chestnut apparently dominated mountain ridges at moderate elevations, ridges that were rounded enough to retain a deep, rich, black soil, perhaps formed under conifer forests when climates were colder Chestnut does not seem to grow as well at high elevations —the critical zone seems to be about 4,000 feet. Above that altitude the diameter may be small, or the trees are limby and short-trunked as are the red oaks. Rich and Little Aaron mountains (Gilmer Co.) have similar soils and profiles, yet northern red oak appears to dominate on Rich (circa 4,000), while on Little Aaron (circa 3,300) chestnut was the dominant. It appears that chestnut may have also dominated the top of Pine Log Mountain (Bartow-Cherokee Co.). Chestnut also occurred on rich, moist slopes and on very gentle slopes or plateaus called "flats" throughout the mountains—principally on the north and east flanks. The native chestnut is gone today, leaving only stump sprouts that grow up to 20 feet or so before being killed by the omnipresent fungus. The stark, white skeletons of former chestnut trees create the effect of a "ghost" forest. The Society of American Foresters (1973) records as Type 55 the red oak-chestnut high altitude forests (3,000 5,500), and forests on ridges, crests, and north slopes in North Carolina.

### Flora.

**Trees.** The chestnut was dominant, with red oak a frequent co-dominant.

DuMond (1970) describes a red oak-chestnut community on Bearpen Mountain (Chatooga River) between 3,100 3,600 feet on 50-60% slopes on a black, crumbly humus up to six inches deep. Sweet pignut hickory (*Carya ovalis*) occurred with it. Dead chestnut was abundant. The hickory, according to DuMond, had invaded following its elimination.

On Little Aaron Mountain (Gilmer Co.) succession is progressing slowly, following the loss of the chestnut. The dominant and probable pioneer species are now black locust, sassafras (often in thickets), and black birch, with shagbark hickory and black cherry encroaching. To a lesser degree (and on a less fertile soil) the ridge between Burnt and Oglethorpe mountains shows (in areas of richer soil) a similar successional pattern, with the addition of white oak and pignut hickory. Just northeast of the top of Cowpen Mountain in the Cohuttas is a fascinating "ghost" forest. Sassafras, northern red oak, and chestnut sprouts dominate the understory which is scarcely over 15 feet high. Other invading (or expanding) species are witch hazel, black birch, red maple, pin cherry, and blackberry. Flame azalea and dwarf willow (*Salix humilis*) are present. This forest is remarkable in that it is either one of the last chestnut forests to die or the young successional forest that is replacing it has been suppressed by altitude or other factors at almost the shrub stage. On the eastern edge of Cowpen top, perhaps following the death of the chestnut, witch hazel has formed an almost soild stand in places.

Photo A20. CHESTNUT RIDGE FOREST [55] formerly occupied rounded mountain ridges with deep soils at moderate elevations. The chestnut was killed in the 1930's by an Asiatic fungus. Sprouts still attain considerable height (and sometimes bear nuts) before dying. This "ghost" forest on Cowpen Mountain in the Cohuttas has a dense understory of sassafras, with chestnut and northern red oak seedlings.

**Shrubs.** The shrubs, if present, are similar to [54] OAK RIDGE FOREST On Little Aaron, except for an occasional sparkleberry or azalea, there are few shrubs. Dominant shrubs on Pine Log are an azalea (*Rhododendron bakeri*), indigobush, and, remarkably, dogberry (*Ribes cynosbati*). DuMond (1970) found a general lack of both undergrowth and herb strata, but found scattered chestnut sprouts and flowering hydrangea.

**Herbs.** DuMond (1970) found an abundance of saprophytic and parasitic herbs (*Corallorhiza, Monotropa, Conopholis*). The limited plant diversity is obvious in the herbaceous stratum. On the very rich soil and gently sloping north face of Little Aaron Mountain (Gilmer Co.) we found a lush herb stratum, but of limited diversity. The dominants were black cohosh and white snakeroot and either hay-scented or New York ferns. Several elements of the moist mountain coves were present, such as jewelweed (common), wood sorrel (*Oxalis grandis*) (common), and water leaf (*Hydrophyllum*) (rare).

Section on submesic forest **Fauna, Values** and **Impact** follows [58] SHRUB BALD.

## [56] CHESTNUT OAK RIDGE FOREST

### Location and Description

These are oak or oak-hickory forests confined to lower ridges and steep, rocky slopes with thin soils. This is SAF type 44, stated to range in altitude from 1,500 to 4,000 feet. The Society of American Foresters (1973) state that this forest "frequently follows fire and clearcutting in types containing a mixture of red oak and chestnut oak." Trees at higher elevations may be very slow-growing; even faster growing species are stunted. Above 4,000 feet I have found seven and eight inch chestnuts and red maples to be circa 50 years old.

### Flora

The dominant tree is the chestnut oak. Radford (1974) recognizes two forest types, a chestnut oak and a chestnut oak-heath. DuMond (1970) recognized several types in the Chattooga River gorge. One he called the "river slope type," the other the "upper slope type." Rosebay rhododendron formed the understory of the more mesic river slope type with some red maple and sourwood. On upper, convex and south-facing slopes DuMond found chestnut oak stands containing scarlet oak and pignut hickory with dogwood, serviceberry, sourwood, and black locust as typical subcanopy. Shrubs were mountain laurel, indigobush (*Amorpha* sp.), several species of blueberries, fringe tree, New Jersey tea, some river cane and greenbriers, with common herbs being spikegrass (*Danthonia*), whorled loose-strife, wild potato, bracken fern, and the composites (*Heterotheca nervosa* and *Silphium compositum*). In the Low Creek watershed (Union Co.) I found this forest to have red oak as a canopy co-dominant with blueberries (*Vaccinium* sp., *Gaylussachia* sp.) as the heath ground cover

Section on submesic forest **Fauna, Values** and **Impact** follows [58] SHRUB BALD.

(2) SLOPE FORESTS

## [57] OAK-CHESTNUT-HICKORY FOREST

### Location and Description

This forest comprises the bulk of Appalachian slope forests, lying upslope from the fertile, moist coves and downslope from the oak-dominated ridges. It is difficult to categorize because of the variation in trees, shrubs, and herbs. With some moisture one finds tulip poplar on drier soils chestnut oak or scarlet oak. Dry bluffs usually south or west-facing may have a nearly impenetrable heath layer of mountain laurel — on the moister slopes a dense thicket of rosebay rhododendron may be encountered. The diversity of this forest is one of its unique features and a fact often overlooked by the wildlife biologist and the forester bent on regeneration cutting (clearcutting) to create a more uniform environment by eliminating "undesirable" species. In nature there are no undesirable trees. Everything has its place and, as we are learning, its function in the ecosystem as well.

Photo A21 Northern red oak-chestnut deciduous slope forest with rosebay rhododendron understory near the summit of Hightower Ridge (Towns Co.). A number of northern plants occur here. Deciduous shrubs such as hazelnut occur on the top of the ridges.

## Flora

**Trees.** The dominant trees are white, red (usually northern red) and black oaks, along with a variety of hickories (usually bitternut, mockernut, shagbark, and pignut). Formerly, chestnut occurred throughout on moist but well-drained slopes with a moderate soil thickness. One or another species of oak will dominate, depending on soil, moisture and slope aspect. DuMond (1970) records a stand in the Chattooga Gorge (2,100 ft.) dominated by red oak and mockernut hickory, with red maple, fraser's magnolia, and tulip poplar as co-dominants. I (report to Threshold, Inc. on the Genesis project, 1974) documented the biotic zones of the watershed of Low Creek (Union Co.) and found white oak dominating on broad low ridges and gentle slopes with black or red oak as co-dominants (apparently depending on soil characteristics), while on slightly drier downslopes and moderately sloping ridges red oak dominated, with black oak as a co-dominant. The red oak group predominated on Fannin soil type while white oak dominated on Fannin soil with a low slope (2 to 10%) and on Braddock soils. Low Creek watershed has a northern exposure and lies between 2,000 3,000 feet.

Within this environment there are several recognizable variations, where one tree or the other dominates the canopy. The "white oak flats" would be a notable example on the headwaters of the Nantahala River (Clay Co., N.C.), another is an overlook in Virginia cited by Radford (1974).

**Subcanopy, Shrubs, and Vines.** DuMond (1970) found the subcanopy to contain silver bell, black birch, sourwood, and dogwood, as well as mountain laurel, doghobble (*Leucothoe axillaris* var *editorum*), and chestnut sprouts. On Low Creek, beneath red oak, I found (26 stations) the following trees as canopy, subcanopy and shrub members: dogwood 0-12-2; sourwood 1-13-1 and blackgum 2-3-4. This suggests that blackgums sprout easily but survive with difficulty. Both sourwood and blackgum participate in the canopy. Flame azalea and blueberries dominated the shrub layer in the red oak community, while spicebush, sweet shrub, and azalea dominated the moister white oak community. The greenbrier (*Smilax* sp.) is especially abundant in the drier habitats.

Pittillo (1972) states that on the drier west slopes of Chunky Gal Mountain (Clay Co., N.C.) he found as shrubs mountain laurel, flame azalea, deerberry (*Vaccinium stamineum*), and blueberry (*V. vacillans*), while on the north slopes he found principally rosebay rhododendron, wild hydrangea, and gooseberry (*Ribes cynosbati*).

In certain areas maple-leafed viburnum is common. Other moist, disturbed areas will have an abundance of sweet pepperbush (*Clethra acuminata*), with wild hydrangea and flowering raspberry. Other dominant shrubs are the northern witherod (*Viburnum cassinoides*), Carolina rhododendron (*R. minus*) in drier areas at lower elevations, the possum haw (*Ilex ambigua* var *montana*), sweet shrub (*Calycanthus*), strawberry bush (*Euonymus* sp.), and buffalonut (*Pyrularia*). The latter two are excellent deer foods.

Photo A22. The poplar cove (tulip poplar) is now characteristic of many moist coves formerly supporting the chestnut phase of the OAK-CHESTNUT-HICKORY FOREST [57] that clothes most of the slopes of the southern Appalachians. Southern mountain environments are still adjusting to the loss of the chestnut. Old chestnut stumps are readily visible against the snow in this winter scene near Patterson Gap (Rabun Co.).

**Herbs.** A very wide variety of herbs grow in the variable microenvironments of this general community. Pittillo (1972) listed the species typical of the sunny western slopes of Chunky Gal Mountain as lousewort (*Pedicularis canadensis*), black snakeroot (*Sanicula smalli*), vetch (*Vicia caroliniana*), Cateby's trillium (*Trillium catesbaei*), and wood lily (*Lilium michauxii*). Common herbs are almost too numerous to mention. One sees poison oak, Virginia creeper wild ginger toothworts, spotted wintergreen, rattlesnake plantain, wild potato, galax (*Galax aphylla*), speckled wood lily, (*Clintonia umbellulata*), trailing arbutus, and whorled loosestrife (*Lysimachia quadrifolia*). On the moister slopes are white snakeroot (*Eupatorium rugosum*), Canada violet (*Viola canadensis*), wild geranium (*Geranium maculatum*), goat's beard (*Aruncus dioicus*), bloodroot (*Sanguinaria canadensis*), mayapple (*Podophyllum peltatum*), black snakeroot (*Cimicifuga racemosa*), wood anemone (*Anemone* sp.), hepatica, cucumber root, (*Medeola*), Solomon's seal (*Polygonatum* sp.), and false Solomon's seal (*Smilacina racemosa*).

In openings one finds wild bergamot (*Monarda fistulosa*), oswego tea (*M. didyma*), hedge nettle (*Stachys clingmanii*), chickweed (*Stellaria pubera*), yellow-fringed orchid (*Habenaria ciliaris*), and dwarf iris (*Iris cristata*), and in dry areas, tick trefoil (*Desmodium nudiflorum*), loosestrifes (*Lysimachia* sp.), New Jersey tea (*Ceanothus*), and various small legumes.

Along streams we commonly encounter yellowroot, foamflower, turtlehead (*Chelone* sp.), New York fern, and cinnamon fern.

Section on submesic forest **Fauna, Values** and **Impact** follows [58] SHRUB BALD.

(3) SUMMIT FORESTS

## [58] SHRUB BALD

Like the boulder fields, the shrub or heath bald is closely associated with the northern forest. It is found only on the tops of our highest peaks, such as Rabun and Brasstown Bald. It is not present on Hightower Bald. **Trees,** if any, are usually northern red oak, dwarfed by the altitude into bonsai form. They sometimes form a shrub growth reminiscent of the ecoform of oaks growing on dune sands. The **Shrubs** are usually dominated by catawba rhododendron (*Rhododendron catawbiense*), seldom found below 4,500 feet. Oddly, rosebay rhododendron dominates Little Bald (5,007 ft.) on the state line (Rabun Co.). Mountain laurel (*Kalmia*) may be present. Some mountain tops are dominated by the huckleberries (blueberries) (*Vaccinium* sp. and *Gaylusaccia* sp.), both lowbush and highbush varieties. The distinctive mountain ash (*Sorbus americana*), with its brilliant red berries, is generally present.

Photo A23. SHRUB BALD [58] on the summit of Brasstown Bald (Union-Towns Co.). Dwarfed northern red oak is on the extreme left, and mountain ash is the tallest shrubby tree. The dense growth to the left of the figure is the dwarf grey willow (*Salix humilis*). Northern birds, such as the raven, nest at these altitudes.

On Brasstown, Photo A23, mountain maple (*Acer spicatum*) is present, along with a viburnum (*Viburnum lantanosus*), a holly (*Ilex monticola*), clumps of dwarf willow (*Salix humilis*), some flowering raspberry and thickets of hawthorn (probably *Crataegus punctata*). Other dominants are bush honeysuckle (*Diervilla sessilifolia*) and black chokeberry (*Sorbus melanocarpa*). A number of plants found on balds also grow remarkably in bogs, A.E. Radford (pers. comm.). Herbs are not dominant; white snakeroot may be present, and also trailing arbutus (*Epigaea repens*). A St. John's wort (*Hypericum buckleyi*), endemic to the southern Appalachians, may be present. Bunch grasses, such as *Andropogon scoparius*, frequently occur. See grasses listed under [54] OAK RIDGE FOREST. Radford *et al* (1972) list an oat grass (*Danthonia compressa*) and a sedge (*Carex brunnescens*) from balds.

For **Fauna, Values** and **Impact** see discussion under submesic forest which follows.

### Fauna of Submesic Forests

The fauna is similar to that of the mesic forests, X, Appendix VI. Two groups, the land snails and millipedes are obvious invertebrate components. As an example of the tremendous speciation undergone in Southern Appalachian forests, here is a generic listing of land snails restricted to the southern Appalachians, according to Burch (1969), with the number of species occurring in the southern Appalachians (first parenthesis) and the number of a species restricted to the southern Appalachians (second parenthesis): *Helicina* (1) (0), *Hendersonia* (1) (0), *Carychium* (3) (2), *Cionella* (1) (1), *Vallomia* (2) (0), *Helicodiscus* (4) (2), *Punctum* (4) (2), *Deroceras* (1) (0), *Retinella* (16) (12), *Mesomphix* (10) (6), *Papoides* (1) (0), *Gastrocopta* (6) (0), *Vertigo* (5) (2), *Strobilops* (3) (0), *Philomyscus* (2) (1), *Pallifera* (5) (2), *Anguispira* (2) (1), *Discus* (2) (2), *Haplotrema* (1) (0), *Bulimulus* (1) (0), *Plygyra* (3) (1), *Stenotrema* (117) (12), *Practicolella* (1) (0), *Mesodon* (21) (15), *Triodopsis* (10) (2), *Allogoma* (1) (0), *Polygyriscus* (1) (1), *Vitrinizonites* (2) (2), *Paravitria* (13) (11), *Pilsbryna* (2) (2), *Hawaiia* (1) (0), *Eucomulus* (2) (0), *Cuppya* (1) (0), *Gastroponta* (1) (1), *Clappiella* (2) (2), *Ventridens* (12) (7), *Zonitoides* (3) (2), *Striatura* (3) (0). There are thus 167 species of snails found in the southern Appalachians, lest anyone doubt that this area has been a speciation center for a long time!

Hoffman (1969) indicates 55 described genera and 234 species of millipedes from Appalachia, and suggests that the number is nearer 500. He concludes the southern Appalachians "to be a primary global center of evolution for these animals." Since over half the species of these prominent arthropods are not even described, it is premature to try to define their ecological requirements. Regrettably, this is the state of our knowledge regarding most of the terrestrial fauna, except for some insect families, Plethodontid salamanders, birds, and a few other organisms. There are more species of Plethodontid salamanders in the southern Appalachians (38) than anywhere else. The Plethodontids have evolved over 100 million years either in the Appalachians or on a tectonically stable upland nearby, Wake (1977).

In **submesic slope forests** the most common salamander by far (almost under every log) is the black, mucus secreting, slimy salamander. On the headwaters of the Tallulah River, Coleman River, Betty's Creek, and Hightower Creek (Rabun and Towns Co.) one finds the interesting red-legged subspecies of *Plethodon jordani,* which occurs sporadically down to 2,500 feet, and is the ecological counterpart of the slimy. If temporary water is available, some spotted salamanders exist in certain areas where there have been beaver dams or other pools, although they are uncommon. The only other common terrestrial salamander is the red-spotted newt whose immature "red eft" stage may be found wandering about on the forest floor and crossing highways after rains. American and Fowler's toads are common. The northern spring peeper and the eastern gray tree frog are the only tree-inhabiting frogs. The only other frog seen away from water is the wood frog (*Rana sylvatica*) which is rare in north Georgia. I have taken it in the Tallulah watershed (Towns Co.) and at Low Creek (Union Co.). It descends to 2,000 to 2,500 feet in these areas. The eastern box turtle is the only terrestrial turtle. Among lizards the submesic forests support the northern fence lizard, ground skink, three larger species of skinks of the genus *Eumeces,* the six-lined racerunner, and in high, rocky areas, the rarer coal skink (*Eumeces anthracinus*).

Appendix VI lists mountain snakes. Among them only the eastern milk snake does not occur outside of the mountains, most of the other species being shared with the Piedmont. The northern banded watersnake is generally confined to the mountains but intergrades in the Piedmont with western and southern subspecies. The pine snake is much more common in the lower mountains than in the Piedmont. The most common terrestrial snakes are the northern ringneck, the worm, the copperhead, and the garter. Remarkably few other species are seen in the denser forests.

Appendix V lists the breeding birds of the southern Appalachians, according to Hubbard (1971). The warblers are the most abundant (9 species), the finches next (8 species), with thrushes and fly-catchers represented by three species each. In Georgia the ruffed grouse is confined to the mountains.

The Appalachian highlands has the most diverse mammal fauna in eastern North America, 93 species within historic times, Handley (1971). I have listed boreal mammals in the **mesic forest** section on fauna. Appendix VI lists Georgia mammals. The following are mammals largely confined to the Blue Ridge and Cohutta sectors: smoky shrew, wood rabbit, ground hog (a few have been taken as far south as Gwinnett Co.), northern deer mouse, woodland jumping mouse, and probably the least weasel and northern flying squirrel. In the northern half of the state the mountain lion is confined to the Blue Ridge usually found only north of Highway 76. The black bear ranges the entire mountain province. there is a subspecies of the wood rat in the Blue Ridge cliffs (see **cliffs and gorge walls**). Presumably, the fox squirrel was once abundant in the mountains. The last colonies known to me were near Nottely Lake (Union Co.), in the Oaky Mountain "wilderness" of Cherokee and Pickens counties, and near Allatoona Dam.

### Natural and Cultural Values

Mountain environments have stabilized their steep slopes in many ways. The forest environments form absorbent and protective humus layers in the soil. They achieve greater and greater diversity until the climax condition is reached with canopy, subcanopy, shrub, herb and humus layers, each with characteristic plants and animals. Mountain forests prevent rapid run-off of water. Water is absorbed, recycled and allowed to feed into streams slowly — this is especially important in the drier fall months. During the summer, convectional currents accumulate transpiration loss and bring water back down as rain almost daily so that much water lost in transpiration is recycled through the watersheds. If it is carried down from the mountains, it cannot recycle. Any factors that affect the soil and humus layers, or the evapo-transpiration rate may send water downstream and out of the system. Fall and winter rains are generally gratuitous gifts from the Gulf of Mexico at the time when the transpiration-precipitation cycle is waning.

The protective and water conservation functions of forests on steep slopes can hardly be overestimated. As educational, recreational and scenic environments the mountains are almost unequalled. Recreation demand is increasing rapidly, at the same time mountain environments are being damaged by being managed primarily for timber. Hunting and fishing have considerable recreational value. The experience of wilderness is another cherished value. The larger areas in particular, where one may hike for a day or two and not repeat a trail, are especially necessary to provide educational and emotional experiences. This environment is not only an Arcto-Tertiary refuge of great antiquity, but offers the closest thing we have to environmental problems faced by early Americans, both Indian and Caucasian, both late-comers from the Eurasian land mass. The mountains are full of archaeological and early-settler artifacts and lore. Native medicinal food and drug plants are numerous. Rare and endangered plants and animals abound in the mountain region, especially in the **mesic forest**, or at high elevations. Sometimes, as at Sosebee Cove, these environments have been provided with protection from the destructive effects of logging but, if too accessible, suffer grievous changes due to shrub and bulb-diggers. Such coves need large buffer areas around them. The mountains are actually a mosaic of many quite different environments. In the course of a half mile one can move through diverse plant and animal associations not only areally, but altitudinally. Wildlife, such as grouse, turkey, and the larger mammals and many small birds, are up high, or on sunny slopes, or in deep ravines at different times of the year. Wildlife species know when and where each kind of blueberry comes into fruit, they know when and where the grapes ripen, and when and where the northern red oak and palatable white oak acorns are available. They know exactly where and when patches of hazelnut and other edibles are ripening, as well as the location of the fall mushroom crop, which provides valuable minerals, such as potassium. The location of buffalonut, strawberry bush, and greenbrier is precisely known to deer. A diversity of oak species at all elevations is essential to maintain a reservoir of wildlife food. Some oak species bear annually, others in alternate years. Climate often affects a single species. In 1976 white oaks in Gilmer County were bearing acorns at low but not at high elevations. Wildlife movements and concentrations are thus not always predictable. Many plants probably offer minerals or organic compounds which animals desire at special times of the year. Deer, for example, graze jewelweed heavily in the fall. It has been recently discovered that this plant contains a cortisone-like steroid.

Every rock den site is known to a host of animals, such as snakes (for hibernation), bears (dens), and wood rats (shelters for food caches). Sourwoods and other trees provide bee food. With the cooperation of heart rot fungus the blackgum provides innumerable hollow trees to shelter birds and mammals. There is both a spatial and an altitudinal mosaic. While a hemlock-rhododendron cove forest may have comparatively few species of plants and resident animals, within a quarter mile are a half-dozen other environments providing a wide variety of food and shelter. Mountain forests are anything but uniform, and any management practice that would make them uniform runs counter to nature. Natural catastrophes normal to conifer forests (spruce-fir types) or longleaf pine Coastal Plain forests are not common in the southern Appalachians. In mature forest old trees die and fall, leaving open spaces which produce further plant diversity. Furthermore, tree species have different life spans (as do individuals) on different soils. Mature forests are not full of dead and dying trees! Some species like the chestnut and, more recently, the white walnut have succumbed to a fungus disease. But forest diversity insures that enough nut-bearing trees of other species can carry on the forest function, albeit with reduced numbers of certain animals. In the spring of 1960 the elm span worm begain a three-year attack through large areas of the North Carolina and Georgia Blue Ridge, eventually destroying about one-half of the hickories and a number of oaks, some denuded by three years of defoliation. The worms, which pupate by July 1, were finally checked by the combined efforts of large flies and tiny chalcidid wasps which parasitized the larvae. Many worms were devoured by carnivorous tiger beetles, some by millipedes, and some by birds. The important point is that the diverse forest, even though it had previously suffered the loss of a major component, the chestnut, did not lose its conserving and protecting function. Had this forest been reduced too rigorously to a few tree species by special management, it takes no genius to predict its vulnerability to destruction by catastrophism. In fact, the overabundance of any single species invites attack, as most monoculturists know.

### Man's Impact

Man's major impact is by timber harvest and the inevitable road network. Near the turn of the century these forests were heavily logged by large timber companies, who then sold the land to the U.S. government. Following this, selective logging was practiced for years. Forest managers are now disgruntled over slopes from which the best trees had been removed by this method. Timber stand improvement (TSI) methods of poisoning and ringing (deadening) were used in the 1950's to eliminate "undesirable" species, such as sourwood and blackgum. White pine interplanting was also employed, but many pines were attacked by insects and this procedure was generally abandoned. In the late 1960's the regeneration cut (clearcut) was adopted for public lands managed by the U.S. Forest Service. This is an attempt to regenerate a white pine, oak, oak-poplar or poplar forest depending on site conditions and seed trees available. All stems are cut and those not of lumber size or quality are left on the ground. This policy may even include the cutting of rhododendron understory to permit shade-intolerant species to sprout. The esthetic devastation is obvious. Other detrimental aspects include serious erosion in steep scenic terrain, export of nitrogen and other nutrients from the watershed, the loss of water downstream due to diminished transpiration, and unknown changes in the fauna and flora, especially that of the soil and humus layers. These cuts often extend across small branches where the streamside zone and root bind of its vegetation are broken. Subsequent rains (up to 8 inches) known as "cloudbursts" devastate the smaller branches, causing what is locally known as a "wash-out." While a clearcut area may not show appreciable erosion under the normal precipitation regime, its vulnerability to the cloudburst has been overlooked.

In eastern deciduous forests one rarely sees a natural devastation comparable to a clearcut. However, the impact of a tornado that leveled 50 acres on Potato Patch Mountain in the Cohuttas in April, 1974 was representative of one.

Chestnut logs (called "sogs" by the mountaineers) are extremely valuable, and are still being removed from slope forests. As early as 1961 wormy chestnut lumber was bringing $800 per thousand board feet. Many mountain log roads have been constructed just for the removal of chestnut as at the southern boundary of the Cooper Creek Scenic Area (Union Co.). Appalachian forests were early "high graded" by the removal of valuable trees, such as black cherry and black walnut.

The road networks involved in timber harvest have led to deterioration of mesic cove environments. On the other hand old log roads do provide good hiking trails, the advantage of emergency evacuation, and emergency fire control access. The Indian, possibly, and the white settlers certainly, burned some mountain **submesic** and **xeric** forests in the fall. The impact of these ground fires on the biotic community is not well known. The Caucasian settlers let both cattle and hogs roam the mountains, fattening on the "mast" or nut crop, especially the chestnut. Stock was salted and tended at regular gaps where it could be captured by log palisade traps when needed. The last feral hogs were removed from the Georgia Blue Ridge in the early 1960's and cattle ranged across from Shooting Creek (Clay Co., N.C.) into the Tallulah watershed as late as 1965. The Eurasian wild boar (*Sus scrofa*) of German and Russian descent has been stocked in the watershed of the Tallulah, Coleman and Chattooga rivers (Rabun, Towns Co.). It now attracts considerable hunting pressure from out-of-state hunters, using dogs. Deer, bear, and boar are pressured by hunting dog packs in this sector of Georgia. Hogs root up and devour plants, bulbs, nuts, salamanders, grubs, and anything edible. They could have a serious impact on wild plants, even endangered species. They are competative with deer for acorns. The only plants which are safe are those in rocky terrain or in crevices. Although more study is needed, we know that wild hogs will eat the roots of mayapple, Solomon's seal, trillium, lily, and spring beauty.

An interesting aspect of stock-ranging was the impact of "milk-silk." Certain coves (known and even fenced off by settlers produced certain plants (white snakeroot *Eupatorium rugosum* and monkshood *Aconitum* sp. are suspect) which, perhaps by virtue of soil changes (perhaps of pH), were able to concentrate or produce substances at toxic levels or their alkaloids accumulated to toxic quantities in the milk. Ingested by cows, the milk poisoned entire families. Such as family is buried on the Coleman River (Rabun Co.), all dead of "milk silk."

Herb digging during the 1930's was an income source for many mountaineers. Extremely valuable herbs, such as golden seal, have been nearly exterminated. Ginseng has been dug up for over 100 years. Most is shipped to the Orient, but now a local market has developed and current prices are $80 per pound (1976). Mountaineers are regularly seen in the fall with dig-stick in hand and cloth "poke" tied to the belt. Other forest products are sold. Salamanders (for fish bait) or "spring lizards" command a high price. There are also moss-gatherers who strip the logs of mats of the beautiful "fern moss", such as *Hypnum imponens.* There is a thriving business, centering around Ellijay and Ballground, of bulb and herb diggers who secure the rhododendrons, laurel and ericad plants, especially the azaleas (*Rhododendron calendulaceum*) and *Rhododendron minus,* as well as young hemlocks.

Jeeps and off-trail vehicles of all types, especially motorcycles, lead to the erosion of log roads, noise pollution, solid waste pollution, and poaching. Regulation by law will be necessary if we are to preserve any degree of wilderness for mountain environments. On the other hand, navigating rough roads, such as the 12 mile circuit through the Rich Mountain Management Area (Gilmer Co.), is extremely popular with local people. Successful traverse of a wild road is somewhat analagous to the traverse of a wild river by canoe or raft — only the points where you begin and end may be really known to you. Old volkswagens fitted with special rear tires are now seen ten to one over the expensive 4-wheel drive vehicles in mountain areas around Ellijay. There are 4-wheel drive clubs who oppose the closing of wild, rough roads. The rougher the road the greater the challenge.

c. XERIC FOREST

## [59] BROADLEAF DECIDUOUS RIDGE FOREST

### Location and Description

This dry forest community consists almost entirely of oaks, sometimes stunted and gnarled, often with a single dominant species, or sometimes of three or four dominant species. It occupies dry ridgelines and tops. These communities are unique and have not been studied. A single species of oak forms narrow communities on ridges surrounding the Low Creek watershed near Nottley Lake (Union Co.). Moist variants, with as many as six species of oaks, may clothe dry, rocky mountain ridges with an oak-dominant canopy, as in the Oaky Mountain "wilderness" of Cherokee and Pickens counties.

### Flora

The most xeric phase is dominated by blackjack oak with some post oak. Usually a heath, such as the blueberry *Vaccinium vacillans,* covers most of the ground surface. The Oaky Mountain forests grow on a sandy, whitish soil derived from the Weisner quartzite. There are at least six species of oaks present; three are dominant; (D) chestnut oak, (D) blackjack oak, (D) scarlet oak, black oak, post oak, white oak. Pignut hickory is common. Typical plants, such as New Jersey tea, occur in the scanty herb layer.

### Fauna

This was probably a major habitat for the fox squirrel; some examples still survive in the Oaky Mountain area and at one locale near Allatoona. See category following [57] for a general discussion of the fauna.

### Natural and Cultural Values

Some ridgeline hiking in the lower mountains is through this environment. It is markedly hot and dry in summer but offers excellent views. The ridges provide variation from the darker shade of the **submesic** and **mesic** forests. The blueberries are so thick that this area is quite well known to bears and berry pickers alike. (Rattlesnakes are also attracted to rodents and birds eating the berries). Deer use the ridges as bedding places, feeding on legumes which occur on the more open forest floor. The abundant oaks provide much food for wildlife, from squirrels to deer.

### Man's Impact

It is questionable how logging has modified this habitat. If logged heavily, a forbidding growth of greenbriers impedes progress. Fire can sweep the drier ridges, and mountain laurel thickets may be common. Virginia pines are almost weed species and suggest disturbance, such as heavy logging. They become susceptible to the southern pine beetle which kills entire stands at one time, especially where they form stands in old clearings. The BROADLEAF DECIDUOUS RIDGE FOREST may have been one of the major habitats of the fox squirrel, now nearly extinct in north Georgia.

2. BROADLEAF DECIDUOUS-NEEDLELEAF EVERGREEN FORESTS

a. MESIC FORESTS

## [60] BROADLEAF DECIDUOUS-HEMLOCK FOREST

### Location and Description

Hemlocks tend to grow in very moist or seepage conditions at the bases of slopes where seeps emerge, in ravines, and in streamside zones or in wet, more or less level stream-side zones or colluvial flats. Colluvial flats resemble floodplains, but their soils are not derived from stream-borne sediment (alluvial sediments) but from landslides, creep, sheetwash, and ice tumble. Hemlocks appear to be addicted to colluvial sites. With the exception of colluvial flats (including some groves near Highlands, N.C.), hemlocks in northern Georgia are rarely found in stands exclusive of hardwoods — and would unnecessarily complicate our classification system if classified separately as a **mesic evergreen forest**, which would be a possible designation. Hemlock often disappears from the streamside zone between 3,000 and 3,500 feet elevation.

Braun (1950) includes hemlock in her mixed mesophytic forest community while Kuchler (1964) does not. Kuchler considers hemlock as a component of his northern hardwoods while Braun does not. Braun has buckeye as a component of northern hardwoods while Kuchler does not. Otherwise the two authors are in general agreement. It appears to me that there are two communities, lying at opposite ends of cove gradients. The BROADLEAF DECIDUOUS-HEMLOCK FOREST occupies the lower end of coves and is characterized, I think, by three trees: hemlock, poplar, and basswood, with buckeye nearly always present. The other end of the cove gradient (the "head" of the cove) is occupied by [52] BROADLEAF DECIDUOUS COVE FOREST.

Cain (1943) divides coves into two groups, one he calls the "tsugion (hemlock) alliance," the other the "Aesculion (buckeye) alliance." I call the the former BROADLEAF DECIDUOUS-HEMLOCK FOREST. Cain recognized three forest types with hemlock: 1) hemlock-beech, 2) hemlock-tulip tree, and 3) hemlock. Most of the coves treated here fall within the hemlock-tulip tree category (Ellicott Rock, Joyce Kilmer, etc.); hemlock "flats" would fall in category (3).

DuMond (1970) describes an apparently virgin cove forest in the Rabun County portion of the Ellicott Rock wilderness. It is a hardwood-hemlock forest with frequent evergreen heath thickets. The cove faces NE at 2,700 feet. The herb layer was the richest that he encountered in the entire Chattooga gorge. Tucker (1973) describes a quite similar forest from the Joyce Kilmer Memorial Forest (Graham Co., N.C.). DuMond found another stand between 1,900-2,100 feet on a steep hillside in the Rock gorge of the Chattooga River above the Nicholson Ford (Rabun Co.). Where hemlocks dominate, the humus layer (thick, undecomposed, needle-rich, and acid) beneath these trees supports a very limited herbaceous layer. Pittillo (1972) describes the vegetation of mesic coves in the southern Nantahalas on Chunky Gal Mountain, not far north of the Georgia line. This is the most common type of cove forest at lower elevations. Examples of this community can be found throughout our mountains.

### Flora

**Trees.** The Ellicott Rock stand was dominated by hemlock and tulip poplar with stem diameters of four to four and one-half feet. Canopy co-dominants were red maple, basswood (*Tilia heterophylla*), Fraser's magnolia, cucumber tree (*Magnolia acuminata*), red oak, and sweet pignut (*Carya ovalis*). The dominance of hemlock in the Joyce Kilmer cove reported by Tucker (1973) is obvious, but here, as with certain high coves on the West Fork of the Pigeon (Haywood Co., N.C.) reported by Radford (1974), yellow birch (*Betula lutea*) and tulip poplar are important co-dominants. Additional co-dominants noted by Braun (1950), Pittillo (1972), and myself are as follows: sugar maple, yellow buckeye, silver bell, cherry (*Prunus serotina*), black birch (*Betula lenta*), and locally beech. The Conasauga Lake cove has yellow and black birch, red maple, and much rosebay rhododendron.

In the Low Creek (Union Co.) watershed I found that the BROADLEAF DECIDUOUS-HEMLOCK COVE FOREST on a colluvial flat after intensive logging is coming back with red maple-tulip poplar canopy dominants, along with ash, black cherry, holly, and umbrella magnolia (*Magnolia tripetala*). It occurred on Tusquitee and some Hatboro soils.

Radford (1974) documents a hemlock-heath community at 4,620 feet in the Craggy Wilderness Area on Porter's loam (topsoil pH 4.0), considered to be climax. The hemlock canopy was 100%, with striped maple, witch hazel, and mountain winterberry (*Ilex montana*), Fraser's magnolia, and fire cherry in the subcanopy. Rosebay rhododendron, mountain laurel, hobblebush (*Virburnum alnifolium*), and *Vaccinium corymbosum* occurred as shrubs, with a limited herbaceous strata of acid-loving herbs.

**Shrubs and Vines.** In the Ellicott Rock stand the principal vines were dutchman's pipe (*Aristolochia macrophylla*) and fox grape (*Vitus labrusca*). Shrubs were buffalonut, wild hydrangea, and witch hazel. The rosebay rhododendron is often the only shrub, as in one forest subtype at Joyce Kilmer, Tucker (1973). One finds along the Chattooga and Warwoman Creek (Rabun Co.) the beautiful *Stewartia ovata* or mountain Camellia, along with dog hobble (*Leucothoe axillaris*) and other ericaceous shrubs, and much *Viburnum cassinoides*.

**Herbs.** DuMond (1970) listed the dominant herbs as Solomon's seal, speckled wood lily, meadowrue, maiden-hair fern, doll's eyes, showy orchid, and erect trillium (*Trillium erectum*). At Joyce Kilmer, Tucker (1973) found partridgeberry, Christmas fern, and

Virginia creeper to be the dominant ground cover under rhododendron. This environment shares other herbs with BROADLEAF DECIDUOUS SLOPE FORESTS.

### Fauna

See [52] BROADLEAF DECIDUOUS COVE FORESTS. This environment possesses some faunal elements of submesic broadleaf deciduous forests.

For **Values** and **Impact**, see following environment [62].

b. SUBMESIC FORESTS

## [61] BROADLEAF DECIDUOUS-WHITE PINE FOREST

### Location and Description

There is some question about the validity of this as a natural environment in the southern Appalachians. DuMond (1970) describes it as "white pine-mixed deciduous" and thought that its abundance warranted description. White pines are widespread in northern Georgia — they occur in bluff forests along the Chattooga River and on the slopes on the headwaters of the Chattahoochee (seen best from the Russell Scenic Highway) and Toccoa rivers. On Cooper Creek (Union Co.), along old log roads in the Turkey Creek sector, almost pure stands of white pine can be seen where old pastures or heavy logging was done. Elsewhere these stately trees occur scattered in the moist downslope zone with hemlock along Cooper Creek itself. In the northern United States around the Great Lakes, white pine formed pure stands or was scattered through hardwood forests and some bog forests in late successional stages (Braun, 1950). White pine is restricted to the mountains above 1,500-2,000 feet in Georgia — its distribution before the great logging era is conjectural. I have never seen a dense stand of white pines in the absence of an old log road. The finest stand of old, mature white pines known to me occupies the colluvial flats along lower Reed's Creek (Rabun Co.).

### Flora

In the Chattooga gorge DuMond (1970) found white pine in a canopy of hemlock, red maple, and mockernut hickory, with a subcanopy of dogwood, sourwood, and American holly. He claims that he found more shrub species here than in any other type, with mountain laurel, buckberry (*Gaylusaccia ursina*), and chestnut common. If the stand was open, deerberry (*Vaccinium stamineum*) and buckberry formed a thick ground cover. The most important herb species were spotted wintergreen, trailing arbutus, speckled wood lily, rattlesnake plantain, galax, wild ginger, broad beech fern, and New York fern.

### Fauna

The fauna is probably similar to that of **broadleaf deciduous submesic forests**. For **Values** and **Impact**, see following environment [62].

c. XERIC FORESTS

## [62] BROADLEAF DECIDUOUS-PINE RIDGE FOREST

### Location and Description

This is the common type of forest on low mountain ridges. It is a mixture of oak and pine, the pines usually overtopping the oaks which may or may not appear stunted. Elevations for this forest type range from 2,100 to 3,400 feet in Rabun County. **Pitch Pine Ridge** is a synonym.

### Flora

The long Oaky Mountain ridge between Rabun and Habersham counties is an excellent example of this forest type. Trees are (D) pitch pine, (D) scarlet oak, chestnut oak, blackjact oak, and black oak. White oak invades in richer or more mesic areas. DuMond (1970) has one of the few complete descriptions of this forest type. He states that the more mesic phases are dominated by scarlet or chestnut oak "with increasing abundance of pitch pine (*Pinus rigida*) toward more xeric situations." He describes a site dominated by deformed and stunted scarlet and blackjack oaks, with blackgums and sourwoods nearly as tall as the dominant oaks. (These environments are not stratified as in the **submesic** and **mesic forests**.) He found four dominant shrubs, the rare sweet fern (*Comptonia peregrina*), (also present on Patterson Ridge in a similar situation), the bristly locust *Robinia hispida, Vaccinium vacillans,* and horse sugar (*Symplocus tinctoria*).

DuMond found the most xeric phase dominated by blackjack and post oak with pitch pine, Virginia pine, and southern red oak as frequent canopy co-dominants. A blueberry (*Vaccinium vacillans*) covered greater than 65% of the ground, and the major herbs were *Aster surculosus*, trailing arbutus, spotted wintergreen, and wild quinine (*Parthenium integrifolium*). Although we have no documented examples from the mountains of Georgia, an edaphic varient of this environment is found on the dunite-serpentine barrens of Buck Creek (Clay Co., N.C.) where pitch pine is the dominant tree in an otherwise deciduous forest zone. Pittillo (1974) reports on this community and indicates that several species of grasses there are typically prairie species.

### Fauna of Xeric Forests

I know no studies of the fauna of this xeric forest type. It should be low in species diversity, catering to arid-life animals, such as swifts (*Sceloporus*), and with very few other species of vertebrates present. For **Values** and **Impact,** see the following section.

### Natural and Cultural Values of Broadleaf Deciduous-Needleleaf Evergreen Forests

For a general discussion, see **Values** section following **Broadleaf Deciduous, Submesic Forests** section. The evergreen-dominant forests of ravines and streamside zones are especially important in preventing sheet erosion during overbank floods, especially those caused by cloudbursts. Soils of valley floodplains are stabilized often by hemlock, forming "flats" with a rosebay rhododendron understory. A good example may be seen while driving up Mulky Branch (Union Co.) near its junction with Cooper Creek. Sometimes white pine "flats" replace the earlier forest, as may have happened along Reed Creek near its junction with the Chattooga River (Rabun Co.). Steep gorge walls are anchored by the root bind of hemlock and white pine. Hemlock often grows at the water's edge; its root bind is a powerful factor in preventing erosion by high water. These evergreens also provide important year around shade, keeping trout waters cold, as well as providing overhang from which foods may fall into the streams. Their esthetic value is incalculable. Hemlock forests provide concealment for many animals, including deer, and for the summer nests of squirrels. Some northern birds and the red squirrel may feed on hemlock cones: white pine cones are regularly "cut" by grey squirrels. The thick, spongy, acid layer (mor) of slowly decaying needles beneath evergreen forests creates a special microenvironment for certain plants and animals that may be less common in the surrounding deciduous forest.

### Man's Impact

The hemlock zone is especially important in preventing streamside erosion. Silt, by smothering the eggs, is the greatest enemy of cold water fish, such as trout. The root bind of streamside hemlocks was put to its strongest test by the use of "splash dams," an early method to flush logs out of the steep mountain valleys. A low log dam was constructed (a few still visible) and logs were stored in the resulting pool. Upon removal of part of the dam the wall of water carried the logs downstream. This method was used where the narrow gauge log railroad was unprofitable, or where the streams were too precipitous to construct railway trams up them, although early tram roads did ascend smaller falls by means of an incline built of log cribbing, the cars being winched up to the top. The downstream impact of early splash-dam logging can be imagined.

Unusually heavy rains called "cloudbursts" have probably always occurred in the southern Appalachians. The severity of their erosive power is considerably increased by either fire or intensive logging. Cloudbursts of unusual severity may strip mountain streams down to bedrock, cause landslides, and make major changes in streambeds. Such a washout occurred in northeast Georgia on June 16, 1949 when, as one mountaineer put it, "he learned that a deed wouldn't always hold land." This deluge stripped as much as five feet of rich topsoil from valleys along the Tallulah River (Towns Co.), soil formerly anchored by a forest of huge hemlocks before the coming of the early settlers. Within its narrow floodplain valleys the course of the Tallulah River was completely changed, meanders were eliminated and the stream incised downward. A tributary, Beech Creek, deserted its former diagonal confluence with the Tallulah, cutting straight across the bottomland to form a completely new channel. The probability of such natural events underscores the necessity of leaving wide streamside zones of uncut timber along all mountain streams, including intermittent ones. Current forestry practices do not sufficiently consider catastrophic washouts.

The breakage of a man-made dam can have much the same effect. The entire streamside zone of the Toxaway River (Transylvania Co., N.C.) was removed by the breaking of the Toxaway Lake dam prior to the 1930's. Flooding of gorges by reservoirs is treated in the next section [63].

The former demand for tannic acid led to the demise of many streamside hemlock forests in the southern Appalachians. The giant trees were felled solely for their bark and left to rot. The white pines and hemlocks of many gorges have been spared only because of their inaccessibility. Others have suffered, such as along the Chattooga's east fork where in places white pines were logged down to the water's edge prior to the creation of the Chattooga Wild River. Heavy logging of a hemlock colluvial flat may result in a thick stand of black birch, tulip poplar, or white pine, depending on the seed trees nearby and the altitude, birch coming in at the higher elevations.

3. ROCK OUTCROPS

## [63] CLIFFS AND GORGE WALLS

### Location and Description

See also [4] WET CLIFFS AND OUTCROPS in the Wetlands section.

These are more or less vertical cliffs. Some are dry and exposed, others moist with seepage flow or adjacent to waterfalls, or shaded. Some are, of course, moist in the winter and spring and dry in the summer and fall. They are found principally close to the main Blue Ridge. Sheer rock walls of quartzite form the walls of Tallulah Gorge (Tallulah River, Rabun Co.). Other cliffs of gneiss and schist occur in the walls of the Chattooga River (Rabun Co.), the gorge north of Nicholson Ford and along section four below Woodall Shoals, along Talking Rock Creek (Pickens Co.) below Highway 5, and along Jack's River (Fannin Co.) between Bear and Penitentiary branches. Other notable cliffs occupy the slopes of Blood Mountain (Union Co.), Raven Cliffs near the Duke's Creek Falls (White Co.) below Three Forks on the west fork of the Chattooga River; the west face of Yonah Mountain, and the spectacular series of cliff-sided mountains such as Buzzard's Rock, Cedar Cliff, and Glade Mountain, lying east of the headwaters of Big Creek (Rabun Co.).

### Flora

The most conspicuous trees in gorge walls are either white pine on drier faces or hemlock on wetter sites. Dominant shrubs are either rosebay rhododendron or mountain laurel.

DuMond (1970) found two basic herb types in the Chattooga River gorge. The first or mesic type was dominated by mats of sphagnum moss where, in small bog-life situations, alders, red chokeberry (*Sorbus arbutifolia*), and a St. John's wort (*Hypericum prolificum*) grew as shrubs, along with herbs, such as *Drosera rotundifolia, Houstonia serpyllifolia, Danthonia sericea* var. *epilis, Calmagrostis cinnoides, Xyris torta, Selaginella apods, Utricularia subulata,* and *Calapogon pulchellus.*

The drier types were dominated by mats of *Selaginella tortipila* and restricted to Rabun County (*S. rupestris* occurs on bare rock elsewhere along the Georgia Blue Ridge, S. Bowling, pers. comm.) with herbs, such as *Houstonia longifolia, Krigia montana,* spikegrass, pinewood (*Hypericum gentianoides*), *Crotonopsis eliptica,* and *Andropogon scoparius*. *Talinum teretifolium* may be common, as on Blood Mountain outcrops, William Murdy (pers. comm.).

DuMond found smaller shaded rock outcrops with *Corydalis sempervirens, Senecio millefolium*, and the ferns *Woodsia obtusa* and *Asplenium platyneuron*. Moist, shaded rock niches with carpets of mosses and liverworts were found to contain the lycopod (*Lycopolium lucidulum* — Rabun Bald Cliffs have the much rarer *L. selago*), the maidenhair spleenwort (*Asplenium trichomanes*), and the mountain spleenwort (*Asplenium montanum*).

It is in shaded crevices and grottos of deep gorges just to the east of the Chattooga that are found perhaps the rarest ferns in North America, the filmy fern (*Trichomanes boschianum* and the tunbridge fern *Hymenophyllum tunbridgense*), the latter not yet recorded from the Chattooga gorge system.

Good indicator plants of moist mountain outcrops are the alumroots (*Heuchers villosa* and *H. parviflora*), the two saxifrages, Michaux's saxifrage (*Saxifraga michauxii*) and the moisture-loving "bear lettuce" (*Saxifraga micranthidifolia*); a deliciously edible plant which grows in seeps and branches above 3,000 feet. We have found the latter as far west as the Rich Mountain wilderness (Gilmer Co.).

Perhaps the most outstanding dry cliffs are those of the cliff-sided mountains in northeast Rabun County (east of highway 28), resembling those around Cashiers (N.C.) W. Duncan (pers. comm.) reports two unique plants common to this Cedar Cliff-Glade Mountain area: sand myrtle *(Leiophyllum buxifolium)*. and twisted hair spike noss *(Selaginella tortipila)* [and gound juniper *(Juniperus communis)*]. Interestingly, the juniper also occurs as a disjunct on rock outcrops in Elbert County and the spikemoss at Heggie's Rock, S. Bowling (pers. comm.).

In cliffs of the Panther Creek Gorge (Rabun Co.) is a limestone outcrop and with it a number of rare plants. The localized Carolina hemlock (*Tsuga caroliniana*) is confined to cliff areas of Tallulah Gorge. A species of trillium (*Trillium persistens*) is largely known only from the Tallulah River basin, Wilbur Duncan (pers. comm.).

### Fauna

Some cliffs, such as portions of Tallulah Gorge, are inhabited by the green salamander (*Aneides aeneus*) if they are cool and have airy crevices near sunlight. According to Robert Gordon (pers. comm.) there is an associated biota that co-habits with this salamander. It includes a primitive insect; a thysanuran (*Machilis* sp.), a spider (*Hypochilus thorelli*), member of a primitive Asiatic family, and a spleenwort (*Asplenium montanum*). Besides these three biotic indicators there are abundant cave crickets and snail-eating carabid beetles. The green salamander is generally confined to the Tallulah and Chattooga gorge areas in the Blue Ridge Province. The Blue Ridge mountain salamander also occurs commonly on moist cliffs. In Tallulah Gorge it was formerly called *Desmognathus perlapsus*, but now is not considered to be a separate species. The fauna of other cliffs is even less known.

Birds, such as the swallow and phoebe, use cliffs as nesting sites. Bats utilize crevices as diurnal retreats. Cliffs provide dens for snakes, raccoon, ground hog, fox, wildcat, and bear. Long-tailed shrews (*Sorex*) and *Peromyscus* mice use them for hunting and, possibly, denning. One notable dry cliff inhabitant is the eastern wood rat. A subspecies (*Neotoma floridana haematomum*) occurs in the cliffs of Blood Mountain (Union Co.). These large, clean, and attractive rodents accumulate stored foods, white pine cones, magnolia fruits, and sticks in large mounds several feet across under the dry overhang of cliffs. I noted colonies along the west fork of the Chattooga in the 1950's, but they have since become quite rare in northern Georgia.

### Natural and Cultural Values

Cliffs and rock gorges are areas of exceptional natural beauty. A number of species of rare plants and a few rare animals are found only in these locations. They are quite discrete ecosystems, though with varied microclimates, and are important in recreation, education, and science. Further inventory and study is needed. Some gorges, such as Talking Rock and along the lower Chattooga, may contain virgin timber.

Logging near or above them and excessive specimen collecting can seriously damage gorge environments. Logging affects not only the shade but the water flow. Fortunately, due to their inaccessibility, most have been spared excessive logging. Power dams are often built to flood gorges. Sections two, three, and four of the Chattooga Gorge above Tugaloo Lake were saved from this fate only by the creation of the Chattooga Wild River. Carter's Dam drowned a gorge that was second only to Tallulah Gorge, Lovell Greathouse (pers. comm.).

## PIEDMONT PROVINCE

1. BROADLEAF DECIDUOUS FORESTS
   a. MESIC BROADLEAF DECIDUOUS FORESTS
      [64] BLUFF AND RAVINE FORESTS OF NORTHERN AFFINITIES
      [65] BLUFF, SLOPE AND RAVINE FORESTS
      [66] RAVINE FOREST OF MIXED AFFINITIES
      [67] EVERGREEN HEATH BLUFF
   b. SUBMESIC BROADLEAF DECIDUOUS FORESTS
      [68] OAK-HICKORY CLIMAX FOREST
   c. XERIC BROADLEAF DECIDUOUS FORESTS
      [69] PIEDMONT FLATWOODS
      [70] XERIC BLUFFS
2. NEEDLELEAF EVERGREEN FORESTS
      [71] PINE CLIMAX FORESTS
3. BROADLEAF DECIDUOUS-NEEDLELEAF EVERGREEN FORESTS
   a. SECONDARY SUCCESSION ENVIRONMENTS
      [72] SUCCESSIONAL FOREST STAGES
   b. ORIGINAL ENVIRONMENTS
      [73] MIXED PINE-HARDWOOD COLLUVIAL FORESTS
      [74] PINE-BROADLEAF DECIDUOUS SUBCANOPY XERIC FORESTS
      [75] PINE-HARDWOOD XERIC RIDGE AND SLOPE FORESTS
      [76] ROCK OUTCROPS

## PIEDMONT PROVINCE

Perhaps the most distinctive feature of the Piedmont is its topography, rather than its flora and fauna. Among the vertebrates I can think of no species unique to the Georgia Piedmont, although two salamanders and three snakes occur as varieties (subspecies), suggesting that speciation will occur in time. Based upon Radford's (1968) maps, there are only 15 species and subspecies of plants confined to the North and South Carolina Piedmont which presumably could occur on the Georgia Piedmont. Some of these, such as the sandwort (*Arenaria uniflora*), appear confined to the unique granite outcrops. In contrast, Georgia has approximately 150 unique mountain plants.

There are perhaps more faunistic than floristic differences between the lower Piedmont and upper Coastal Plain, just as the sharpness of the geologic break is more evident than the topographic. In general, deciduous hardwoods are the predominant vegetative growth on the Piedmont, while needleleaf evergreens predominate in the Coastal Plain. Locally, some areas of the Coastal Plain, such as the red hills, appear to have been predominantly hardwood also.

Nelson (1957) reviewed evidence that suggested that there were originally more pines towards Alabama, and an increase from the mountains towards the Fall Line. Early reports cited by Nelson seem to indicate that from 10 to 15% of many Piedmont counties was in pines. He concluded from the historical evidence of early surveys and reports that at the time of the earliest settlement what everybody called "the red lands" (red clays often overlain by deep, sandy loams of the Cecil, Floyd and Davidson soil series) covered approximately 40% of the Piedmont and bore a deciduous hardwood forest; that "gray sandy lands," covering about 45%, bore hardwood forests mixed with pine to varying degrees; and that "granitic lands," comprising about 15% of land area, bore pine or predominantly pine stands.

Brender (1974) studied the impact of man on lower Piedmont counties, presumably from Atlanta south. He stated that 75% of the uplands of this section consisted of the heavy clay soils of the Cecil, Floyd and Davidson soil series. Brender has reviewed the writings of Bartram and others indicating that when the first settlers arrived in the eastern Piedmont in 1773 (as far west as the Ogeechee River) they found here and there numerous fields, second-growth forests, and occasional stands of pine attributable to Indian agriculture and to Indian use of fire. By 1825 most of the Piedmont east of the Chattahoochee had been occupied by the Caucasians. By 1935 most or all of the topsoil had been eroded from the Piedmont. There were apparently two peaks of cotton monoculture after the invention of the gin in 1793, the first maintained by whatever residual fertility remained, the second spurred by the availability of Chilean nitrate. The end result was the loss of almost all the remaining Piedmont topsoil, and serious gully erosion. Piedmont lands were gradually abandoned, due to economic and social circumstances in three general phases of abandonment; Civil War (10%), agricultural depression of late 1880's (30%), and boll weevil in 1920's (35%), according to Brender. This totals 75% abandonment by the 1930's. The land then passed back into secondary forest which (in 1974) Brender estimated to cover 70% of the lower Piedmont, with 55% of this in pine, the pine cordwood amounting to 12.5 cords/acre and growing at an annual rate of nearly 1 cord/acre.

The latest study of 18th century vegetation is that of Plummer (1975) based on old survey corner trees, hopefully correctly identified and hopefully randomly chosen. In western Haralson County the surveyor's records suggested a forest of 50% pine - 16% post oak; in central Carroll County 30% pine - 34% post oak, nearer the Chattahoochee 43% pine - 16% post oak. Some 3-5% chestnut and 5% hickory were present in both counties. Plummer indicates that pines were recorded particularly on steep slopes and upland soils of micaceous origin (Tallapoosa-Grover and Madision-Louisa-Tallapoosa associations). The higher the clay the more post oak found. Plummer states that longleaf pine (*Pinus palustris*) occurred on the hillsides in Haralson County. He cites Meriwether County forests to contain 51% post oak, 18% red oak, 9% hickory, and 9% pine (Madision soil assoc. — red clay loam). Eastward near Monroe (Morgan Co.), forests appeared more mesic with fewer post and blackjack oaks and pines and more hickories, poplars, dogwoods and sweet gums, and less chestnut. In Bibb County, the northern half of Cecil (upland) soils, there appeared to be forests dominated by post oak, red oak, pine, hickory, and white oak, while there was an abrupt transition to 89-96% pine at the Fall Line.

The secondary forests which grew back on the Piedmont were exploited at least three times: light harvest by small sawmills until 1920, severe harvest during World War II and after, and harvest for pulpwood since the mid 1940's. Cutting sequences seemed to center on the removal of pine which, together with fire protection, hastened the succession back to hardwoods in the Piedmont, May (1968). Nelson (1975) cites other sources to support this contention.

As we ride across the Georgia Piedmont, apart from the obvious old fields grown up or planted to loblolly pine, we are looking at modified second growth deciduous hardwood and hardwood-pine mixtures. The probability of finding an upland virgin stand of hardwoods in the Piedmont is remote. One can, however, locate numerous small hardwood forest areas which, although they may have been cut-over or grazed, may closely resemble the original timber. The presence of very large oaks would probably be the best indicator of near-original environments, although numerous large trees of any species make the area suspect. Areas of near-original growth occur most often where it was too steep or rocky for agriculture. The bluff forest of the Chattahoochee palisades (Fulton Co.) is an example. Other examples are found in the steeply undulating terrain just SW of Gainesville (Hall Co.), on bluff forests at Fernbank (DeKalb Co.), and along the Oconee River. It is from such remnants that we must obtain most of our information about the natural environments of the Piedmont. The bulk of the flora is gone, and, unhappily, we cannot as yet determine the impact of man on the fauna which once occupied these extensive hardwood forests.

To exemplify upland Piedmont soils Walton County is typical. East of the Alcovy River the Cecil-Lloyd-Appling Association dominates, west of the river it is the Appling-Louisburg-Cecil Association, USDA (1961). The typical "red clay" of the Piedmont comes largely from the Cecil, Lloyd and Davidson soils which originally supported [68] OAK-HICKORY CLIMAX FOREST and currently mostly [72] SUCCESSIONAL FOREST STAGES. Cecil soils occur chiefly on smooth uplands and have a yellow-brown, coarse sandy loam surface, underlain at 10 inches with red clay and bedrock from 3-30 feet below. The Lloyd soils are deeper. The Davidson soils occur on ridgetops as well as smooth uplands and have a profile similar to Cecil soils. With erosion of the shallow surface layers from these soils, the red clay subsoil comes to lie at the surface — it is this firm layer that makes lawn care and farming difficult, not so much due to the lack of fertility as it is to the lack of oxygen and water in these compact clays. Piedmont slope forest on highly dissected uplands may grow on a Pacolet-Madison-Davidson Association with red clay subsoils. The Madison soils are often derived from mica schists and contain many mica flakes.

Appling and Louisburg soils, on the other hand, lack red clay subsoil and are commonly known as "light sandy soils" or "gray lands." Both may be associated with gneiss, granite or quartzite fairly near the surface. Most of the uplands of Rockdale County are either Appling sandy loams or Cecil sandy loams, USDA (1932). Appling soils are sandy loams and sandy clay loams with bedrock commonly less than 15 feet deep. Louisburg soils are coarse and sandy and very shallow, with bedrock from 12-48 inches deep. Soils similar to Louisburg might support a pine climax forest [71], or mixed pine-hardwood colluvial forest [73].

Other soils lacking red clay are derived from quartzites. The top of Pine Log Mountain (Bartow-Cherokee Cos.) is quartzite which forms the DeKalb fine sandy loam, with fine sandy loam composing both surface and subsoil and bedrock at 60 inches.

Soils along the Brevard Fault (Gainesville Ridges) are somewhat different from the bulk of the Piedmont. A small watershed at Chattahoochee State Park presents a variety of soil types, USDA (1958). The nearby Palisades are simply bedrock forming steep cliffs. Colluvial soils along a small branch are classed as "mixed alluvium." The surrounding slopes (environment [65]) are underlain by shallow Louisburg sandy loam, 15 inches of structureless sandy loam overlying decayed granitic rock. On broad interstream ridges the most extensive soil appears to be the Madision fine sandy loam, a variety of which has a micaceous red clay loam subsoil. Another ridgetop soil with a red clay loam subsoil is the Madison gravelly sandy loam, distinguished by fragments of mica schist and quartz covering 25% of the ground surface. Disintegrating mica rock is found as shallow as 36 inches. Both these Madision soils occur on ridges along the trail to the Palisades overlook.

On uplands underlain by diorite gneisses and hornblende schists, Davidson Clay and Davidson clay loams occur ,USDA (1918). The latter has a chocolate brown surface layer. Both have a heavy, deep red clay subsoil. The remarkable glades (see wetlands introduction) of Jasper County are underlain by Iredell and Mecklenburg loams derived from norite gabbro and possessing a sticky, plastic, olive-colored clay layer which causes them to be classed as wetlands.

The following key may be helpful. Attempts to pigeon-hole nature are very frustrating. For example, environments [64] and [65] grade into one another readily, and [67] is but a facet of [64] and perhaps is not valid to segregate out. Environment [68] of course grades downslope into either [75] [64] or [65]. The reader should realize that these are convenience categories, hopefully leading to a more critical evaluation of nature's variability and the preservation of more of the state's remarkable diversity.

## KEY TO PIEDMONT UPLAND (MESIC TO XERIC) ENVIRONMENTS

1a Areas of naked rock exposed horizontally or as rounded domes (not cliffs)
[76] ROCK OUTCROPS.

1b Terrain covered with soil and vegetation (Select 2a or 2b).

2a Terrain usually the tops of broad hills and gentle slopes. Forested, usually with loblolly pines forming pure stands or present among hardwoods. Walk-through reveals old cottonfield terraces on contours, or ditches, trenches or gullies; or piles of rock here and there (possibly former pasture), chimneys, or cultivated or non-native plants such as privet hedge, honeysuckle, kudzu, or fruit trees present.
SUCCESSIONAL FOREST STAGES [72] EVOLVING TO [68]

2b Terrain flat near small streams, or sharply undulating, usually with narrow ridges lacking red subsoils, or if broad ridge-tops or gentle slopes present there are large rocks protruding occasionally, or much whitish, shiny rock (bull quartz or quartzite) scattered about; or steep bluffs (often with cliffs) near streams. Forested with hardwoods with or without pines. or, rarely, with pure pine stands. Walk through reveals no evidence of human use as outlined in 2a. (Select 3a or 3b).
NEAR-ORIGINAL FOREST, LOGGED, BUT NEVER IN AGRICULTURE

3a Forest cover dominated by prominent pine overstory, hardwoods if present forming scrubby undergrowth dominated by xeric species such as blackjack oak. (Select 4a or 4b).

4a Pine dominantly longleaf (6" cones) growing on soil-covered ridgetops, undergrowth usually with blackjack oak.
[74] PINE-BROADLEAF DECIDUOUS SUBCANOPY XERIC FORESTS

4b Pine dominantly loblolly or shortleaf, growing on or near granite or gneiss outcrops, soils thin, never with red subsoil.
[71] PINE CLIMAX FOREST

3b Forest cover either mixed pine-hardwood, or predominantly or entirely hardwood. (Select 5a or 5b).

5a Mixed pine-hardwood forest. (Select 6a or 6b).

6a Forest on level land along small streams, hardwoods usually include tulip poplar and beech; pines, although sometimes absent, predominantly loblolly, herbs and shrubs similar to those of nearby north-facing bluffs, and possibly of northern affinities.
[73] MIXED PINE-HARDWOOD COLLUVIAL FORESTS.

6b Forests on dry ridges and rocky slopes with xeric oak species including blackjack, post, scarlet, and southern red; chestnut oak nearly always dominant on rocky soils; shortleaf usually the dominant pine.
[75] PINE-HARDWOOD XERIC RIDGE AND SLOPE FORESTS

5b Forest predominantly or entirely hardwood. (Select 7a or 7b).

7a Forest dominated by stunted, gnarled blackjack and post oak, with or without red cedar. (Select 8a or 8b).

8a Forest of scrubby, gnarled blackjack and/or post oak on more or less level terrain.
[69] PIEDMONT FLATWOODS

8b Forest similar, but often with red cedar, yucca and other xerophytes, on dry, rocky bluffs.
[70] XERIC BLUFFS

7b Oak-hickory forest, trees of normal size and form. (Select 9a or 9b).

9a Oak-hickory forest with a dense understory of a single species of heath, either evergreen rhododendron species, or mountain laurel.
[67] EVERGREEN HEATH BLUFF

9b Oak-hickory forest, with an understory of diverse shrub species, or shrubs scarce or absent; evergreen heath plants confined to cliffs and along streams. (Select 10a or 10b).

10a Moist, hardwood forests associated with slopes, bluffs or ravines. (Select 11a or 11b).

11a Moist ravines or bluffs with remarkable mixtures of Coastal Plain and Mountain plants and animals; among plants expressed largely in the shrubs and herbs. Chiefly Pine Mountain area.
[66] RAVINE FOREST OF MIXED AFFINITIES

11b Forests associated with moist bluffs, slopes and ravines not showing a marked representation of Coastal Plain plants. (Select 12a or 12b).

12a North-facing bluff or deep ravine forest with numerous herbs and some shrubs normally found on rich mountain slopes and in mountain coves.
[64] BLUFF AND RAVINE FORESTS OF NORTHERN AFFINITIES

12b South, east or west-facing bluffs and shallow ravines, and moist slopes containing few if any species normally associated with rich mountain environments.
[65] BLUFF, SLOPE AND RAVINE FORESTS

10b Drier hardwood forests on broad hilltops and rolling uplands.
[68] OAK-HICKORY CLIMAX FOREST

1. BROADLEAF DECIDUOUS FORESTS

These forests lie within Braun's (1950) oak-pine or eastern oak-hickory forest region. They are basically oak-hickory forests. Piedmont bottomlands fall under the HYDRIC category in this study. The xeric or dry phase is considered to be the climax (Oosting, 1942; Moore, 1973). Oosting (1942), and seemingly Radford (1974), regard the hydric and mesic Piedmont forests as "post-climax" (with maximum moisture, hence evolving farther than climax). Oosting calls the very xeric, drier Piedmont environments "pre-climax."

a. MESIC BROADLEAF DECIDUOUS FORESTS

## [64] BLUFF AND RAVINE FORESTS OF NORTHERN AFFINITIES

### Location and Description

These are the mixed mesophytic forests of Nelson, Ross, and Walker (1957) and the north-facing bluffs of Oosting (1942). They are found adjacent to streams or rivers and almost invariably on steep slopes facing due north. The best examples I have seen are at Fernbank, Pumpkinvine Creek, and along the Chattahoochee and tributaries in the Brevard zone. Sometimes the tree species are near-original in composition and the herb layer modified by man and livestock (Fernbank), or the tree layer is modified by logging and the herb layer is relatively original (Pumpkinvine Creek). These environments are rare. Few examples are documented. There are tree, shrub and herb elements that are normally found only in the mountains, hence the term "northern affinities." Obviously, fire seldom burns through this moist forest.

The unique Pumpkinvine Bluff herb community grows on the Iredell gravelly loam soil (USDA 1926) with or without a sticky, waxy clay layer in the subsoil but, more importantly, underlain by greenish iron and magnesium-rich slates. Certain northern vegetation communities along the Chattahoochee are on the thin soils overlying granitic rock (Louisburg sandy loam, USDA 1958). A bluff in Fernbank Forest is composed of Louisa soils derived from mica shists, and classified as a sandy gravelly loam, lacking the clayey layers of typical upland soils. The adjacent flatter soils of the forest are classed as Hiwassee or Gwinnett, and closely resemble typical upland soils such as the Cecil, USDA (pers. comm.)

### Flora

We are fortunate to have a suburban relict of this environment occupying part of a bluff of a 25 hectare (about 65 acres) forest in the metro Atlanta area. Skeen (1974) indicated that most of it has not been logged. It has been owned by relatively few individuals from 1820 to the time of its acquisition and permanent protection in 1939 by Fernbank, Inc.

Poplars on the north-facing bluff at Fernbank have ages ranging around 225 years. Skeen's transects included both bluff and west-facing slope forest, hence the presence of pines in the six dominant **trees** for which he ascertained importance values: tulip poplar (136), white oak (39), hickory sp. (36), loblolly pine (33), northern red oak (31), dogwood (27). The pines range in age from 65-130 years and are rapidly dying out.

Other noted components are basswood (*Tilia heterophylla*) (8), black cherry (*Prunus serotina*) (1), *Magnolia tripetela* (5), and black walnut (*Juglans nigra*) (.5).

Though the shrub strata is probably modified by the removal of azaleas and other species, below are the present day dominants (D) of the linear north-facing bluff community, and a few plants eliminated by man (E) but present up until 1920, according to W.B. Baker (pers. comm.):

**Shrubs** - (D) sweet shrub (*Calycanthus*), (D) spice bush, (*Lindera*) paw paw (*Asimina triloba*), pinxter-flower (*Rhododendron nudiflorum*), (E) Oconee azalea (*R. speciosum*), (E) swamp azalea (*R. vgscosum*), maple leaf viburnum (*Viburnum acerifolium*), rusty viburnum (*V. rufidulum*).

**Herbs and Vines** - (D) doll's eyes (*Actaea pachypoda*), wild hydrangea, (D) climbing hydrangea (*Decumaria barbara*), (D) wild potato (*Dioscorea* sp.) (2 spp.), wild ginger (*Hexastylis* sp.), (D) false Solomon's seal (*Smilacina racemosa*), (D) horsemint (*Collinsonia canadensis*), (D) poison ivy (*Rhus vernix*), (D) Jack-in-the pulpit, (D) heal all (*Prunella vulgaris*), pipsissewa (*Chimaphila macularum*), rattlesnake plantain, wild geranium (*Geranium maculatum*), (D) hepatica (*Hepatica americana*), (D) bloodroot, foam-flower (*Tiarella*), (D) bellwort (*Uvularia perfoliata*), (D) nodding trillium (*Trillium cernuum*), strawberry bush (*Euonymus americanus*), (E) black cohosh (*Cimicifuga racemosa*), (E) goat's beard (*Aruncus dioicus*), Catesby's trillium (*T. catesbaei*), confederate violet (*Viola papillionacea*), green and gold (*Chrysogonum virginianum*), probably (E) ginseng (*Panax quinquefolia*), (E) wild columbine, (E) yellow ladyslipper, (E) Solomon's seal, (E) wake-robin (*Trillium flexipes*), (E) tall meadowrue (*Thalictrum revolutum*), (E) devil's bit (*Chamaelirium luteum*), (E) yellow root (*Xanthorhiza* on branch), (E) rue anemone (*Anemonella thalictroides*), (E) toothwort (*Dentaria* sp.), rattlesnake fern (*Botrychium virginianum*), common grape fern (*B. dissectum*), southern lady fern (*Athyrium asplenioides*), Christmas fern (*Polystichum acrostichoides*), broad beech fern (*Phegopteris hexagonoptera*), sensitive fern (*Onoclea sensibilis*), resurrection fern (*Polypodium polypodioides*).

It is thought that a good number of the north-facing bluffs and ravines along Nancy and Peachtree creeks also once supported northern herb strata. The Georgia Botanical Society has located a few that still support such plants as ginseng, toothwort, yellow ladies' slipper, doll's eyes, goat's beard, hepatica, *Trillium cernuum,* starry campion, and *Schizandra glabra*, Steve Bowling (pers. comm.).

The Chattahoochee sites are typified by Miner Mountain (Gwinnett Co.) north of the Holcomb bridge, where steep north-facing slopes support rhododendrons and mountain laurel, with an exceptional northern flora. The plants below were reported by Norma Seiferly and Haskell Venard to the Georgia Natural Areas Unit during the Chattahoochee Corridor Study. The list is by no means complete; I have selected elements most commonly found in the mountains and I have no evidence of the dominants.

**Trees** - beech, white oak, northern red oak, black oak, umbrella magnolia (*Magnolia tripetela*), big leaf magnolia (*M. macrophylla*), tulip poplar, chestnut oak (rocky areas), sourwood, black locust, serviceberry (*Amelanchier laevis*).

**Shrubs** - Carolina rhododendron (*Rhododendron minus*), rosebay rhododendron, mountain laurel.

**Herbs** - northern maidenhair fern (*Adiantum pedatum*), lady fern (*Athyrium asplenioides*), marginal wood fern (*Dryopteris marginalis*), Solomon's seal (*Polygonatum biflorum*), northern ginger (*Asarum canadense*), doll's eyes (*Actaea pachypoda*), grass of parnassus (*Parnassis asarifolia*), lousewort (*Pedicularis canadensis*), gentian (*Gentiana saponaria*), toothwort (*Dentaria multifida*).

At the rocky "Orkin Bluff" below the Morgan Falls Dam on the Chattahoochee (Fulton Co.), the tree dominants are chestnut oak with a Florida sugar maple and silver bell (*Halesia*) sub-canopy. Northern red oak, hickory, tulip poplar, and dogwood are subdominants. The shrub layer is dominated by Carolina rhododendron (*Rhododendron minus*) and mountain laurel in thick patches. Rosebay rhododendron (*Rhododendron maximum*) is also present. *Leucothoe* forms dense thickets at places. Wild hydrangea and sweet shrub and a few herbs, such as galax, false Solomon's seal, and alumroot, are present.

Panther Creek Cove (Stephens Co., 300 acres) can be considered here, although it would also qualify as [52] BROADLEAF DECIDUOUS COVE FOREST in the Blue Ridge Province. It lies in the extreme northeastern part of the Gainesville ridges in the Brevard Fault zone of the Piedmont. The rocks are Brevard schist, associated with a rare outcropping of dolomite rock producing circumneutral clay loam. A series of north-facing coves (800 feet elevation) contain magnificent assemblages of plants of northern affinites, studied in detail by David Boufford and Emily Wood and summarized by Radford and Martin (1975). The dominant trees are beech, tulip poplar, basswood, and red oak with buckeye and black walnut. Paw paw (*Asimina triloba*) and dogwood are conspicuous in the sub-canopy. Many mountain herbs, such as waterleaf (*Hydrophyllum canadense*), are present in fantastic diversity. A sample of the more remarkable rare plants are the vine *Schisandra glabra, Collinsonia verticillata,* the filmy fern (*Trichomanes petersii*), and the uncommon glade fern (*Athyrium pycnocarpon*); the latter in great beds. Wildflower density is as high here as in high mountain coves, or in the Smokies, Wilbur Duncan (pers. comm.).

Equally as remarkable are the bluffs of Pumpkinvine Creek (Bartow Co.) with their incredible assemblages of northern herbs. The Pumpkinvine Creek site is on or near the junction with Paleozoic dolomites, but is derived from iron and magnesium-rich slates.

There are plants that one would scarely expect to see outside of the Blue Ridge Sector (a total list of herbaceous plants includes over 400 species). The overstory has been heavily cut-over and the area has been pastured. There are beech, basswood, walnut, tulip poplar, northern red oak, umbrella magnolia, white oak, chalk maple (*Acer leucoderme*), hickory, slippery elm, and yellow buckeye (*Aesculus octandra*). During a brief visit I did not see any rhododendron or laurel but noted mulberry and spicebush. Three unusual **shrubs** are the gooseberry (*Ribes cynosbati*), leatherwood (*Dirca palustris*), and prickly ash (*Xanthoxylum americana*). Outstanding **herbs** (some are of northern affinities) are: green violet (*Hybanthus concolor*), shooting star (*Dodocatheon media*), waterleaf (*Hydrophyllum canadense*), greek valerian (*Polemonium reptans*), phacelia (*Phacelia bipinnatifida*), Canadian mayflower (*Maianthemum canadense*), trilliums (*Trillium vaseyi, T. lancifolium, T. grandiflorum*), showy orchis (*Orchis spectabilis*), yellow lady slipper (*Cypripedium calceolaris*), monkshood (*Aconitum uncinatum*), white larkspur (*Delphium tricorne*), doll's eyes (*Actaea pachypoda*), dutchman's breeches (*Dicentra cucullaria*), alumroots (*Heuchera americana, H. villosa,* and *H. parviflora*), senega snakeroot (*Polygala senega*), and Indian physic (*Gillenia stipulata*). Radford and Martin (1975) add as rare herbs yellow fumeroot (*Corydalis flavula*), spike cress (*Arabis laevigata*), sweet chervil (*Osmorhiza longistylis*), wood spurge (*Euphorbia commutatus*); the glade fern (*Athyrium pycnocarpon*), and the rare vine (*Schisandra glabra*).

Apparently a fourth bluff of this type is the Oconee Bluff forest reported by Skeen (1969). This forest fringes a narrow floodplain and is dominated by four tree species (with importance values): beech (24), northern red oak (29), white oak (16), and tulip poplar (12). Two species of hickories occur, *Carya tomentosa* (6) and *C. glabra* (7), as does black oak (2).

A hardwood-hemlock ravine forest, similar to [69] BROADLEAF DECIDUOUS-HEMLOCK FOREST, is reported by David Boufford and Emily Wood in the Highlands Biological Station inventory. In the steep ravine of Cedar Creek (Stephens Co.) they have located an apparently virgin ravine forest dominated by beech, hemlock, and northern red oak with an evergreen heath understory dominated by *Rhododendron minus*. The cliffs are covered with climbing hydrangea, with areas of the rare filmy fern, *Trichomanes petersii*. Many rare, endemic and endangered plant species are present, including *Cardamine clematitis, Collinsonia verticillata, Liparis lilifolia, Solidago curtisii, S. flaccidifolia,* and *Asplenium rhizophyllum.*

Radford (1959) documents a similar forest (Stevens Creek) which he calls a relict mixed mesophytic community near Clark Hill Reservoir (McCormick Co., S.C.) on the steep north-facing slope. He found a pH of 7.0 and an alkaline subsoil (pH 7.5-8.0). Many of the herbs are similar to those from Fernbank and Pumpkinvine Creek.

Another Piedmont ravine with northern affinities is Whooping Creek in extreme southern Carroll County. Faculty at West Georgia College have been instrumental in preventing the proposed West Georgia tollway from destroying this remarkable area. Whooping Creek resembles a mountain stream. Its banks are clothed with mountain laurel, galax, and yellowroot. Its very narrow floodplain supports buffalonut (*Pyrularia*) and mountain laurel. The steep ravine sides are dominated by northern red oak, shagbark, and mockernut hickories, with some white oak. Beech occurs at seeps. The forest is largely uncut on the east side of the stream. Wild hydrangea is a shrub component. On 22 March the halberd leaf violet, toothwort (*Dentaria (Cardamine) diphylla*), was very common, along with trout lily, windflower *Anemonella thalictroides*, and roundleaf hepatica.

Many of the streams in the Brevard Fault Zone north of Whooping Creek have bluffs or ravines with a northern type flora. Bluffs and ravines along Anneewakee Creek (Douglas County) carry black cohosh, goat's beard, northern maidenhair fern, wild hydrangea, mountain laurel, galax and lobed strawberry (*Waldsteinia lobata*). Hurricane Creek (Douglas Co.) which resembles a mountain stream and is reported to have sustained trout at one time, supports a ravine with such northern elements as dog hobble (*Leucothoe axillaris* var. *editorum*), yellowroot, mountain laurel, galax and buffalo nut. Parts of the Dog River (Douglas Co.) and Rottenwood Creek (Cobb Co.) have similar or even more northern species. The steep ravines of any streams dropping off the Brevard Zone's western escarpment (circa 1000 feet) to the Chattahoochee (circa 800 feet) should be suspect. In fact, if one draws a line between the 1000 foot and 800 foot contours, most north -facing bluffs north of this line (Atlanta lies on the 1000 foot plateau) will have herbaceous vegetation with strong northern affinities — south of this line the relationship diminishes and most bluffs fall into environment [65]. MacDaniel's Bluff on the Yellow River and the Alcovy Bluffs near Dacula (Gwinnett Co.) barely fall within the higher contour but have definite northern elements such as northern red oak, wild hydrangea, mountain laurel, northern maidenhair fern, galax, black cohosh, goat's beard and lousewort.

On these north-facing bluff cliffs of amphibolite schist along the Yellow and Alcovy Rivers there is a characteristic cliff flora, probably due to the high calcium and magnesium content of the rock. Abundant redbud may be one evidence of this, Near the cliffs the dominant subcanopy trees are hop hornbeam and chalk maple. At the cliff base grows oat grass (*Uniola latifolia*), a saxifrage (*Saxifraga virginiensis*) and lobed strawberry (*Waldsteinia lobata*). On the moister cliffs grow *Forestiera ligustrina* and coral berry (*Symphoricarpus orbiculatus*) and on drier sites hairy lip fern (*Cheilanthes lanosa*) and maidenhair spleenwort (*Asplenium trichomanes*). At the top of the rocky bluff was abundant fragrant sumac (*Rhus aromatica*) and shooting star (*Dodecatheon meadia*) under a prolific growth of red cedar. Cliffs of garnet-rich mica schist in the Brevard Fault zone bear by contrast marginal wood fern (*Dryopteris marginalis*), alumroot (*Heuchera parviflora*) and the same saxifrage, Steve Bowling (pers. comm.).

**Notes on Fauna, Values and Man's Impact follow environment [65].**

# [65] BLUFF, SLOPE AND RAVINE FORESTS

## Location and Description

This category covers all of the non-hydric, moist varieties of Piedmont forest, such as occupy stream valleys, slopes, and bluffs, that do not have an abundance of northern plants. During his studies of the slope forests on the Cobb County side of the Chattahoochee, Richard Lee (pers. comm.), in addition to the plants reported under **flora**, found scattered northern plants, such as toothwort, foamflower, and Indian physic, in his area but so scarce as to be insignificant, certainly not dominant, elements of the flora.

There is a narrow border of this type forest fringing the Alcovy floodplain (Newton Co.), and beech is the characteristic tree there. Beech flats are sometimes encountered adjacent to Piedmont floodplains. The vegetation is not especially northern. Much of the moisture comes from downslope seepage.

The reader is again reminded that this and the previous environment share many similarities and grade into one another

Photo A24. A "beech glen" ravine, environment [65], near the Chattahoochee River (Fulton Co.). Beech, northern red oak, and white oak are the dominant trees. Mountain laurel and other mountain species occur on nearby river bluffs.

## Flora

Beech, and sometimes a few floodplain species, are characteristic of the moister zones of this forest. How far this environment extended upslope in pre-agricultural days is unknown. Beech shares the canopy with white oak, tulip poplar, and other hardwoods.

Lee (1974) made a survey of autumn flora at three sites along the slopes bordering the Chattahoochee River on the western (Cobb Co.) side. His hardwood forest zone was generally east or SE facing. I include below only those plants that he noted to be abundant (A) or common (C) (trees only):

SITE CO-42.-**Trees-**(A): white oak; (C): pignut hickory, mockernut hickory, beech, white ash, tulip poplar, black gum, scarlet oak, southern red oak, red oak *(rubra)*, black oak, dogwood, wourwood. **Shrubs -** strawberry bush. **Herbs and Vines -** river cane, New Jersey tea, spotted wintergreen, wild ginger (*Hexastylus arifolia*), poison ivy, St. Andrew's Cross, horsemint (*Pyncnanthemum icana*), greenbriers (*Smilax bona nox, S. glauca*), Christmas fern.

SITES CO -143 and 125. - (A): beech, mockernut hickory, white oak; (C): pignut hickory, sweet gum, tulip poplar black gum, northern red oak (*Q. borealis*), swamp chestnut oak, black gum, dogwood, sourwood, red cedar **Shrubs** - witch hazel, privet. **Herbs and Vines** - New Jersey tea, spotted wintergreen, elephant's foot (*Elephantopus nudatus*), wild ginger, poison ivy, St. Andrew's Cross, greenbrier (*S. glauca*), Christmas fern.

SITE CO-161 - (A): beech, tulip poplar, white oak; (C): red maple, Florida maple, pignut hickory, mockernut hickory, sweet gum, black gum, scarlet oak, southern red oak, swamp chestnut oak, black oak, slippery elm, dogwood, sourwood. **Shrubs** - witch hazel, sparkleberry, privet. **Herbs and Vines** - New Jersey tea, spotted wintergreen, elephant's foot, St. Andrew's Cross, horsemint (*S. glauca*), bear's foot (*Polymnia uvedalia*), Chirstmas fern, foxgrape (*Vitus labrusca*), muscadine.

Examination of this plant list indicates that these sites are quite closely related. Site CO-42 faces southeast and, indeed, beech is less numerous; neither witch hazel nor grapes are common. Site-161 appears somewhat moister although both it and CO-143-125 have swamp chestnut oak, a normal floodplain component (as well as slippery elm). The presence of the two maples at site CO-161 also suggests moister conditions.

In a north-facing ravine forest on the southside of the "The Cove" at Pine Mountain (Meriwether Co.) scattered beech trees dominated the canopy, with sourwood and sweet gum as co-dominants (chestnut oak-longleaf pine occupied most of the west face). American holly, tulip poplar, red maple, and dogwood were present. The dominant shrubs were river cane (along the branch and in seeps) and the dwarf rhododendron (*Rhododendron minus*), an odd pair of plants. Other common shrubs were maple-leafed viburnum, witherod viburnum, oak-leafed hydrangea, flame azalea, buffalonut and witch hazel. The dominant herb was climbing hydrangea (*Decumaria*). Other common vines and herbs were wild ginger, yellowroot, and Christmas, cinnamon, royal and netvein chain fern.

For comparision, an northeast-facing hill in the extreme southern Piedmont a few miles north of Roberta (Crawford Co.) had the following late summer flora: **trees**: basswood, northern red oak, black gum, dogwood, sweet gum, sourwood, southern sugar maple, mockernut hickory.

**Shrubs**: red buckeye, hop hornbeam.

**Herbs**: wild indigo (*Baptisia megacarpa*), rattlesnake root (*Prenanthes serpentaria*), Virginia creeper, New Jersey tea, bloodroot, coral root (*Corallorhiza odontorhiza*), Solomon's seal, and a mint (*unident*). According to Robert Lane, *Silene polypetala* is endemic to such bluff forests close to the Flint River.

One of the best examples of semi-original Piedmont forest lies along the valley of a picturesque branch in Chattahoochee State Park (Fulton Co.) between the Palisades and Long Island Creek. Upstream it begins with a xeric oak-hickory forest and as the ravine deepens, adds beech and other mesic species. The north-facing slope has, occasionally, mountain forms, such as mountain laurel and maidenhair fern. The ravine floor is exceptionally rich in seven dominant fern species: Christmas, royal, cinnamon, New York, sensitive, southern lady and broad beech ferns. The dominant **tree** of this mesic stream valley is white oak. There are two species of hickories, and two magnolias (*Magnolia macrophylla, M. tripetala*) which I suggest as indicator species for this environment; northern red oak is occasional. The dominant **shrub** is dwarf paw paw, with some azalea. Virginia willow occurs in moist places, along with fly poison (*Amianthium muscaetoxicum*), alumroot (*Heucheria* sp.), and some arrowhead (*Sagittaria latifolia*). Elsewhere crossvine, greenbrier (*Smilax glauca*), and poison ivy are common vines. As the stream approaches the Chattahoochee floodplain, one encounters an abundance of mayapple, trillium (*Trillium cernuum*), and the very rare lily (*Lilium canadense* var. *editorum*) along the stream bank.

Steve Bowling considers three plants, wild geranium, broad beech fern and bloodroot, as indicators of this environment, as opposed to environment [64].

### Fauna of Bluff and Ravine Forest of Northern Affinities and Fauna of Bluff, Slope and Ravine Forest.

Like most Georgia environments, the fauna is poorly known. In Appendix VI the habitat would be X, with some elements from M invading. Since the small branches at Chattahoochee State Park were inhabited only by creek chubs (*Semotilus atromaculatus*) and, if rocky,, a few brook trout (from fingerlings stocked below Morgan Falls), we electrofished the best one of 10 small streams with protected watersheds in steep terrain along the Chattahoochee bluffs. This stream empties into the Chattahoochee 1.4 miles south of Sope Creek (Cobb Co.) and contained (D) band fin shiner (*Notropis zonistius*), (D) creek chub, stoneroller (*Campostoma anomalum*), chub (*Hybopsis* sp. cf *amblops*), creek chubsucker (*Erimyzon oblongus*), Alabama hog sucker (*Hypentelium etowanum*), yellow bullhead (*Ictalurus natalis*), bluegill (*Lepomis machrochirus*), and banded sculpin (*Cottus carolinae*). I accept this as near-original species composition of small Piedmont streams along the Chattahoochee. The floodplain adjoining bluffs is relatively rich in species and biomass (see Piedmont river floodplains). The small, rocky bluff streams support an abundant salamander population of *Desmognathus* species, probably of the *ochrophaeus* or *fuscus* groups. In the forest two salamanders predominate — the small red-backed salamander (*Plethodon cinereus*), which is now a bluff and slope form, and the large black slimy salamander (*Plethodon glutinosus*). The spotted (*Ambystoma maculatum*) is undoubtedly present where floodplain pools make breeding sites available.

The smooth earth snake, worm snake, ringneck, black rat, king snake, and copperhead are the most common snakes. In this type environment the timber rattlesnake, largely exterminated from the central Piedmont, occurs. Common lizards are the little brown skink (*Lygosoma laterale*) and several of the larger skinks of the genus *Eumeces*.

David Funderburk (pers. comm.) records the common box turtle, fence lizard, little brown skink, greater five-lined skink, copperhead, midwestern banded watersnake, DeKay's snake, garter snake, ringnecked snake, worm snake, black rat snake, and king snake from the 60-acre Fernbank Forest.

Since Fernbank birds have been recorded, the list below tallies the breeding native species (B) and those seen in summer that should be breeding there (S), David Funderburk and Georgann Schmalz (pers. comm.).

(S) Barred Owl, (B) Yellow-shafted Flicker, (B) Pileated Woodpecker, (B) Red-bellied Woodpecker, (B) Red-headed Woodpecker, (S) Hairy Woodpecker, (S) Downy Woodpecker, (S) Crested Flycatcher, (S) Eastern Wood Pewee, (B) Blue Jay, (B) Carolina Chickadee, (B) Tufted Titmouse, (B) White-breasted Nuthatch, (B) Brown-headed Nuthatch, (B) Carolina Wren, (B) Mockingbird, (B) Catbird, (B) Brown Thrasher, (B) Robin, (B) Wood Thrush, (S) White-eyed Vireo, (S) Yellow-throated Vireo, (S) Red-eyed Vireo, (S) Yellow-throated Warbler, (B) Ovenbird, (S) Hooded Warbler, (B) Cardinal, (B) Rufous-sided Towhee, (S) Chipping Sparrow. These species would be generally the same for the **submesic broadleaf deciduous forests**.

Of the smaller mammals, the chipmunk, shorttail shrew, pine vole, and deer mouse are undoubtedly the most common. Funderburk records the following mammals from Fernbank: opossum, least shrew, mole, chipmunk, flying squirrel, cottontail, and raccoon. There is a specimen of the rare hoary bat (*Lasiurus cinereus*) in the Georgia State collections from near Fernbank.

Photo A25. A cave in oak-hickory dominated BLUFF, SLOPE AND RAVINE FOREST [65] along the Chattahoochee palisades (Fulton Co.). Indians continuously used such caves from Archaic times to the Cherokee farming era up to the early 1800's and had village sites on the highest terrain of nearby floodplains. The river shoals here provided abundant fish and clams.

**Natural and Cultural Values of [64] and [65] above.**

The north-facing bluffs are so valuable for education and science that all other considerations are overshadowed. They are possible relicts of glacier-age flora now reduced to a few examples still not developed by man. They are also important seed sources. Both Pumpkinvine and Panther Creek areas are recommended as National Natural Landmark sites by Radford and Martin (1975), the latter being considered among the five most outstanding sites in the Piedmont of eastern America. Panther Creek in particular is a relict of that ancient Tertiary forest that was once widespread over the northern hemisphere 50 million years ago. Panther Creek, as depicted by David Boufford and Emily Wood, shares many Tertiary forest species with eastern Asia, perhaps more than any other location in the southeast. They conclude that this area is a living laboratory "in which the many questions associated with this disjunct pattern might be elucidated as well as providing a sample of a very ancient forest system." The esthetics of the narrow gorge of Cedar Creek (Stephens Co.), with its virgin timber and unusual and rare species, places great importance on preservation.

**Man's Impact on Environments [64] and [65]**

These communities have been damaged by logging, fire, shrub-digging, bulb-digging, plant collecting, and packing down the humus by the tread of many feet (as at Fernbank Forest). Livestock have rooted and destroyed areas, and erosion on the steep slopes is serious following removal of the herb-shrub layer The introduction of Boston Ivy and Japanese honeysuckle has caused serious devastation on parts of Fernbank Forest and other northern slopes around Atlanta.

## [66] RAVINE FOREST OF MIXED AFFINITIES

**Location and Description**

The ravines, slopes, and bluffs of the Pine Mountain area (Meriwether and Harris counties) support classic examples of these environments with their curious mixture of mountain and Coastal Plain plant life, as well as mixtures of Piedmont and Coastal Plain animal life. Singer's Hill, Rockhouse Mountain, and Dripping Rock are specific areas of special interest.

Although these communities may have existed along Potato Creek gorge (Upson Co.) and elsewhere, the best ravines away from the Flint River water gap that I have found open into the Chattahoochee (or Bartlett's Ferry Lake) in Harris County. These ravines are cool and moist, with small streams and steep sides. Soils along the Chattahoochee are in the Cecil-Wilkes-Gwinnett association.

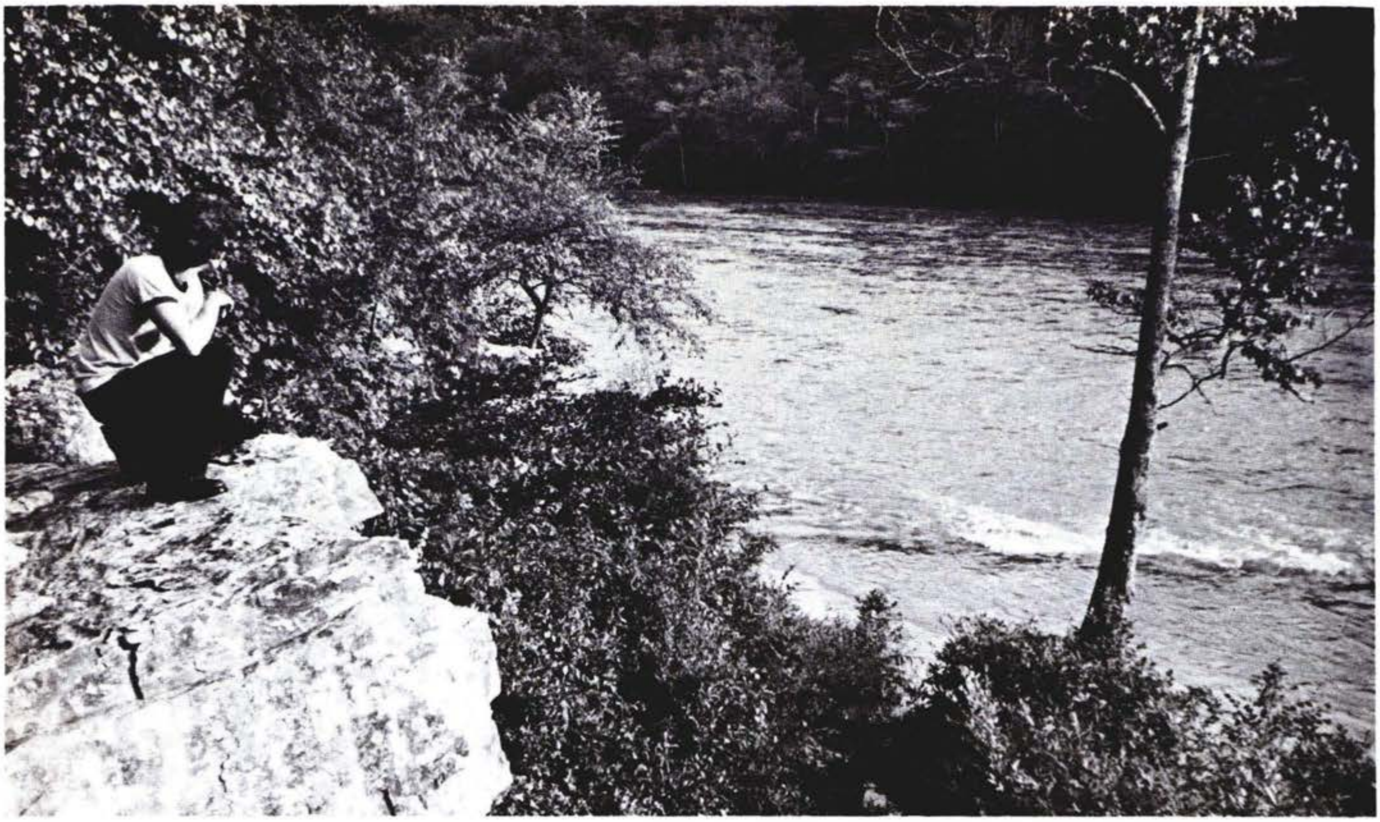


Photo A26. Shoals on the Flint River at Dripping Rock (Upson Co.) produced by quartzite outcrop. The tree at water's edge is a tupelo gum; the weedy growth is water willow (*Justicia americana*). The Coastal Plain shrub, titi (*Cyrilla*), occurs here in abundance alongside mountain species such as *Rhododendron minus* Coral snakes have been taken here in the narrow, sandy floodplain, environment [66], along with such mountain forms as the purple salamander (*Gyrinophilus*).

### Flora

Radford has observed the following communities: beech-mountain laurel-rhododendron slopes; beech-oak leaf hydrangea-spring herb; chestnut oak-mountain laurel; water tupelo-swamp oak; silver bell (2 or 3 species); buckeye-magnolia cove hardwoods, Radford and Martin (1975). Jones (1974) lists all northern and southern plant species but does not give specific localities. Radford and Martin (1975) describe a bay swamp with sweet and red bays and titi, resembling a coastal sandhill bay assemblage, on Cooler Branch (Meriwether Co.).

In one Harris County ravine the principal **trees** were northern red oak, beech, chalk maple, Florida maple, and an ash. The understory contained both silver bells (*Halesia caroliniana, H. diptera*) and hop hornbeam as dominants. The principal **shrubs** were black haw (*Viburnum prunifolium*), buckthorn (*Rhamnus* sp.), sweet shrub, and mulberry. This is the most northern area where I have found the needlepalm (*Rhapidophyllum*). **Herbs** of note were hepatica, alumroot (*Heuchera americana*), doll's eyes (*Actaea*), black cohosh (*Cimicifuga*), Jack-in-the-pulpit, and ginseng (*Panax quinquefolia*), the latter being a new record this far south. A north-facing river bluff bore a forest of white oak, buckeye, red elm, poplar, Florida maple, and mockernut hickory. The shrub layer had red bay, witch hazel, *Amorpha fruticosa*, and mountain laurel. It is quite odd to see mountain laurel side by side with Coastal Plain red bay. Jones (1974) records some other interesting species from the Mulberry Creek Gorge: the swamp privet (*Forestiera ligustrina*), the black titi (*Cyrilla racemiflora*), and devilwood (*Osmanthus*). In this same dry gorge I found the dominant trees to be an elm, red cedar, and loblolly and shortleaf pines, with sparkleberry as the dominant shrub.

Dripping Rock ravine between Dripping Rock Falls and the Flint River (Upson Co.) is another example of disjunct northern and southern floral elements together, Photo A26. The following plants were either dominant or common:

**Trees** - (D) beech, black gum, sourwood, sweet bay (*Magnolia virginiana*), American holly. **Shrubs** - Carolina rhododendron (*Rhododendron minus*), leucothoe (*Leucothoe axillaris*), titi (*Cyrilla racemosa*), myrtle (*Myrica heterophylla*), (D) Hercules'-club (*Aralia spinosa*), mountain laurel, sweet shrub, greenbriers (*Smilax walteri, S. laurifolia*).

**Herbs** - lousewort (*Pedicularis*), *Ligusticum canadense,* yellowroot, Indian cucumber (*Medeola virginiana*), *Silphium compositum,* small green wood orchid (*Habenaria clavellata*), Indian plantain (*Cacalia atriplicifolia*), (D) cinnamon fern, (D) chain fern, southern lady fern, bracken fern, royal fern, angelica (*Angelica venenosa*).

Other plants of interest, though uncommon, were the oak-leaf hydrangea, french mulberry, wild hydrangea, grass of parnassus, and the net-vein chain fern (*Lorinseria areolata*). A wet rockface at a water fall bore liverworts, *Selaginella apoda,* and a St. John's wort (*Hypericum mutilum*).

Steve Bowling and Lovell Greathouse report (pers. comm.) an extraordinary plant mix in a ravine on the east side of the Savannah (Aiken Co., S.C.), just above Augusta. Within 100 meters of each other were bald cypress, spanish moss, sabal palmetto, round-leaved hepatica, and the mountain tree, yellowwood (*Cladrastis*).

**Fauna**

Specimens of *Desmognathus* and 3-lined salamanders occur at Dripping Rock Falls. A mountain species, the purple salamander (*Gyrinophilus porphyriticus*) occurs in the Dripping Rock ravine, T.W. French (pers. comm.). Since this property belongs to Camp Thunder, the resident naturalist, Carlton Colquitt, may have faunal records from this ravine. We also took desmognathine salamanders from the Mulberry Creek area. Needless to say, the fauna is poorly known. It is distribution P with some MT and CP elements; habitat X with some X and SX elements, Appendix VI.

**Natural and Cultural Values**

Radford and Martin (1975) recommend almost the entire area where the Flint flows through Pine Mountain as a Natural Landmark called "Flint River Water Gap Wilderness Area," and list it as one of the three most ourstanding sites in the Piedmont of eastern America when the following criteria are considered: community and species diversity; endemic, rare and disjunct species; edaphics, topography, and geology.

These incredible assemblages of northern and southern species make these ravines valuable in education and science. They are also highly recreational — the open gorge and falls of Mulberry Creek and the Water Gap area are ideal for trails and esthetic vistas. The dark ravines themselves are pleasantly cool, but are fragile, and must be protected.

**Man's Impact**

Logging the overstory, livestock, and overuse can easily damage these systems. Dams at Spewrell Bluff and below would drown most of the magnificent biota of this area of the Flint River water gap.

## [67] EVERGREEN HEATH BLUFFS

**Location and Description**

These bluffs are common in the Piedmont area. They are generally more rocky, or drier, or with thinner soil than covers the slopes of the deciduous bluff forest. They occur on a number of compass facings — often a north-facing one. I have seen examples on the South River above the Island Shoals bridge (east bank), along the Chattahoochee and Sweetwater Creek, on the Alcovy below the 278 Bridge (west bank) and at other places, usually a steep hillside bordering a river. The arboreal vegetation is more inclined to be drier, with southern red oak and white oak. Little is known of the flora and fauna of these bluffs, except that they are dominated by a dense thicket of mountain laurel on drier slopes, and rosebay rhododendron on moist slopes, (Brevard Zone).

b. SUBMESIC BROADLEAF DECIDUOUS FORESTS

## [68] OAK-HICKORY CLIMAX FOREST

This is considered by various authors to be the **climax** forest of the Piedmont. **Postclimax** forests are moister (i.e., floodplains, bluff forests) and **preclimax** forests are drier.

**Location and Description**

These forests formerly covered 50% to 75% of the Piedmont uplands; most have been eliminated by agriculture. The downslopes and seepage areas were covered by Piedmont bluff and ravine forests. This forest occupied the "red lands" discussed by Brender (1952, 1974). Nelson (1957) puts pure hardwood cover at about 40% and mixed pine-hardwood at 45% at the time of settlement. May (1968) indicates that even bare eroded Piedmont soils tend to change for the better after 150 to 200 years of forest cover, and quotes Kuo (1965) who found that soils beneath hardwood forest have more nitrogen, organic carbon, and a higher pH and soil moisture capacity than soils beneath pine forests.

I personally feel that hardwood forests originally covered more of the Piedmont than estimated by the authors above. This forest occurs on soils derived from a wide variety of rock types. In the western Piedmont I have seen it over phyllite (sou. red oak appears dominant), biotite gneiss, and various micaceous schists (sericite, biotite, etc.). Except for arid, thin-soiled ridges, shallow soils around outcrops, and moist ravines and bluffs most of the Piedmont was apparently covered with this type of climax forest.

Piedmont soils were derived from two main sources: metamorphosed sediments such as mica schists, and from several types of igneous rocks injected upwards into the metamorphosed sediments. The most widespread of the igneous rocks are the granites and gneisses which are rich in silica and aluminum (silicic rocks) and these compose the major rock outcrops of the Piedmont. These rocks, along with the mica schists and other metamorphosed sediments, weather into a soil with a shallow sandy loam surface soil and a deep (3-40 feet), red clay or red clay loam subsoil, conspicuously visible in road cuts. These deep soils are predominantly classified as Cecil, Lloyd and Madison soils in the central Piedmont. Where depth to bedrock is less, often a less reddish or non-red subsoil will develop (Appling soils), or where bedrock reaches to within 12-48 inches of the surface, the soils are entirely gray to brown sandy loams (Louisburg soils).

The other type of igneous outcrop, far less common, is crystallized from a magma rich in iron and magnesium and poor in silica and aluminum (basic rocks). Sodium and calcium-rich feldspars (plagioclase) dominate in this rock type while the granitic rocks have more potassium-rich (orthoclase) feldspars. Some plants require high levels of calcium or magnesium. Redbud, chalk maple, beaked hazlenut and some hepaticas seem to prefer basic rocks. The calcium-loving red cedar occurs more commonly on soils from basic rocks-on granite it occurs close to where the calcium is being liberated from the bedrock.

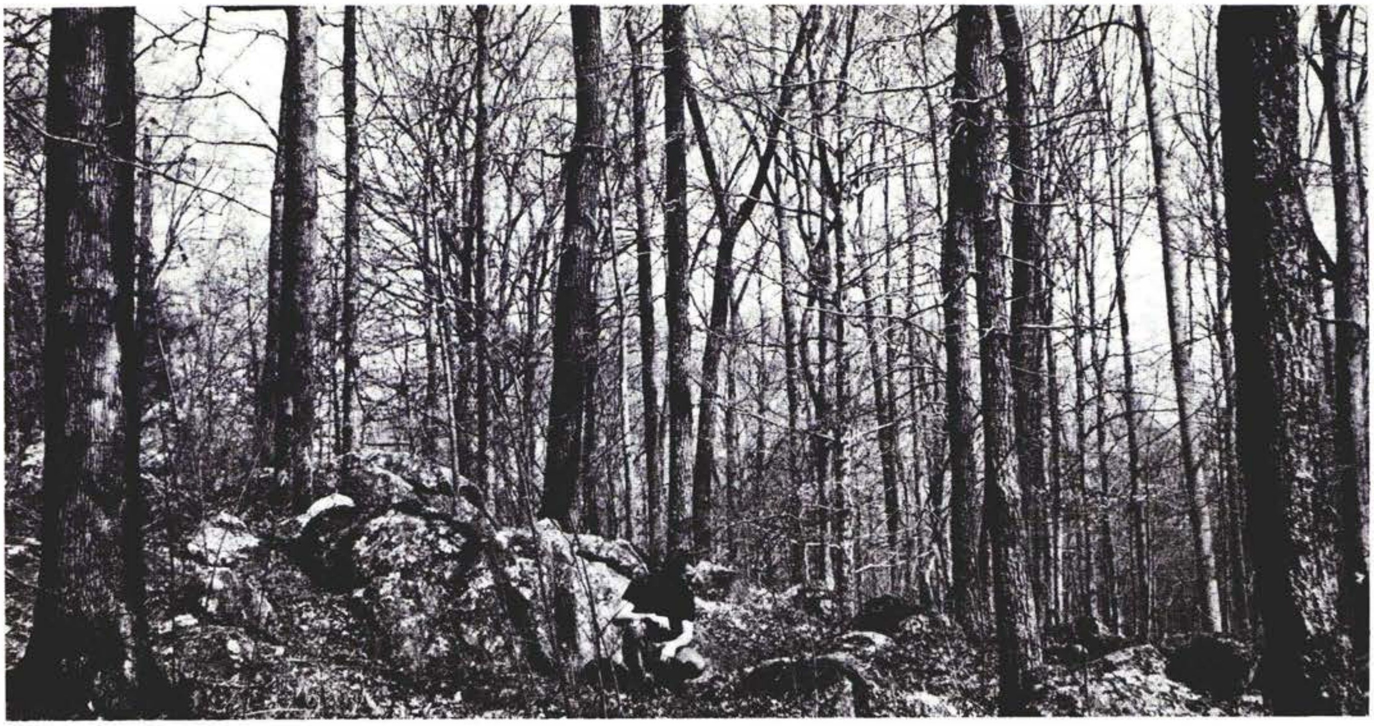


Photo A27 The ridgetop of Soapstone Ridge (DeKalb Co.) was never farmed because of the rocky terrain. Here OAK-HICKORY CLIMAX FOREST [68] grows on magnesium-rich ultramafic rocks. It is dominated by white oak, northern red oak, and hickory. Chipped bowls from the soapstone outcrops in various stages of manufacture can still be seen on the outcrop rock faces. These pre-pottery vessels date from the late Archaic to the early Woodland period, 3,000-1,000 B.C.

The dividing line between the silicic and basic rocks lies in the neighborhood of diorite; diabases, gabbros, peridotites, dunites and soapstones are considered to be mafic or "ultramafic" deposits, the latter catch-all category indicates rocks that are dark with ferro-magnesian minerals, which become increasingly dominant over plagioclase feldspar Some soils, such as the Davidson and Iredell, may be drived from basic rocks. Davidson soils, however, may weather to red clay indistinguishable from that derived from silicic rocks. In fact, the minerals that remain in the weathered clays probably determine the vegetation. Rock types become more important when closer to the surface. Often the physical structure of the soil may be as important as its chemistry, particularly on ridges. Phyllites and quartzites both, because of physical structure, may support a pine-dominated community. Quartzites commonly yield a very poor soil usually dominated by pines and xeric oaks (blackjack, post). The fact that many different rock types weather into similar-appearing soils makes it difficult to relate vegetation to rock type. If one locates near-original forests, however, some differences can be found.

### Flora

Soils with deep, red subsoils such as Cecil in Walton County appear to be dominated by white oak, black oak, southern red oak and pignut hickory with some post oak and blackjack oak on drier sites. Dogwood and dwarf paw paw are characteristic in the sub-canopy and shrub zones. A near-original, north-facing slope forest on Appling soil (Walton Co.) was dominated by mockernut hickory, black oak, silverbell, dwarf paw paw and muscadine grape. Other prominent species were white oak and sourwood. Serviceberry, *Rhododendron canescens* and chinquapin were dominant in the **shrub** layer, along with American chestnut, which probably was originally a co-dominant on moist Piedmont slopes. Fly poison, wild geranium, lopseed (*Phryma*), elephant's foot, Catesby's trillium and poison oak dominated the **herb** zone. Phyllites in Taliaferro County had much the same vegetation as Cecil soils except from more southern sugar maple, post oak, southern red oak and red bud. A former pasture on Louisburg soil (Walton Co.) was dominated by white oak with mockernut and post oak as co-dominants — hawthornes and sparkleberry indicated the drier environment.

A near-original forest on ultramafic deposits in Elbert County had an unusual and diverse plant community, in spite of heavy grazing by cattle. **Trees** were dominated by large winged elm and post oaks; co-dominants were southern sugar maple, white oak, black oak, sweet gum, American elm, Oglethorpe oak, southern red oak and southern shagbark hickory. Subcanopy dominants were mulberry, red bud, ironwood and dogwood. **Shrubs** were French mulberry, with *Viburnum prunifolium*, and the buckthorns (*Rhamnus caroliniana* and *Bumelia lycioides*) present. On a nearby basic deposit red bud, ash and willow oak were more prominent. As in the case of the curious Monticello upland glade "swamp" (see Piedmont alluvial stream systems, floodplain flora) over norite gabbro, there was a unique combination of wet and dry-tolerant species. DeKalb's Soapstone Ridge is a better drained ultramafic site. Here the dominant **trees** are white oak, southern shagbark hickory, northern red oak, basswood (formerly), with chalk maple in the subcanopy. Dominant **shrubs** are bigleaf storax (*Styrax grandifolia*), hazlenut (*Corylus americana*), serviceberry, *Rhododendron speciosum*, blueberry (*Vaccinium vacillans*), dwarf paw paw and fringe tree (*Chionanthus*). Characteristic **herbs** in the scant herb layer appear to be muscadine grape, *Collinsonia serotina, Viola tripartita, Taenidia integerrina, Silene stellata, Zizia* sp. and *Smilax herbacea*. In a moist cove some herbs with northern affinities occur: American alum root, featherbells (*Stenanthium*), bloodroot, round-lobed hepatica, goat's beard and yellow root. Very dry ridges support a blackjack oak-shortleaf pine forest.

May studied Piedmont forests on steep to moderate slopes in Clarke and Jackson counties, on deep porous sandy clay to clay soils. He found the overstory of 42½ acre plots to be dominated by white oak, northern red oak (*Q. rubra*), post oak, black oak, southern red oak, scarlet oak, yellow poplar, shortleaf pine, and hickories. Steep north-facing plots would account for northern red oak and yellow poplar Much drier plots probably showed more post oak, southern red oak, and scarlet oak.

These forests are referred to as oak-hickory forests (Moore, 1973) or oak-hickory communities (Oosting, 1942). Oosting classifies Piedmont climax communities, based upon relict samples in the North Carolina Piedmont, containing trees from 200 to 300 years old (agriculture dates back to 1750). He recognized one major and one minor type. The major type he calls the white oak-black oak-red oak type. The common hickories were southern shagbark (*Carya carolinae septentrionales*), mockernut hickory, and pignut hickory (*Carya glabra*), and to a lesser degree pale hickory (*Carya pallida*). The minor type Oosting called the white oak-post oak type, associated with "inferior exposures, drier ridges and knolls and apparently poorer soils " The principal difference in these two types is that the post oak was the most abundant canopy member in the white oak-post oak type. The post oak was present in the moister variety, as was the scarlet oak. The blackjack oak, however was restricted to the post oak type. Oosting found a few pine scattered throughout these old forests; shortleaf was restricted to the drier post oak dominated type and loblolly to the moister type. Oosting felt that a few pines in climax communities were probably normal. We have seen at Fernbank Forest loblolly pine reproduction in openings in the near-original hardwood forest. These openings may be created by falling hardwoods. It is moot whether young poplars or pines eventually dominate such an opening.

In the understory Oosting found, common to both forest types: sourwood, dogwood, black gum, and red maple, which he stated characterized the upland hardwood forest. Some species, serviceberry, sassafras, black cherry, and possum haw (*Ilex decidua*) appeared in the moister variant, while ash, elm, ironwood, and red bud were confined to the post oak type. Only two **shrubs**, the buckberries (*Viburnum affine* and *Polycodium* spp.) were abundant; *Viburnum prunifolium* and the fringe tree were common. American holly and maple-leafed viburnum occurred only in the moister stands, and pinxter-flower (*Rhododendron nudiflorum*) and the rusty black haw (*Viburnum rufidulum*) occurred only in the post oak type.

In white-oak dominated sites Oosting found the following **herbs**: bellworts (*Uvularia sessilifolia*) and beggar's lice (*Desmodium obtusum, D. laevigatum, D. dillenii,* and *D. rotundifolium*). In post oak dominated types he found panic grass (*Panicum microcarpon*), skullcap (*Scutellaria* sp.), pink wildbean (*Strophostyles unbellata*), heal all (*Prunella vulgaris*), wild ginger (*Asarum virginicum*), bedstraw (*Galium circaezans*), mint (*Pycnanthemum flexuosum*), broomsedge, *Aster ericoides, Lespedeza repens* St. John's wort (*Ascyrum hypericoides*), Maryland stonemint (*Cunila origanoides*), Coreopsis (*Coreopsis major*), goldenrod (*Solidago nemoralis*), goat's rue (*Tephrosia virginiana*), gold aster (*Chrysopsis mariana*), bushy aster (*Aster dumosus*), and white-topped asters (*Seriocarpus linifolius, S. asteroides*).

He found that both types share the following herbs: spotted wintergreen, barestem tickclover (*Desmodium nudiflorum*), hawkweeds (*Hieracium venosum, H. gronovii*), panic grass (*Panicum* sp.), sedge (*Carex* sp.), bedstraw (*Galium pilosum*), agrimony

Photo A28. Hulm's Woods, a SUBMESIC BROADLEAF DECIDUOUS FOREST [68] remnant in Clarke County has as dominant trees, scarlet oak, post oak, black oak, and southern red oak. Both shortleaf and loblolly pines occur in drier portions. The area has been logged, but never farmed. Such forests are rare on level Piedmont terrain.

(*Agrimonia gryposepala*), Virginia snakeroot (*Aristolochia serpentaria*), and foxglove (*Aureolaria flava*). I would prefer to indicate only the dominants, except Oosting did not. I think it is important, however, to have a list of the species from these old near-virgin Piedmont forests. We have so few examples left.

Occasionally in driving through the Piedmont, one will see remnants of near-mature hardwood forest in the midst of fields. The lack of pines may indicate that it was never an old field, but again the pines may have been cut out. Exploring the history of such a forest with the help of local people can be exciting and rewarding. To find a Piedmont hardwood forest that has never been in agriculture, especially on level ground or on a gentle slope, is indeed a prize.

Apparently Hulm's woods, a 40-acre forest north of Winterville on the Clark-Oglethorpe line, is such a tract, Photo A28. Wilbur Duncan (pers. comm.) believes that it represents near-original forest although it has had three timber cuts, twice for pine (1942, 1969), and once for hardwoods (1950). None of the present hardwoods appear old. Either the pines have encroached from cutting of hardwood prior to 1942, or it is a pine-hardwood forest and should be differently classified. Duncan leans towards the theory that the pines have come in, either due to logging the hardwoods or to fire. He mentions even the possibility of a crown fire in the fall before leaves are down as a catastrophic possibility in these dry Piedmont oak-hickory forests. In any event, Hulm's woods were never in agriculture.

Judging from the dominance of scarlet oak (*Quercus coccinea*), it is perhaps a drier forest than normal. In fact, it caps the highest terrain. The dominant trees are scarlet oak and white oak. There are smaller numbers of red oak (*Quercus borealis* var. *maxima*, largely on the north side), a few southern red oak, black oak, post oak, and some blackjack oak. There are three species of hickories: red hickory (*Carya ovalis*), mockernut (*C. tomentosa*), and pale hickory (*C. pallida*), the latter being quite common. Sourwood is present, but dogwood is not common in the understory. Some cherry (*Prunus serotina*) is present. The dominant shrub is deerberry (*Vaccinium stamineum*). Sparkleberry is common throughout. The wooly azalea (*Rhododendron canescens*) forms clumps here and there. In certain parts of the forest the blueberry (*Vaccinium vascillans*) forms thick patches.

Among the common vines and herbs are the muscadine (*Vitus rotundifolia*), greenbrier (*Smilax glauca*), wild indigo (*Baptisia australis*), the oat grass (*Danthonia* sp.), and the needlegrass (*Stipa avenacea*).

The presence of dominant scarlet oak is unusual for Piedmont forests (W. Duncan, pers. comm.) and may be due to the poor soil. Elsewhere in xeric situations one would expect to find more southern red oak (*Q. falcata*) and post oak.

On the Gainesville connector in Hall county, because of the steepness of the Gainesville Ridges, one can find forest in near-original species composition. Here we find white oak, northern red oak, black oak, and southern red oak and, in places, chestnut oak with pignut hickory, sourwood, dogwood, and some ironwood in the understory. Study of forests in this area (vicinity of Buford-Lawrenceville exit sign) should be rewarding.

Due to slope and soil, all variations between xeric upland and the more mesic forests appear. In a branch valley (with bedrock close to the surface) on Cedar Creek (Clarke Co.) the forest is predominantly northern red oak (now dead due to prolonged drought), white oak, and mockernut hickory with the following trees also present: southern sugar maple (*Acer floridanum*), chalk maple (*A. leucoderme*), and Oglethorpe oak (*Q. oglethorpensis*), with some pignut hickory. The common shrubs were a buckeye (*Aesculus pavia*), the rusty black haw (*Viburnum rudifulum*), and strawberry bush (*Euonymus americanus*), with snowbell (*Styrax* sp.) along the creek bank.

Comments on original timber summarized by Nelson (1957) tell us that chestnut was an important component of Piedmont forests. These trees were reported to have a diameter from six to nine feet (Jackson Co.). Apparently, chestnuts were one of the few trees vulnerable to disease. They existed in Fulton County forests in 1830, and in Haralson and Morgan counties in 1883, and in "Middle Georgia" until 1904. A few sprouts can be found now in Fulton, Gwinnett, Greene, Walton, Douglas, and Paulding counties and elsewhere, Steve Bowling (pers. comm.). The chestnut was a large, fast growing, and relatively soft-wooded tree. They probably were the first to be cut for local construction purposes and were probably gone before the chestnut blight struck the Piedmont.

Bartram reported black oaks measuring up to 11 feet in diameter. Tulip poplar up to nearly 10 feet in diameter was also reported, Nelson (1957). The largest poplars I have seen in the Piedmont stand on the bluffs along the west side of the Murder Creek Natural Area in Jasper County, and are close to five feet in diameter.

### Fauna

The resident vertebrate fauna is somewhat poor compared to mesic bluffs and bottomlands. About the only salamander one finds is the cosmopolitan slimy (*Plethodon glutinosus*). There are toads and box turtles; frogs are rarely encountered. Snakes are mostly the subsurface dwelling ringnecks, earth snakes, and the mole snake. Above ground the black rat snake, black racer and, perhaps, the copperhead are dominant. The little brown skink is the only common lizard. DeKay's snake, copperhead, and pygmy rattlesnake are locally abundant in slope forest around Atlanta.

In 1975-1976 small terrestrial fauna was collected in can and snap traps in near-natural forest along the Chattahoochee River. Preliminary and tentative identifications were made so that the results might be included in this study. The dominant animals were: earthworms (unident.), snails (*Mesomphix* sp.), spiders (unident.), Harvestment (unident.); millipedes (*Scytonotus* sp., *Euryurus* sp.), *Fontaria* sp.; crayfish (near branches) (*Cambarus bartoni*), camel cricket (*Diestrammena apicalis*), wood roach (*Cryptocercus punctulatus*); carabid beetles (*Eumolops sodalis, Chlaenius* sp., *Orthoma brunneum, Carabus limbatus, Sphaeroderus canadensis*); scarabeid beetles (*Canthon chalcites, Geotrupes splendidus*); silphid beetles (*Nicrophorus marginatus*); red salamander (*Pseudotriton ruber*), slimy (*Plethodon glutinosus*); green frog (*Rana clamitans melanota*), bullfrog, box turtle, worm snake, ringnecked snake, rat snake, garter snake; short-tailed shrew, pine vole, and chipmunk. Oddly, the white-footed mouse (*Peromyscus leucopus*) is quite rare in slope forests along the Chattahoochee River.

The dominant birds are the more common perching varieties, such as Red-eyed Vireo, Towhee, Carolina Wren, Brown Thrasher, Cardinal, Blue Jay, Wood Thrush, Tufted Titmouse, Chickadee, and Red-breasted, Pileated, Downy and Hairy Woodpeckers, Crow, and the Red-tailed Hawk.

The common mammals are the short-tailed shrew, the pine vole, the deer mouse, either *Peromyscus leucopus* or the larger Coastal Plain form *P. gossypinus*, the chipmunk, grey squirrel, opossum, raccoon, and deer.

If temporary water is available, as on nearby Piedmont floodplains, one finds two tree frogs present under surprisingly xeric conditions, the spring peeper and the gray tree frog. On warm hillsides near temporary or permanent water, we have taken the red salamander (*Pseudotriton*) and the red-backed salamander (*Plethodon cinereus*).

In branches running through these forests one finds, naturally, a more abundant fauna — principally the two *Eurycea* salamanders, (the two and three-lined) and the dusky salamander (*Desmognathus fuscus*). Formerly, the little branches were full of chubs (*Hybopsis, Semotilus*) and shiners (*Notropis*). The dominant survivor is now the chub *Semotilus atromaculatus.* Relative to Appendix VI, the habitat is X.

#### Natural and Cultural Values

This environment is found on undulating hills, and sometimes on bluffs or very rocky areas of the northern Piedmont. In tillable terrain there are only a few samples. These are mainly valuable for educational and scientific purposes to tell us about the original soil and other life in pre-Caucasian times. In Blue Creek, draining the ultramafics of Soapstone Ridge (DeKalb Co.), mussels (chiefly *Anadonta cataracta*) are abundant and eaten by local landowners.

#### Man's Impact

Like the case with the prairies, it is a shame that we have systematically eliminated the great hardwood forests without hardly a trace over vast areas. We apparently have few uplands comparable to the Duke Forest area of Piedmont, North Carolina. Logging has modified whatever remnants remain. Perhaps county agents could help locate still existent vestiges of our forest heritage. According to Steve Bowling (pers. comm.), Swan Woods at the Atlanta Historical Society was a cottonfield 50 years ago and is a good example of succession back to this environment. The dominant, loblolly pine, with a few shortleaf, is giving way to tulip poplar, mockernut hickory, and white oak. The understory is dogwood, sourwood, black cherry, and sassafras. One serviceberry and a few red maples are present. The herbaceous strata is also beginning to return.

c. XERIC BROADLEAF DECIDUOUS FORESTS

## [69] PIEDMONT FLATWOODS

"Glades" are reported by Nelson (1957) to comprise 2 to 3% of the Piedmont in localized belts occupying from 30 to 50 square miles. I have not yet seen this environment. I include it because it is discussed by others. Nelson appears to be quoting Loughridge (1883) who indicated that in Elbert County the forest cover was chiefly blackjack oak, and in parts of Jasper County, "blackjack, post oak, and hawbushes."

Oosting (1942) treats these environments as "preclimax," and stated that they comprised only 1% of the area of mature upland hardwoods on Duke Forest (N.C.). He stated that it occurred on "Orange, Iredell . . . soils" not eroded or disturbed, characterized by a highly impermeable clay layer a few inches below the surface. The type also occurs when a thin soil mantle overlies solid rock. Vegetation and fauna will be described under Xeric Bluffs below.

## [70] XERIC BLUFFS

#### Location and Description

These are usually rocky bluffs and face south or west. They occur principally along the major streams. They bear some pine (usually shortleaf) and scrubby oak growth, yucca, and red cedar. They are dry, hot environments. Trees are scrubby, irregular, and growth is very slow. Soils are shallow and rocky.

#### Flora

The blackjack oak is the indicator species. Post oak is a co-dominant. Other upland oaks can be found. On the bluffs along the Alcovy below Factory Bridge Shoals, one finds red cedar to be very abundant, but hickories are present with black gum and sourwood. Some white oaks and southern red oaks occur. The pine is shortleaf. Hornbeam (*Ostrya*), winged elm, winged sumac, and sparkleberry are the dominant shrubs. Oosting (1942) found mats of the mosses *Dicranum condensatum* and *D. scoparium* in his area, and the most common herb in Piedmont communities (N.C.) was *Danthonia spicata*. Radford (1974) records a xeric community on a stony clay loam (Chatham Co., N.C.) with white oak and post oak as dominants and several hickories and loblolly pine as co-dominants. Usually the east-facing river bluff will be more mesic, and there will be moist pockets on the drier side as well. The lip fern (*Cheilanthes lanosa*), alumroot (*Heuchera americana*), and other unusual species occur along the Alcovy. On dry bluffs at Yellow Jacket Shoals on the Flint River (Upson Co.) there is much century plant (*Agave virginica*), and Marie Mellinger (pers. comm.) reports Michaux's lily (*Lilium michauxii*) from there.

2. NEEDLELEAF EVERGREEN FORESTS

## [71] PINE CLIMAX FOREST

#### Location and Description

Pine dominated forests are so common in the Piedmont that we hardly think much about them. Most of these, however, are successional forests following abandoned agriculture. The true or "climax" pine forest is much less evident. Oosting (1942) did not recognize pine forests, except as secondary communities. Such forests, if they may be validly separated into a distinct community, appear to occur only near or on the outcrops of exposed igneous (granitic) and gneissic rocks that emerge at places on the Piedmont. Nelson (1957) calls these the "granitic lands" and indicates that they involve about 14% of the Piedmont. He states that they are localized in two principal sections: one in Hart, Elbert and Oglethorpe counties, the other southeast of Atlanta. There are other stands in Heard County. There are varying species of hardwoods co-existing. Soils are light-colored and sandy, and quite unlike the normal Piedmont "red clay hills." The only forest of this type that I have seen that was not maintained by fire, is high on the slopes of granite monoliths such as Stone Mountain.

**Flora**

Obviously loblolly and shortleaf are the principal overstory species. This environment is probably more or less regularly burned. The incidence of fire will determine the understory and shrubs. I could find no floral lists available from this community.

**Fauna**

As in the flora, the vertebrate fauna will be intermediate between that of the xeric and very xeric broadleaf deciduous forests, and closely related to certain stages of secondary succession. Lizards, especially the fence swift, racerunner, and some of the skinks, will be plentiful, along with black racers and coachwhips. Rabbits, foxes, pine voles, and short-tailed shrews are likely to dominate the mammalian fauna. The habitat (Appendix VI) is X.

3. BROADLEAF DECIDUOUS-NEEDLELEAF EVERGREEN FORESTS

a. SECONDARY SUCCESSION ENVIRONMENTS

## [72] SUCCESSIONAL FOREST STAGES

The vast bulk of the Piedmont is in one state or another of what Eugene Odum calls "old field succession." In fact, it is so well illustrated here that scientists from around the world have visited the Georgia Piedmont to examine the rather sharp successional stages from bare mineral soil to hardwood climax forest. It is, however, becoming increasingly difficult to find old fields, especially in the earlier stages of succession, at least around Atlanta. These environments are fascinating in that each successional stage offers different niches which are occupied by assemblages of plants and animals that are adapted to that particular stage, all stages eventually culminating in the so-called climax forest, which in the drier uplands on deep weathered soils would be the **submesic broadleaf deciduous forest**. Fire, of course, arrests the progression towards hardwood forest, and fire is a common and frequent visitor to these environments. The Indians had many fields and they undoubtedly used fire to maintain them or to flush game from them. The Indian was not a conservationist — he used every method at his disposal to modify his environment to suit his needs. The reason the Caucasian man inherited so much unmodified environment was because Indian populations were low and many forests were too moist to burn. The Indian probably knew plant and animal succession as well as we do, and used it to his advantage whenever possible.

Odum (1971) details old field succession, from fields with crabgrass, horseweed (*Erigeron*), and aster — through a grass-shrub stage beginning with broom sedge (*Andropogon virginicus*) about the 3rd year and through pine forest (25-100 years) to an oak-hickory forest climax (150 years plus). The fauna appears in successional stages also, from the insects through the mammals. If the ground stays bare long enough, the beach mouse (*Peromyscus polionotus*) may take up residence (if breeding stocks are nearby), or in the weed stage the seed-eating harvest mouse (*Reithrodontomys*) may predominate. In the grass stage the cotton rat (*Sigmodon hispidus*) moves in, but disappears in the shrub stage as grass cover thins out. If the grass stage is prolonged by pasturage, the cool, moist microenvironment may prove acceptible for meadow mice (*Microtus*) in portions of the Piedmont. As the hardwood understory builds with storable food, such as acorns or nuts, and as leaf litter forms, pine voles and deer mice become dominant small mammals.

Some interesting birds, such as the Blue Grosbeak, are found only in areas of secondary succession. Quail, doves, rabbits, and foxes appear to be more common in such areas also. Many old cotton fields have been put into pasture; others have been planted to pines which grow slowly in many instances, for Piedmont Georgia is making a slow recovery after 200 years of use and abuse.

Johnson and Odum (1956), in a classic paper, documented the breeding passerine birds in the stages of secondary succession in the Piedmont of Georgia. They found two species (grasshopper sparrow and meadow lark) in the first three years (forb-grass stage); five other species were added in 15 years (grass-shrub stage), and new species were added as the community progressed. Maximum species diversity was reached about the 60th year (pine forests and understory of hardwoods); the number of species then held steady around an average of 19 through the oak-hickory climax. Some species were added to the oak-hickory (Black and White Warbler, Kentucky Warbler, Acadian Fly-catcher), and others were deleted. These authors record the dominant (by density) species for each stage as follows: *Forb-grass stage,* Grasshopper sparrow, Meadow Lark; *grass-shrub stage,* Field Sparrow, Yellow-throat, Meadow Lark; *young pine forest* (25-60 years), Pine Warbler, Towhee, and Summer Tanager; *old pine forest* (with well-developed deciduous understory), Pine Warbler, Carolina Wren, Hooded Warbler, Cardinal; *oak-hickory climax*; Red-eyed Vireo, Wood Thrush, and Cardinal.

Plant succession changes soil conditions from inhospitable red-clay subsoil to a true organic-rich top soil with abundant micro-organisms. Kuo (1965) documented this change from pine (age 20-30 years), through mixed pine-hardwood (60-90 years) to hardwood climax (120 years) in the Georgia Piedmont. He found little change in pH (from 5.4 to 5.8). He did find definite changes in the floral community of the soil. The pine community favored the fungi, the mixed pine-hardwood favored the actinomycete fungi, and the hardwood forest soils, with their high organic content and low carbon-nitrogen ratio, had the most bacteria. The soil showed steady improvement through these forest stages.

b. ORIGINAL ENVIRONMENTS

Nelson (1957), depending largely on Loughridge (1883), suggests that as much as 45% of the Piedmont had a mixed pine-hardwood forest originally, on what he calls gray, sandy lands — "probably the uneroded Cecil, Appling and Durham soils." No mention is made of pre-Caucasian forest modification by Indians. Except in the specific environments cited below, I find it difficult to accept Nelson's figures for such a large area to be in a stable pine-hardwood climax type, if this is what he implies. Further study is needed to clarify this question. Other than on the very shallow soils overlying the Piedmont granitic intrusions, I have seen only two forests types that appeared to be original and stable environments. These are described below.

## [73] MIXED PINE-HARDWOOD COLLUVIAL FORESTS

### Location and Description

Colluvial forests occur on colluvial "flats," superficially resembling floodplains but of a different origin. Here the soil is not deposited by the stream (alluvial) but tumbles or washes in from the adjacent slopes. Colluvial "flats" occur along small streams with small watersheds, or the streams are largely spring-fed. The water seems colder than normal. The stream bed is gravelly and there is little evidence of annual overbank flow (levees, deposits of silt, sand or debris). One theory holds that these are relict Pleistocene floodplains, formed when stream discharges were greater. Usually there is steep terrain on one or both sides of a colluvial floodplain, providing a source of colluvial material. The water table does not remain high enough for long enough to form a community of wetland species such as is found on typical alluvial floodplains. The vegetation therefore is similar to that on adjacent moist slopes. a good example is a NE-flowing tributary of Anneewakee Creek (Douglas Co.). Other examples occur on tributaries of Bay Springs Creek near Highway 61 (Carroll Co.). Loblolly pine can grow on colluvial flats much as it does on the highest terraces (presumably Pleistocene) of alluvial streams. Another example occurs on colluvium on the southwest and northeast face of Stone Mountain (DeKalb Co.), where soils are rather deep and fertile. On these "creek flats;" the soil is a tan, sandy loam. Microenvironments are close together at the southwest station. These areas were apparently never cultivated, having been in the Venable Estate until sold to the state of Georgia. Above the branch heads, the small community of Stone Mountain protected one watershed from pollution by silts and clays. If the forest was logged or highgraded, it was done prior to 1940.

### Flora

The Anneewakee tributary "floodplain" bore trees such as beech, tulip poplar, basswood, umbrella magnolia and silverbell. It also supported herbs such as black cohosh, goat's beard and northern maidenhair fern, similar to the adjacent bluff with northern affinities.

On the deepest, level soils adjacent to the branch at Stone Mountain (SW station) one finds a forest of tulip poplar, bigleaf magnolia (*Magnolia macrophylla*), sweet gum, black gum, and shortleaf pine. On a branch where soils were thin are beech, bigleaf magnolia, tulip poplar, mulberry, pignut hickory, black gum, white oak, and both loblolly and shortleaf pine. On a steeper slope with drier soils we find loblolly pine, some white oak, shagbark hickory, and in the uppermost zone, chestnut oak (*Quercus prinus*). Sourwood is a subcanopy tree. The **shrub** layer is dominated by dense mountain laurel. Other common shrubs in the area are devil's walking stick (*Aralia spinosa*), witch hazel, sweet shrub, spice bush, and buffalonut. The most common **herbs** present are flowering hydrangea, yellowroot, New York fern, and wild potato (*Ipomea* sp.). This forest has northern elements (mountain laurel, buffalonut, flowering hydrangea) obviously shared with environment [64].

Small colluvial flats on small branches in Chattahoochee State Park (Fulton Co.) have beech, white oak, red maple, ironwood, and umbrella magnolia. The shrub stratum dominant is paw paw (*Asimina triloba*). Dominant herbs are mayapple, poison ivy, and nodding trillium. A very remarkable colluvial bottomland bearing a forest with both hydric and mesic elements occurs on a tributary of Bay Springs Creek (Carroll Co.). Probably old second growth (circa 75-100 years), it is dominated by large tulip poplars and huge loblolly pine (up to 3 feet DBH) and, remarkably, large sweet bay (*Magnolia virginiana*). Dominant shrubs are *Viburnum nudum* and storax (*Styrax americana*). The brown clay loam soil is densely carpeted with yellow root or climbing hydrangea or, sometimes, poison ivy. Chain, lady and New York ferns are abundant. Some of these species are components of spring seeps, see environment [34].

### Fauna

Salamanders were formerly abundant in the streams at Stone Mountain, as were large clams (see HYDRIC section, Piedmont streams) which existed here until the acquisition of the property by Georgia State Parks Department and the construction of a lake. The dusky salamander was common, along with some two and three-lined, and an occasional red (*Pseudotriton ruber*) salamander. This is the only Piedmont locality where I have taken the purple salamander (*Gyrinophilus*). King snakes were abundant there; I have very little additional information on the fauna. Relative to Appendix VI, the habitat is X, with a few mountain elements.

## [74] PINE-BROADLEAF DECIDUOUS SUBCANOPY XERIC FORESTS

### Location and Description

There appear to be two subtypes of this forest. The most spectacular is on the Hollis quartzite on the high ridges of Pine Mountain. It is similar to the BROADLEAF DECIDUOUS SUBCANOPY FOREST of the Coastal Plain. Another type has a more diverse understory of deciduous trees and shrubs and occurs on dry ridges throughout the western Piedmont north of Pine Mountain. Longleaf grows over a variety of rock types: along US 278 (Paulding Co.) it appears on quartzite capping ridges of hornblende and biotite gneiss, on phyllite north of Yorkville (Paulding Co.), on mica schists in western Carroll County (Highway 100) and on gneiss at Mill Rock Hill (Heard Co.).

#### Flora

The Pine Mountain localities have typically a longleaf pine overstory and a blackjack oak understory, instead of turkey oak as in Coastal Plain environment [85]. The common sandhill sticky foxglove (*Aureolaria pectinata*) is common. (Loblolly pine and sourwood seedlings will seed in on the highway right of way). On ridges and west-facing bluffs along the Flint River there are still some good stands of longleaf pine.

On a phyllite ridge west of Atlanta (US 278, Paulding Co.), a longleaf stand had a shrub zone of scattered blackjack oak, horsesugar and sourwood, with a ground cover of goat's rue (*Tephrosia virginiana*) and bracken fern. Evidence of recent fire was obvious. A two-acre Mill Rock Hill stand (Heard Co.) on old cotton terraces had as a dominant shrub winged sumac, with scattered shrubby blackgum and persimmon. A dominant grass (unident.), goat's rue and bracken fern constituted ground cover. I believe that longleaf pine was once much more extensive on western Piedmont ridges before logging and fire suppression. Steve Bowling and I have recorded several occurences of native longleaf pine on original sites in the Brevard Fault Zone. One was near Hurricane Creek (Douglas County), the other a beautiful dense stand on a narrow ridge east of Lake Eleanor (William Ristau property) near Campbellton (Fulton County). The latter stand has the typical goat's rue-bracken fern ground cover, along with blackjack oak.

Longleaf pine grows very slowly. Those planted on Pine Mountain by F.D. Roosevelt in 1930 are now only about 15 inches DBH. Generally speaking, longleaf pine-blackjack occurs on the very top and south face of the ridgetop, and loblolly pine-hardwood community dominates the north-facing upper portion of the ridge. Apparently, the longleaf pine community on Pine Mountain was much more extensive up until 50 years ago (Carlton Colquitt, pers. comm.) and has been invaded by hardwoods following logging.

Radford and Martin (1975) discuss a unique, parklike blackjack oak "barrens" community mixed with short and longleaf pines overlying magnesium-rich serpentine rock (Burk's Mountain, Columbia Co.), seemingly similar to the edaphic (soil) controlled, blackjack-dominated [69] PIEDMONT FLATWOODS.

#### Fauna

The Hollis quartzite apparently does not always weather into a sand but strata overlying the Manchester schist do, resulting in sandy soils on top of Pine Mountain ridges. Somewhat surprisingly, this soil is an adequate habitat for the burrowing coral snake — several have been taken as early as 1947 at Camp Thunder on top of one of the northernmost ridges of Pine Mountain, according to Carlton Colquitt. It is quite unusual to find coral snakes this far north in the Piedmont. Most have come from the narrow sandy Flint River floodplain from ¼ mile above Dripping Rock south. Colquitt, who was a naturalist for many years at Camp Thunder, indicates that the common snakes in this community are the black racer, black rat, DeKay's, hognose, garter, copperhead, timber and pygmy rattlesnakes. Apparently, no pocket gophers or gopher tortoises are known from the Pine Mountain area. A most interesting fact is that fox squirrels (the red phase with an occasional melanistic specimen) were native and common to this environment until fairly recently. Concerning Appendix VI, distribution is P with CP elements, habitat X with SX elements.

#### Natural and Cultural Values

This is obviously a rare community. Its remarkable fauna, especially the coral snake, needs study. There are theories that his may have been the Tertiary refugium for the longleaf pine which, following recession of the Cretaceous seas, invaded the Coastal Plain, occupying sandy areas. Although they have been heavily and almost completely logged, the forests we are seeing have not followed agriculture. Camp Thunder (scouts) uses this area heavily. It is excellent for hiking and recreational use. The remaining pine stands need to be preserved and perhaps burnt regularly.

#### Man's Impact

The slow-growing longleaf has suffered heavy logging. Jones (1974) recounts land-use history of the mountain, and indicated the fires set annually by the settlers — this action would favor pine dominance. Settlement began following the Treaty of Indian Springs in 1825. Clearing began and continued until 1920, when 60% of Meriwether and Harris counties was cleared. Pine Mountain itself generally escaped agriculture.

## [75] PINE-HARDWOOD XERIC RIDGE AND SLOPE FORESTS

#### Location and Description

This type of dry forest occupies much of Pine Mountain, the phyllite slopes lying south of the Cartersville Fault (Dugdown Mountain), the slates near Rockmart (Polk Co.) and the dry, rocky ridges along the Brevard Zone on both sides of the Chattahoochee River. Some of these ridges should seemingly grow longleaf pine but for some reason (soil, infrequent fire, lack of seed source) they maintain other species of pine along with oaks and hickories. Sometimes shortleaf or loblolly pines completely dominate the ridge tops. In rocky situations chestnut oak (*Quercus prinus*) tends to dominate.

#### Flora

The forest on Dowdell's Knob (Pine Mountain) consists of shortleaf pine, much hickory, blackjack oak, chestnut oak, and black oak. Sam Jones records the Georgia oak (*Quercus georgiana*) from "chestnut-oak mixed hardwood" forest. For **shrubs** he records red buckeye, (*Aesculus pavia*), dwarf paw paw, Piedmont azalea (*Rhododendron canescens*), sparkleberry, blueberry (*Vaccinium pallidum*), and squaw huckleberry (*V. stamineum*). He found yellow honeysuckle, Virginia creeper, poison ivy, thorough-wort (*Eupatorium aromaticum*), and the summer grape to be common **herbs**. Along the top of the escarpment of Dugdown Mountain (Polk Co.) the forest is dominated by shortleaf and loblolly pines, post and blackjack oaks, with chestnut oak on the steeper slopes. On phyllite slopes near Hightower Falls (Polk Co.), shortleaf and chestnut oak dominate, with Georgia oak (*Quercus georgiana*) as a sub-dominant.

On ridges in the central Piedmont, especially on Louisburg sandy loam, notably on the drier, rocky ridges of north Fulton County at Sandy Springs, there is a xeric ridge forest similar to some ridges in the mountains. **Trees** are: (D) chestnut oak, blackjack oak, scarlet oak, (D) shortleaf pine, loblolly pine, (D) sourwood, with some dogwood, dwarf buckeye, blueberry (*Vaccinium stamineum, V. vacillans,* and Oconee azalea (*Rhododendron speciosum*). Herbs are scarce. Goat's rue and bracken fern dominate.

A very dry environment is the linear series of quartzite mountains (Cornish, Alcovy, Jacks Creek, Turkey Creek) in Newton, Walton and Oconee Counties. These isolated hills protrude sharply above the surrounding Piedmont to heights of 1,000 feet. Cornish Mountain soils derived from quartzite (and inclusions) are dominated by blackjack oak, black oak and sweet pignut hickory, with southern red oak, post oak and shortleaf pine as co-dominants on the moister east slope. Dominant shrubs were dwarf paw paw and dwarf chestnut oak (*Quercus prinoides*) recorded there by Steve Bowling. Muscadine grape and New Jersey tea occur on the east side; *Vaccinium vacillans* and sparkleberry were dominant on the drier westerly side.

Rocky, narrow ridges and rocky slopes in the Piedmont, especially in the Gainesville Ridges (Brevard Fault Zone) often have chestnut oak as the dominant tree. It is common on the ridges and bluffs along the Chattahoochee (Fulton Co.). While a broad, interstream ridge at Anneewakee Creek carried an extensive near-original forest dominated by black oak, with white oak, southern red oak, red and mockernut hickories, both the dry, rocky northwest and northeast-facing ravine slopes below it supported chestnut oak over hornblende-rich gneiss, along with chalk maple, and co-dominants ranging between tulip poplar (more northerly exposure) and loblolly pine (more southerly exposure). Beaked hazlenut and maple-leaved viburnum, *Vaccinium vacillans* and mountain laurel were dominant shrubs. In the Hurricane Creek ravine walls, chestnut oak shared dominance with shortleaf pine, with much sourwood.

### Fauna

The fauna may resemble that of the **Xerix Broadleaf Deciduous Forests** and **Needleleaf Evergreen Forests.** It will have a distribution P, with some CP forms, habitat X, with some SX forms, Appendix VI. The ravines of Anneewakee Creek apparently house a good population of canebrake rattlesnakes. Rattlesnakes in the Piedmont are rare and confined to localized areas where dens are available and away from people, and areas of remote cliffs with undisturbed forests. There are colonies reported near Kellytown (Henry Co.), Pine Mountain, and in the Dugdown Mountains of Polk County.

## [76] ROCK OUTCROPS

### Location and Description

Rock outcrops are spectacular Piedmont ecosystems. They occur in a zone almost entirely across the Piedmont. The state of Georgia (1969) mapped all flat rock outcrops (including cliffs) over ¼ acre in size in the northern half of Georgia (fig. 26). The following counties lead in the number of outcrops: Walton (168), Gwinnett (117), Heard (69), Lumpkin (66), Douglas (64), Rockdale (62), and Newton (60). The largest acreages are found in DeKalb (2,045), Walton (1,165), and Rockdale (1,093). The cliffs of mountainous Rabun County make it fourth (867). Some outcrops, (Greene Co.), average over 100 acres each.

While superficially resembling one another and perhaps bearing similar plant communities, Piedmont rock outcrops may be geologically dissimilar. For example, the light bands of Mount Arabia's rock are igneous but the dark bands are metamorphosed sediments. Panola is distinct from Arabia, being an igneous granite — Stone Mountain is yet different from Panola. Outcrops can be quartzite (Pine Log, Pine Mountains) or gneissic (Kennesaw). Most of the outcrops are classed as "silicic" rocks, high in silica and aluminum and low in iron and magnesium, in contrast to other igneous outcrops (Soapstone Ridge) which are high in iron and magnesium and low in silica and aluminum.

Burbanck and Platt (1964) indicated that the batholithic intrusion of Stone Mountain was harder granite than that of modified granites of the Lithonia area (Rockdale Co.).

Rock outcrops consist of either monadnocks like Stone Mountain rising above the Piedmont surface, or as simple "flat-rock" outcrops. Most have shallow solution pits of varying depths in which soil has formed. Because some of these rounded basins have more soil than others, one can usually find these "mini-ecosystems" in various stages of succession. Mt. Arabia and Mt. Rollaway are noted for their solution pools with more or less permanent water and submerged aquatic plants.

### Flora

The outcrops are excellent places to observe primary plant succession from bare rock with crustose lichens, such as *Parmelia* sp., to moist rock with the pioneer moss *Grimmia* sp., to very thin soil with foliose lichens, such as reindeer "moss" (*Cladonia rangifera*), and various succulent annuals (*Diamorpha, Sedum pusillum*) adapted to extremes in moisture. With deepening soil, perennial herbs like broomsedge (*Andropogon* sp.) and groundsel (*Senecio tomentosus*) replace the annuals, and finally the community becomes dominated by shrubs and trees. There are other plants, such as the yucca (*Yucca filamentosa*) and cactus (*Opuntia* sp.), which are associated with arid outcrop conditions.

One of the early, lucid accounts of outcrop vegetation was written by Baker (1956), who described three basic types of outcrop pool. His "type A" has an intact rim and shallow soil (½ to 3" deep) and is limited to housing the rare aquatic endemic plants *Isoetes melanospora* and *Amphianthus pusillus*. His "type B" occurs on slopes, and has an eroded rim on one side with deeper soil (< 4 in.).

In the outer zone, dominated by *Diamorpha cymosa,* only plants germinating in early fall and forming seeds in spring can survive the intensely hot summer. In the central zone grow *Minuartia uniflora* and the rock saxifrage (*Saxifraga virginiensis*), with the groundsel, *Senecio tomentosa* or *S. smallii*. If the soil is still deeper (10-12 in.), the lily *Schoenolirion croceum* and the trout lily (*Erythronium americanum*) occur. Baker's "type C" had intact rims with humus in addition to coarse sand and housed the spring bloomers. Baker gives a limited but illuminating glimpse of the phenologic sequence. By the end of May new plants appear, such as *Coreopsis,* pink primrose (*Oenothera linifolia*), *Polygala*, the succulent *Talinum*, deer flower (*Rhexia virginica*), spiderwort (*Tradescantia*), and *Lindernia*. In the fall one sees a new spectacle, seas of the yellow, endemic, confederate daisy (*Viguiera porteri*), a *Crotonopsis*, blazing star (*Liatris*), and dense mats of the endemic rush, *Juncus georgiana*.

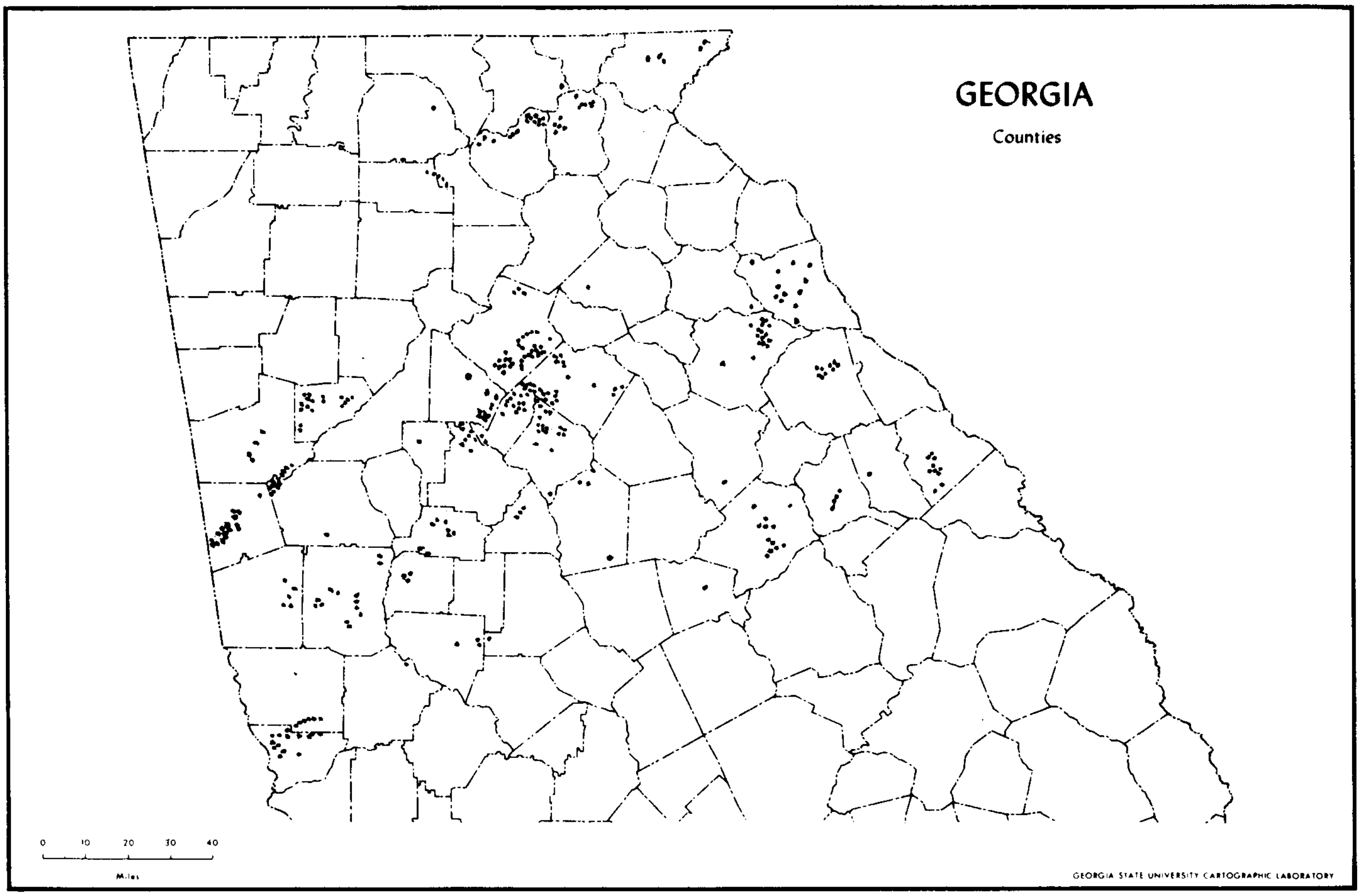



Fig. 26. Distribution of granite outcrops (over 1.5 acres in size) in Georgia. Data provided by S. Pickering, Geologic and Water Resources Division, Geogia Department of Natural Resources.

The definitive work on the granite outcrop communities in Georgia was done by Burbanck and Platt (1964) who classified the habitats into the following: (1) meophytic forested areas adjacent to outcrops, (2) ecotones between (1) and (3), (3) exposed rock surfaces, (4) natural depressions containing soil, (5) rock crevices, and (6) rubble heaps. The natural depressions often occur on the sides of steep outcrops, contain varying amounts of soil, and are of different ages. One depression on Mount Arabia (now a county park) yielded a radio-carbon date of 670 years. Burbanck and Platt studied 40 of these depressions and, on the basis of maximum soil depth correlated with characteristic flora, divided them into four categories: (1) **Diamorpha community** (soil depth $<$ 9 cm), containing the stone crop (*Diamorpha cymosa*), some lichens (*Cladonia leporina* and *Campylopus* sp.), with *Cladonia caroliniana* in the deepest one. Fcr 18 weeks in summer and fall, these shallow depressions contain few or no living plants. (2) **Lichen-annual herb community** - (soil depth 7 to 15 cm). In addition to the plants in (1) above, this community has the annuals, *Agrostis elliottiana, Minuartia uniflora, Linaria canadensis,* and *Rumex hastatulus* flowering in the spring; the annuals *Bulbostylis capillaris, Crotonopsis elliptica,* and *Hypericum gentianoides* flowering in the summer, and the annual confederate daisy (*Viguiera porteri*) flowering in the fall. (3) **Annual-Perennial herb community** - (soil depth 14-38 cm). This most diverse community, Fig. 27, has, in addition to plants of shallow soils in (1) and (2) above, around the edge, mostly the moss *Polytrichium commune* and the perennials, sunnybell (*Schoenolirion croceum*) and groundsel (*Senecio tomentosus*). (4) **Herb-Shrub community** - (soil depth 40-50 cm). In addition to many of the species in (3) above, this community may have greenbrier (*Smilax glauca*) and at least one small tree, usually either serviceberry (*Amelanchier arborea*), red cedar (*Juniperus virginiana*), or cherry (*Prunus serotina*). Other woody species usually present are yellow jessamine, Virginia creeper, greenbrier (*Smilax smallii*), sparkleberry, and young loblolly pine.

## Fauna

Unfortunately, the fauna has been neglected. D.A. Crossley, Jr. (pers. comm.) has kindly provided me with what little information is available on invertebrates. The inconspicuous outcrop animals are in thin soil and under rocks, such as the black rock mite

(*Caeculus* sp.). In the *Diamorpha* zones an oribatid mite (*Phauloppis* sp.) is tremendously abundant ($5 \times 10^5$ per $m^2$). In the winter there is an abundant collembolan insect in outcrop solution basins. The diurnal dry rock lichen community supports the protectively-colored grasshopper, *Trimerotropis saxatilis*, studied by Duke (1971), a beetle (*Collops tricolor*), some small ants (unident.), and some mites (*Erythraeidae*). The nocturnal fauna appears dominated by a Thysanuran (*Machilis*). Mole crickets are common in soil areas.

Regarding the vertebrates, the outcrops with trees are lizard heaven, with fence swifts and skinks dominating. Regarding mammals, there is a subterranean fauna, if the soils are thick enough and with trees. I have seen runways of pine voles and probably short-tail shrews on top of Panola Mountain. Cottontails, foxes, and some squirrels appear to visit the dwarfed forests on larger outcrops.

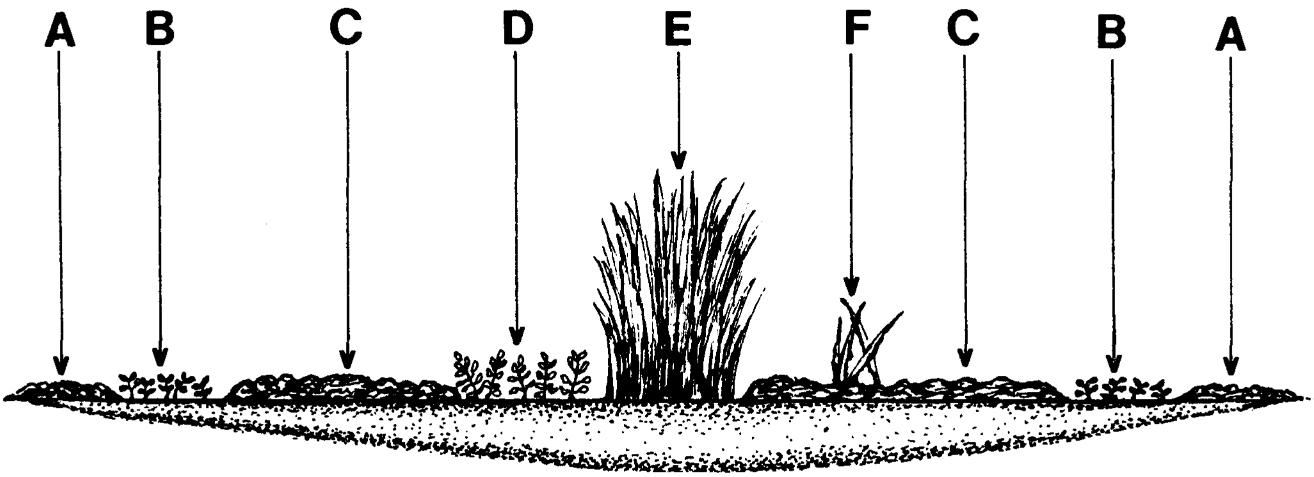



Fig. 27. Profile of a "dish garden," an idealized annual-perennial herb community as described by Burbanck and Platt (1964). (A) moss (*Bruchia sullivanti*); (B) the stonecrop (*Diamorpha cymosa* or *Sedum smallii*); (C) moss (*Polytrichum commune*); (D) clump of grounsel (*Senecio tomentosus*); (E) broom-sedge (*Andropogon virginicus*); (F) sunnybell (*Schoenolirion croceum*).

**Natural and Cultural Values**

The outcrops beautifully demonstrate principles of evolution and succession. They are educational and scientific, rather than recreative. They illustrate the primordial steps in primary succession beginning with lichens on bare rocks and ending with forest. Soil formation is nowhere else so well-illustrated. Mineral soil is constantly forming in outcrop solution basins under the action of lichens, freeze-thaw phenomena, and carbonic-acid fallout. Of the 22 minerals in the banded gneiss of the Lithonia area, there need be added only nitrogen (from fallout, bacteria, plant and animal life) and sulfur and iodine (from atmospheric fallout in rain) to provide all of the fundamental elements required by life. Plant microcosms and animal droppings add nitrogen, and true soil is gradually built up *in situ* with whatever increments wash in from above.

A number of plants are endemic to rock outcrops and a few (such as the confederate daisy) grow nowhere else. Many are very rare. Outcrops are genetic museums. Murdy (1968) indicates that outcrops with their large numbers of endemic plant species have served as active sites for plant speciation for long periods of time. Speciation is seemingly accelerated on outcrops. Chromosome changes, such as polyploidy, may be favored, Murdy (ibid). Two Georgia outcrops have been recommended as potential Natural Landmarks, Radford and Martin (1975). One, Echol's Mill outcrop (30 acres, Oglethorpe Co.) was said by McVaugh (1943) to be a very interesting outcrop "much dissected by ravines." The other, "Heggie's Rock" (92 acres, Columbia Co.), is said by Radford and Martin (ibid) to be "the most outstanding potential Natural Landmark site in eastern North America," containing 11 of 19 endemic plant species, subspecies, and varieties; the greatest number (21 of 26) of characteristic outcrop species; rare and disjunct species, and the best mat zonation and succession communities.

**Man's Impact**

The outcrop plants and solution "dish gardens" are very vulnerable to tramping feet and picking hands. Many serve as trash dumps. Motorcycles, jeeps, and automobiles have damaged the communities on many outcrops — as on dunes and tundra it may take years for these traces to disappear. Waste water destroys the lichen and moss. Quarrying rock has all but eliminated a number of outcrops and has base-leveled former rock domes. Granite is sold for monuments, building stone, curbstones, rubble for road work, gizzard-stones for domestic and zoo birds, and as rock flour for fertilizer ("Hybrotite") which, with the addition of chicken manure and innoculated with several species of bacteria (gleaned from the outcrop soil), forms an "instant soil" sold as "Activated Hybrotite." Applied to chicken houses, it quickly converts chicken manure into odorless soil (if watered and turned). Outcrop owners have dreamed of supplying the world with rock flour fertilizer which would, of course, eventually leave gaping holes where outcrops once stood. With its crushed granite industry near Atlanta and its monument industry near Elberton, Georgia is the world's largest granite producer.

## COASTAL PLAIN PROVINCE

1. BROADLEAF DECIDUOUS-BROADLEAF EVERGREEN FORESTS
   (Southern Mixed Hardwood Forests)
   a. MESIC SLOPE FORESTS
      [77] BLUFF FORESTS OF NORTHERN AFFINITIES
      [78] BLUFF AND SLOPE FORESTS
   b. MESIC RAVINE FORESTS
      (1) CHATTAHOOCHEE ESCARPMENT TYPE
         [79] CHATTAHOOCHEE RAVINES
      (2) PELHAM ESCARPMENT SOLUTION TYPE
         [80] TORREYA RAVINES
         [81] SOLUTION RAVINES AND SINKS
      (3) TIFTON UPLAND EROSION TYPE
         [82] TIFTON UPLAND RAVINES
2. BROADLEAF DECIDUOUS-NEEDLELEAF EVERGREEN FORESTS
   a. BROADLEAF DECIDUOUS-NEEDLELEAF EVERGREEN SUBMESIC FOREST
      [83] BROADLEAF DECIDUOUS-NEEDLELEAF EVERGREEN UPLAND FOREST
   b. NEEDLELEAF EVERGREEN-BROADLEAF DECIDUOUS SUBCANOPY XERIC FORESTS
      (1) CLAY RIDGE TYPE
         [84] CLAY RIDGE FOREST
      (2) SAND RIDGE TYPE
         [85] DWARF OAK FOREST (longleaf pine-turkey oak)
         [86] DWARF OAK-EVERGREEN SHRUB SUBTYPE
3. BROADLEAF EVERGREEN-NEEDLELEAF EVERGREEN FORESTS
   [87] LOWLAND MARITIME FOREST
   [88] MARITIME STRAND FOREST
   [89] UPLAND MARITIME FOREST
4. BROADLEAF EVERGREEN FORESTS
   a. INLAND BROADLEAF EVERGREEN FORESTS
      [90] LOWLAND BROADLEAF EVERGREEN FOREST (hammock)
      [91] UPLAND BROADLEAF EVERGREEN FOREST (hammock)
   b. EVERGREEN SCRUB FORESTS
      [92] EVERGREEN SCRUB FOREST
      [93] EVERGREEN SCRUB-LICHEN FOREST
5. NEEDLELEAF EVERGREEN FORESTS
   a. MESIC PINE LOWLANDS
      [94] MESIC LOWLAND PINE FOREST (Pine Flatwoods)
   b. SUBMESIC PINE UPLANDS
      [95] LONGLEAF PINE UPLAND FOREST (Longleaf pine-wiregrass)
      [96] LOBLOLLY-SHORTLEAF PINE UPLAND FOREST
6. MARITIME DUNE COMMUNITIES
   [97] INTERDUNE TYPE
   [98] DUNE MEADOW TYPE
   [99] DUNE OAK-EVERGREEN SHRUB TYPE
7. ROCK OUTCROPS
   [100] SANDSTONE OUTCROPS

## II. MESIC TO XERIC SYSTEMS

### COASTAL PLAIN

The Coastal Plain has been covered by successive inundations of the sea. Numerous fossil localities yield whale bones, shark teeth and marine shells across the breadth of it. The greatest of these inundations occurred during the last epoch of the age of Dinosaurs, the Cretaceous, which left great quantities of marine sands and clays that we now call the Fall Line Sand Hills. The seashore has withdrawn further during each successive inundation, so that as we drive from Macon to Brunswick we cross younger and younger sea floors and, sometimes, the remnants of old beaches and dune systems.

The Coastal Plain presents an enormously varied number of environments as the physiography and geology suggest. Like the Piedmont, its biotic communities have been greatly altered by man. While a good deal of mining is conducted in the Fall Line Sand Hills, the Coastal Plain is the agricultural zone of Georgia, with the exception of the lower part or Plio-Pleistocene sea floor which is largely devoted to the silviculture of slash pine. The original vegetation has been all but eliminated from vast portions of terrain. Only on some dry, sterile sandhills or in wetland depressions or in river swamps and creek swamps do we find much resembling the original Georgia landscape.

Certain physiographic areas (Fall Line Red Hills, Fort Valley Plateau) are not especially distinct from the highway, but others (Tifton Plateau, Limesink Area, Pliocene-Pleistocene marine flatlands) are distinguishable by the vegetation or the soils. Of the soils the "sandhills" are perhaps the most distinctive. I will use them to introduce some details of Coastal Plain soils.

Cretaceous dune sands are the best developed in the western (Talbot, Taylor Cos.) and eastern (Ft. Gordon area) sectors. Such dunes on the east side of the Ocmulgee at Macon are classed as Lakeland soils belonging to the Lakeland-Eustis Association, USDA (1963a). Lakeland "soils" here are deep sands over clays on knolls, ridges, and slopes.

Dune sands along the east bank of streams such as the Oconee are also classed as Lakeland, USDA (1964). The sand ridge east of Lott's Creek (Bullock Co.) is classed as Kershaw coarse sand, coarser than Lakeland, USDA (1968b). Lakeland sands have a thin (1-3 inches) organic A1 horizon underlain by a yelowish C horizon, Bozeman (1964). Bozeman also described the Lakewood coarse sand from ridges east of the Altamaha (McIntosh Co.), apparently a highly evolved soil with a leached A2 and a dark brown B horizon.

Lakeland and Kershaw soils bear environments [85], [86] (longleaf pine-turkey oak) and [93], while the Lakewood Series bears environments [91] and [92] (largely laurel oak-live oak dominated).

It is now thought that the sandhills (of Kershaw and Lakeland sands) lying east of Southeastern Coastal Plain streams were formed during the full-glacial Pleistocene times by gale-force winds blowing from the soutwest, Thom (1967), Whitehead (1973).

In the Fall Line Sand Hills of Twiggs County, for example, the bulk of the upland soils are placed in the Orangeburg-Red Bay-Americus Association, derived from Eocene sands, USDA (1963). The Orangeburg series are deep friable soils developed on thick beds of acid sandy loam and sandy clay loam. The Red Bay Series has a darker surface layer. Georgia has but remnants of the famous "black belt" so prominent in central Alabama. It can be seen in southwest Twiggs County, where it develops over Eocene limestones, marls, and chalks and is known as the Oktibbeha-Eutaw-Susquehanna-Binnsville Association, USDA (1963). These soils, except the Susquehanna, are alkaline and all have beds of heavy clays. They may become hard and shrink and crack in dry weather. The surface soils of these "blacklands" is a thin veneer of dark brown sandy loam. In the Limesink Area of Southwest Georgia, soils on undulating uplands belong to the Orangeburg-Red Bay-Grady Association, USDA (1968a). Grady soils occur in ponded upland depressions and plugged limesinks and have a gray clay subsoil and black muck surface.

Treutlen County typifies the Tifton Plateau region of the central Coastal Plain. Most of its upland soils are classed in the Norfolk-Tifton Association, USDA (1964). Norfolk soils have a foot-thick surface layer of loamy sand, below it to a depth of 42 inches is a sandy clay loam; below that a firm, mottled clay loam. Such mottlings, which are often colorful and visible in road cuts, indicate a wet or inundated condition when the soil was formed. Tifton soils are basically similar and grade into mottled sandy clay at 32 inches. Tifton soils are readily distinguished from Norfolk by having less sand and by having many small, rounded, dark brown to reddish iron concretions in the soil layers and accumulated on the surface, probably inspiring Harper (1906) to call the Tifton Plateau the "Altamaha Grit Region." Some Tifton soils are so iron-rich as to be considered for mining. The remaining Treutlin County uplands belong to the Gilead-Lakeland-Cuthbert-Sawyer-Norfolk Association, a "catch all" group of well drained soils with sandy surface layers and variable subsoils (some have compact, clayey layers). On the Tifton Plateau depressions and drainageways have poorly drained acid, sandy soils called the Plummer Series. Shrub bogs, herb bogs, cypress ponds, and gum ponds may occur on Plummer soils.

In the Lower Coastal Plain (Plio-Pleistocene) creek swamps and depressions are floored by either Rutlege, Rains or Portsmouth loam soils and Carolina Bays, cypress ponds and shrub bogs may occur on these soils.

While upland longleaf pine forests may appear on the drier Norfolk and Tifton soils and sand-capped ridges, the pine flatwoods (generally of Plio-Pleistocene age) occur on Leon or St. John's soils, USDA (1965). Both are poorly drained and have a brown, organic "hardpan" layer several feet below the surface. Not only do roots find this layer difficult to penetrate, but water "ponds" on top of this impermeable or slowly permeable layer and thus causes the water table to fluctuate markedly between dry and wet conditions. Leon sands are strongly acid and have a "salt and pepper" colored surface layer with leached white sand below. They originally bore longleaf pine, with slash pine in the lower areas. The St. John's sites are lower and wetter and bear slash and pond pine.

## KEY TO COASTAL PLAIN UPLAND (MESIC TO XERIC) ENVIRONMENTS

1a Outcrops of naked rock or boulders exposed on ground surface or at shoal areas on Coastal Plain streams
[100] SANDSTONE OUTCROPS

1b No rock masses visible on ground surface (Select 2a or 2b).

2a "Sandhills", soils obviously loose sand (whitish or yellowish), best seen on hilltops; usually occupying the full depth of roadcuts (common in the Fall Line Sand Hills; along streams, especially the east bank; sporadically throughout the Tifton Plateau; inland from the beach of the coastal islands; as rises or low hills in otherwise flat terrain in lower Coastal Plain) (Select 3a or 3b)

3a Biotic communities near (behind) the beach of present coastal islands (Select 4a or 4b)

4a Communities on conspicuous dunes (Select 5a or 5b)

5a Communities covering the rear dunes (often several 100 feet from the beach with an intervening flat or meadow area); the inland side of the rear dunes usually dominated by live oak.
[99] DUNE OAK — EVERGREEN SHRUB TYPE

5b Treeless and shrubless communities dominated by grass-like plants and vines occupying recent dunes (foredunes) just behind beach.
[98] DUNE MEADOW TYPE

4b Terrain intervening between fore and rear dunes (if dual systems exist), flora is dominated by grass-like plants, shrubs or even trees.
[97] INTERDUNE TYPE

3b Sandhill communities not near the present ocean shoreline. Burrowing fauna may exhibit a linear series of mounds (pocket gopher), a single isolated mound (fire ant), or a single hole with a flat mound in front (gopher turtle) (Select 6a or 6b)

6a Forests of oaks seldom over 15 feet high, species are either genetically or environmentally dwarfed. (Select 7a or 7b)

7a Forest of large-leaved turkey oaks with deeply lobed leaves (the 3 lobes resembling turkey's track), with or without blackjack oak (leaves spatulate, wider at the tip, with no particular lobing); longleaf pine overstory present, or may have been entirely logged out. (Select 8a or 8b)

8a Forest with blackjack oak conspicuously present.

[84] CLAY RIDGE FOREST

8b Forest lacks blackjack oak (Select 9a or 9b)

9a Forest predominantly a "thicket" of turkey oak; shrubs and herbaceous vegetation scanty.

[85] DWARF OAK FOREST

9b Forest a thicket of turkey oak but with occasional dark green, waist-high shrubs resembling squat cedars, and/or a growth of gray-green woody mints (leaves smelling mint-like when crushed).

[86] DWARF OAK — EVERGREEN SHRUB SUBTYPE

7b Forest of oaks with tiny, unlobed, shiny, rounded leaves (Select 10a or 10b)

10a Forest of twisted, gnarled (bonsaid) dwarfed live oaks (leaves thick, dark green, holding water when inverted) and a dense carpet of lichens underneath; may be surrounded by environments [85] and [86].

[93] EVERGREEN SCRUB — LICHEN FOREST

10b Forest dominated by shrub-sized oaks (myrtle oak, Chapman oak) and evergreen shrubs. Usually always bears dwarfed or normal trees of hammock environments.

[92] EVERGREEN SCRUB FOREST

6b Forests of oaks of moderate to normal size, dominated by live and laurel oaks: locally called "HAMMOCK".

[91] UPLAND BROADLEAF EVERGREEN FOREST

2b Soils not obviously loose sand (may, however, be sandy or sandy loams). not an obvious "sandhill" as described under 1a. (Select 11a or 11b)

11a Forests either entirely pine, or mixed pine-hardwood (Select 12a or 12b)

12a Terrain flat or rolling, essentially covered with a pine forest away from streams, and depressions such as cypress ponds and limesinks. (Select 13a or 13b)

13a Terrain flat, or to all appearances flat, topsoil usually sandy with a salt and pepper appearance. If pines have cones over 6 inches and finger-sized twig ends it is **longleaf pine flatwoods**; otherwise it is **slash pine flatwoods** (or pond pine in wet spots); thick shrubby undergrowth dominated by gallberry heath, with or without trunkless palms (saw palmetto).

[94] MESIC LOWLAND PINE FOREST

13b Terrain rolling, not flat (Select 14a or 14b)

14a Pines with huge cones (longer than 6 inches) and finger-sized twig ends; ground cover often clumps of straw-thin, wiry grass.

[95] LONGLEAF PINE UPLAND FOREST

14b Pines with cones rarely exceeding 4 to 5 inches, twig ends thin and not stubby, needles usually less than 10 inches.

[96] LOBLOLLY-SHORTLEAF PINE UPLAND FOREST

12b Terrain flat or rolling, forest obviously a mixture of pines and hardwoods, or cedars and hardwoods. (Select 15a or 15b)

15a Forests usually within several miles of salt or brackish water. (Select 16a or 16b)

16a Forest containing trunked cabbage palms and red cedar along the edge of salt or brackish water.

[88] MARITIME STRAND FOREST

16b Forest not immediately adjacent to salt or brackish water, red cedars and/or cabbage palms not conspicuous (Select 17a or 17b)

17a Forests in low grounds of coastal islands, presence of bay trees, fetterbush and ferns suggest high water table.

[87] LOWLAND MARITIME FOREST

17b Forests occupying the flat interior of coastal islands and higher zones on mainland near salt marsh-dominated by live oaks with slash pine obvious.

[89] UPLAND MARITIME FOREST

15b Inland forests not near the coast, usually on clay-rich soils. A dry oak-hickory forest resembling many late successional stages of Piedmont forests; pines are shortleaf or loblolly.

[83] BROADLEAF DECIDUOUS-NEEDLELEAF EVERGREEN UPLAND FOREST

11b Forest contains few or no pines, environments appear as hardwood forests (if certain pines species present, then water tables probably high or seepage is pronounced). (Select 18a or 18b)

18a Hardwood forests with live and laurel oaks conspicuous or dominant, the former having thick, dark green, shiny, oval leaves that may hold water when inverted. (Select 19a or 19b)

19a Live oaks appearing bonsaid (dwarfed, gnarled) with heavy lichen (reindeer moss) ground cover.

[93] EVERGREEN SCRUB — LICHEN FOREST

19b Live oaks and other trees of normal height (Select 20a or 20b)

20a Forest usually within several miles of salt or brackish water, or on the flat interior of coastal islands.

[89] UPLAND MARITIME FOREST

20b Forest not very near coast, but inland (Select 21a or 21b)

21a Predominantly hardwood forest, with a variety of tree species, high water table evidenced by presence of spruce pine (*Pinus glabra*); shrub layer may be dense and diverse; rare, except in Chatham County. Locally called "HAMMOCK".

[90] LOWLAND BROADLEAF EVERGREEN FOREST

21b Forest dominated by live and laurel oaks. Widely but only locally common over Limesink Region and lower Coastal Plain; occurs over a broad range of soil moisture. Also called "HAMMOCK".

[91] UPLAND BROADLEAF EVERGREEN FOREST

18b Hardwood forests lacking live oaks, or live oaks not a conspicuous element in the flora. (Select 22a or 22b)

22a Hardwood forests on steep bluffs, or on moist seepage slopes adjacent to streams or low ground. (Select 23a or 23b)

23a Hardwood forest on steep north, northeast or east-facing bluffs along Savannah River (mostly) or Chattahoochee (partly).

[77] BLUFF FORESTS OF NORTHERN AFFINITIES

23b Hardwood forests on moist, gentle to moderate slopes; water sometimes visible as spring seeps or flows on impermeable layer under shallow soil. Beech and/or southern magnolia (evergreen) frequently obvious. Often called **"beech-magnolia hammock"**.

[78] BLUFF AND SLOPE FORESTS

22b Hardwood forests on more or less steep-walled ravines, or clothing the walls or bottoms of ravines, pits or sinks. Springs, seeps or streams may or may not be present. (Select 24a or 24b)

24a Ravines with the walls of exposed rock, or softer clay in layers. (Select 25a or 25b)

25a Ravine walls of soft, slick, layered clay; found chiefly in Clay and northern Early Counties.

[79] CHATTAHOOCHEE RAVINES

25b Ravine walls of hard rock (Select 26a or 26b)

26a Ravines and sinks along the Pelham Escarpment (see physiographic map), often connected with extensive underground caverns.

[81] SOLUTION RAVINES AND SINKS

26b Ravines in the Tifton Plateau (see physiographic map) not connected to extensive underground caverns.

[82] TIFTON UPLAND RAVINES

24b Ravines with walls soil-covered and vegetated; chiefly confined to Decatur County.

[80] TORREYA RAVINES

## 1. BROADLEAF DECIDUOUS-BROADLEAF EVERGREEN FORESTS (Southern Mixed Hardwood Forest)

### Introduction

The southern mixed hardwood forest was defined as the climax for the southeastern Coastal Plain by Quarterman and Keever (1962). Ninety-three sample stands were selected across southeastern states. Twenty sites were established in Georgia, at least two of which still exist (Oglethorpe Bluff, Wayne Co.; Troupville Woods, Lowndes Co.), Quarterman (pers. comm.). Although the authors took care to select mesic sites, their sites encompassed a rather wide spectrum of habitats, which would naturally yield a large number of species if lumped together and identified as a single floristic unit, presumably the climax vegetation. Monk (1965) did a somewhat similar study in north-central Florida, selecting 60 stands in a thirteen-county area. Monk found that compositional complexity was an outstanding attribute when his 60 stands were lumped together, which was much the same conclusion reached by Quarterman and Keever. Since different tree species were more prominent in one stand or another, Monk sought to determine why (using moisture, calcium, phosphorus, potassium, and magnesium). He arrived at some conclusions when considering the tree species composition (floristics) of Coastal Plain deciduous forests. His conclusions may be summarized as follows: (1) Calcium is extremely important, soils high in calcium produce the maximum diversity; (2) Soils low in calcium, potassium, phosphorus, and moisture support a community dominated by evergreen trees; (3) Some trees, such as water oak, swamp chestnut oak, sugarberry, spruce pine, and blackgum, favor wetter environments; (4) Some trees, such as sweet gum and live oak, do well at both extremes of wet and dry (meaning that factors like fire and longevity may be more important when these trees appear or do not appear in the forest); (5) American holly and wild olive prefer dry areas, dogwood and hop hornbeam prefer dry to mesic conditions, and ironwood prefers the more hydric soils; (6) Some shrubs and herbs also prefer xeric conditions (sparkleberry, *Elephantopus*, horse sugar, sarsaparilla vine); (7) Of 49 tree species, Monk found only four (cabbage palm, red bay, wild olive, and buckthorn) to be of subtropical affinities.

## a. MESIC SLOPE FORESTS

### Introduction

If the slope is north-facing and of sufficient height (circa 50 feet), a forest may develop where herbs, shrubs, and some trees are characteristic of the mountains of north Georgia. Most bluffs are found along rivers, only two having bluffs noted for the extension of northern plants, such as mountain laurel and flame azalea, deep into the Coastal Plain. Along the Savannah one can find distinctive northern plants as far south as Two-Sisters Ferry in Effingham County. William Bartram (1791) crossed here and noted the strange flora. The other river is the lower Chattahoochee before and after its junction with the Flint. Here, both the flora and the fauna (salamanders notably) have northern members.

Other forests, by virtue of their slope, receive groundwater seepage and their biota is modified by the additional moisture. These forests are often unique in growing in gorges or steep ravines where the combined effects of slope, moisture, and protection from sun, drying winds, and fire create exceptional microclimate environments.

# [77] BLUFF FORESTS OF NORTHERN AFFINITIES

### Location and Description

Found on ridges or low hills truncated by river erosion or held up by rock outcrops, especially on north-facing bluffs, the vegetation shows strong northern affinities. They may also be found on north-facing valley walls along Upatoi Creek (Chattahoochee Co.) and other streams which have cut ravines as they drop towards the Chattahoochee River The appearance of the shell bluff forest is one of almost subtropical luxuriance (photo A29). Examples are Shell Bluff (Burke Co.) and Savannah Bluff (Screven Co.).

Bartram noted the occurrence of huge fossil oyster shells (*Crassostrea gigantissima*) at Shell Bluff. These deposits are late Eocene oyster reefs approximately 43 million years old. The best locality is not at Shell Bluff but at Girffin's landing where the heavily-forested bluff is only about 15 feet high.

Photo A29. This scene of forest luxuriance greets the visitor standing on the west bank of the Savannah River looking up at the BLUFF FOREST OF NORTHERN AFFINITIES [77] at Shell Bluff (Burke Co.). The dominant trees visible are black walnut, southern sugar maple, sweet gum, and mulberry.

### Flora

At Shell Bluff a remarkable assemblage of plants is found, Photo A29. Those found mostly in the mountains or Piedmont are marked (N), the dominants marked (D). Some of the plants, such as the bluebell (*Campanula americana*) and Canadian wild ginger (*Asarum canadense*), can be regarded as disjunct species. Many of the following records are courtesy of John Bozeman (unpublished data).

**Trees:** tulip poplar, (D) sweet gum, (D) hickories, (D) (N) black walnut, (D) (N) basswood (*Tilia caroliniana*), black oak, (D) red oak (*Quercus rubra*), (D) southern sugar maple, swamp chestnut oak, sugarberry, red elm, beech, white oak, (N) northern paw paw (*Asimina triloba*), (D) cherrybark oak, cottonwood (*Populus heterophylla*), box elder, dogwood.

**Shrubs:** redbud, red buckeye (*Aesculus pavia*), (N) wild hydrangea, mulberry, (N) sweet shrub (*Calycanthus floridus*), hop hornbeam, (N) strawberry bush (*Euonymus americanus*), bluehaw (*Viburnum rufidulum*), mock orange (*Philadelphus inodorus*), bladdernut (*Ptelea*).

**Herbs:** (N) wild ginger (*Asarum canadense*); *Thalictrum* sp., (N) bluebell (*Campanula americana*), (N) maiden hair fern, (N) alumroot, (N) Hybanthis concolor (N) mayapple, false Solomon's seal, (N) thimbleweed (*Anemone virginiana*), (N) liverleaf (*Hepatica americana*), (N) erect trillium (*Trillium erectum*), (N) starry campion (*Silene stellata*), black cohosh, skullcap (*Scutellaria ovata*), (N) meadow parsnip (*Zizia* sp.), foxglove.

We assume that fire here has nearly a zero frequency. Some light ground fires may occur in drought years.

Duncan (pers. comm.) remarks on flame azalea, umbrella magnolia (*Magnolia tripetela*), mountain laurel, sourwood, and northern red oak from the Screven bluff on the Savannah. He states that there are more bluffs with northern flora along the Savannah than along any other river, except perhaps the Apalachicola. The Ogeechee and Satilla, both floated by Duncan and the author, possess relatively few bluffs. Duncan recalls only about three on the Ogeechee between Millen and Highway 17 (a three day power boat "float" trip). No bluffs with northern flora were found along the Satilla; Magnolia Bluff on the lower Satilla is classed as a seepage type, and treated elsewhere (see BLUFF AND SLOPE FORESTS). A Upatoi Creek bluff possessed ginseng, doll's eyes, mountain laurel, and trailing arbutus, Steve Bowling (pers. comm.).

### Fauna

The fauna will be habitat X (mesic to xeric forests) with a mixture of distribution MT, P, and CP, Appendix VI. The most interesting faunal elements will be the presence of mountain (MT) forms which can survive in the cool, moist microclimates of the slopes. As in the case of the seed transport of plants, the fact that streams heading in the mountains of northern Georgia could carry down certain animals, such as salamanders or their eggs, must not be overlooked.

### Natural and Cultural Values

Absolutely essential to prevent bluff erosion, these irreplaceable and rare environments hold botanical and zoological rarities — not yet studied in any detail. They are unknown genetic reservoirs, and important to science. Sometimes unusual rock outcrops or fossil reefs are associated.

Sometimes paleontologically significant (Shell Bluff), they are frequently associated with archaeological sites or historic cannon revetments (Shell Bluff). They are esthetically pleasing and natural outdoor laboratories of exceptional value.

### Man's Impact

These bluffs are threatened by logging or other mismanagement, or as sites for cabins and refuse dumps. They are not recognized by the public.

## [78] BLUFF AND SLOPE FORESTS

### Location and Description

This forest resembles bluff forests of northern affinities but lacks northern floral elements. A basic type is a seepage forest on low bluffs, such as are found along the east bank of the Alapaha River (fig. 28), at the Springhill Plantation bluff and at Magnolia Bluff. These situations are obviously downslope, with water often reaching the surface as springs and small bogs, and grading to more xeric bluffs, such as the Altamaha Bluff in Wayne County (see examples). Usually beech and southern magnolia are obvious in the canopy; it is often called a beech-magnolia hammock. In the Tallahassee Hills this hammock often borders creek swamps. In the moister type there are additional trees (such as water oak and sweet bay) indicating very mesic conditions. Some, such as the remarkable Magnolia Bluff, are moist enough to even have floodplain species (swamp chestnut oak, water hickory, planer tree, ironwood, and cypress) growing on the bluff slope itself. Stilson Bluff on the Ogeechee is a remnant of the Penholoway barrier island into which the river has eroded forming a steep northern face.

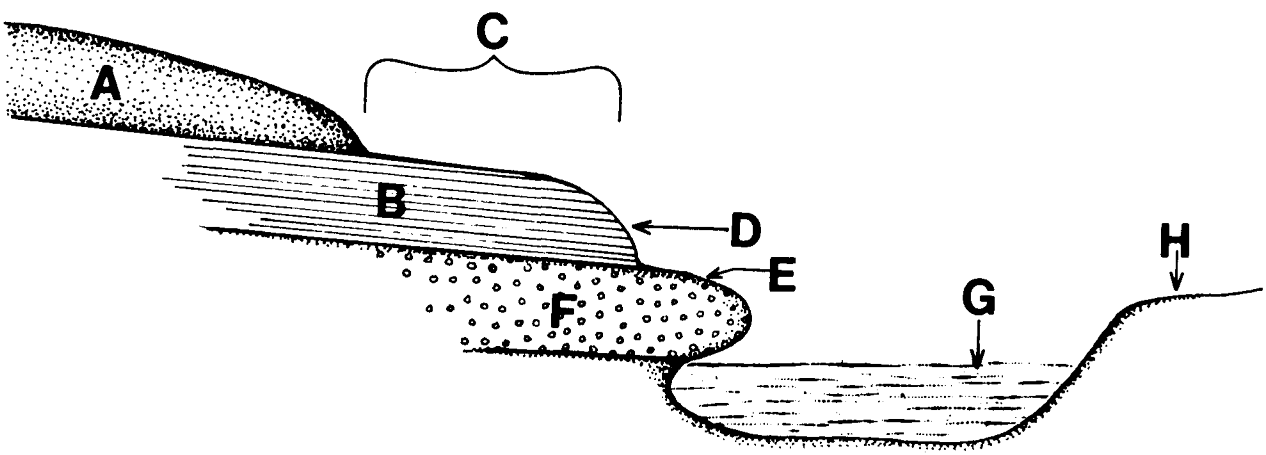



Fig. 28. Cross section of the Alapaha River bluff forest substrate (east side, Norsworthy Tract) seepage type. (A) sand-capped ridge (in agriculture and pine); (B) clays, (about 10 feet thick) with seepage on surface from sands; (C) mesic hardwood bluff forest; (D) steep face with *Polytrichum* and sphagnum mosses; (E) royal fern and liverworts on wet marl surface; (F) marl; (G) summer level of Alapaha River; (H) lower ground with pines.

Examples are: Slope low — Springhill Hammock (Grady Co.), Troupville Woods (Lowndes Co., photo A30); Slope moderate — Alapaha riverine forest (Echols Co. east bank between Highway 94 and 187 near Mayday), Magnolia Bluff (opposite Burnt Fort, Highway 252, Camden Co.) on Satilla River; Stilson Bluff (Bulloch Co.) on the Ogeechee River, Harper (1906) listed bluffs on the Ogeechee (upper Seven Bluffs, Wilcox Co.).

Photo A30. This is an aspect of Troupville Woods (Lowndes Co.), looking downslope into a seepage slope forest [78] adjacent to Little River The dominant trees are beech, basswood, and American holly; the shrubs, wild olive, *Viburnum rufidulum*, fringe tree, and *Bumelia* Behind the figure, the forest grades upslope into a BROADLEAF DECIDUOUS - NEEDLELEAF EVERGREEN SUBMESIC FOREST [83].

### Flora

#### Dry Type — Altamaha Bluff

**Trees:** (D) spruce pine (*Pinus glabra*), (D) beech, (Co-D) white oak, (Co-D) laurel oak, (Co-D) southern magnolia, mockernut hickory, water oak (occ.); black gum (occ.); ironwood.

**Shrubs:** red buckeye (*Aesculus pavia*), wild olive, horse sugar, witch hazel, hop hornbeam, rusty haw (*Viburnum rufidulum*), blueberry (*Vaccinium elliottii*), wax myrtle, saw palmetto, Piedmont azalea (*Rhododendron canescens*), and possum haw (*Viburnum dentatum*).

#### Seepage Type — Springhill Plantation

**Trees:** (D) southern magnolia, (D) beech, spruce pine, white oak, basswood, dogwood, red bud, mockernut hickory, ash, sweet gum.

**Shrubs:** American holly, dwarf paw paw (*Asimina*), horse sugar red buckeye, witch hazel, two-winged silver bell (*Halesia diptera*), hop hornbeam.

**Herbs:** Virginia creeper, partridgeberry, green fly orchid (*Epidendron*), horse balm (*Collinsonia serotina* or *canadensis*), Lopseed (*Phryma leptostachys*), leafcup (*Polymnia* sp.).

#### Seepage Type — Alapaha Bluff, Norsworthy Tract

**Trees:** (D) southern magnolia, (D) sweet gum, dogwood, (D) tulip poplar (D) pignut hickory, (D) white oak, red maple, laurel oak, beech, swamp red bay (*Magnolia palustris*), sweet bay (*Magnolia virginiana*), water oak (occ.), swamp chestnut oak, black gum (occ.), American holly (occ.).

**Shrubs:** (D) horse sugar (on the higher sand cap areas), dwarf paw paw (*Asimina parviflora*), (D) pinckneya (*Pinckneya*), (D) large gallberry (*Ilex coriacea*), coast pepper bush (*Clethra alnifolia*) (occ.).

**Herbs:** rivercane, Christmas fern, maiden fern (*Thelypteris normalis*), Florida wood fern (*Dryopteris ludoviciana*), sedges (*Carex* spp.), panic grasses (*Panicum* spp.), partridgeberry, horse balm (*Collinsonia*).

#### Seepage Type — Upper Dooly, Lower Houston Counties (U.S. 41 site)

**Trees:** (D) southern magnolia, (D) beech, white oak, dogwood, northern red oak, pignut hickory, swamp chestnut oak, water oak, (D) Florida maple, black gum, poplar, loblolly pine, mockernut hickory.

**Shrubs:** sparkleberry, witch hazel, American holly, red bud, fringe tree, dwarf paw paw, horse sugar, hop hornbeam.

**Herbs:** sarsaparilla vine (*Smilax pumila*), Christmas fern, wild ginger, erect trillium (*Trillium flexipes*), partridgeberry.

### Seepage Type — Magnolia Bluff (Very Mesic)

**Trees:** beech, planer tree (*Planera aquatica*), water oak, water hickory, (D) southern magnolia, sugar berry, elm (*Ulmus floridanus*), overcup oak, ironwood, (D) swamp chestnut oak, pond cypress (*Taxodium ascendens*), spruce pine (*Pinus glabra*), hickory, sweet bay, white oak.

**Shrubs:** swamp palmetto (*Sabal minor*), pepper bush (*Clethra alnifolia*), storax (*Styrax* sp.), mulberry, swamp privet (*Forestiera acuminata*), titi (*Cyrilla*), dwarf paw paw, red buckeye (*Aesculus pavia*), cornel (*Cornus asperifolia*), walter's viburnum (*Viburnum obovatum*), swamp dogwood (*Cornus microcarpa*).

**Herbs:** southern lady fern (*Atherium asplenioides*), cinnamon fern (*Osmunda cinnamomea*), royal fern (*Osmunda regalis*), air plant (*Tillandsia tenuifolia*), (D) river cane.

Photo A31 The remarkable seepage slope forest [78] at Magnolia Bluff in Camden County is so wet that magnolias such as this grow side by side with floodplain species, such as water hickory and cypress. Abundant springs and seeps drain the sand-capped slopes of higher ground.

### Seepage Type — Lower Slopes of Troupville Woods

**Trees:** southern magnolia, beech, American holly, tulip poplar, swamp chestnut oak, white oak, swamp red bay, black gum, basswood, hop hornbeam.

**Shrubs:** dwarf paw paw, large gallberry (*Ilex coriacea*).

**Herbs:** *Trillium* sp., jack-in-the-pulpit; sword fern; partridgeberry; horse balm (*Collinsonia*).

The following reasonably complete list of plants was made by Wilbur Duncan at Stilson Bluff on the Ogeechee River, June 1, 1968. Dominants are not indicated.

**Trees:** beech, southern magnolia, black walnut, shellbark hickory (*Carya ovalis*), white oak, black oak, southern red oak, red bays (*Persea borbonia, Persea pubescens*), American holly, southern sugar maple, basswood (*Tilia* sp.), dogwood, ironwood.

**Shrubs:** chinquapin (*Castanea ashei*), dwarf paw paw, witch hazel, red bud, stewartia (*Stewartia malacodendron*), Hercules'-club (*Aralia spinosa*), fetterbush (*Leucothoe axillaris*), Storax (*Styrax grandifolia*), mock organge (*Philadelphus* sp.), Sebastianbush (*Sebastiania ligustrina*), and southern cornel (*Cornus micro-carpa*).

**Herbs:** green fly orchid (*Epidendron conopseum*), spider lily, wildginger (*Hexastylis arifolia*), birthwort (*Aristolochia serpentaria*), bloodroot, spurge (*Euphorbia mercurialina*), false wintergreen (*Chimaphila maculata*), white verbena (*Verbena urticaefolia*), horse balm (*Collinsonia canadensis*), false foxglove (*Aureolaria virginica*), partridgeberry, leaf cup (*Polymnia radiata*), lady fern (*Athyrium asplenioides*), brownstem spleenwort (*Asplenium platyneuron*), net-vein chain fern (*Lorinseria areolata*).

Generally, this is a stable, self-perpetuating ecosystem which is intolerant of fire. Harper (1911) was one of the first to point out that hammocks located along creeks and rivers of the Tifton Upland probably owed their existence to the absence or infrequency of fire. He stated that the swamps on one side and the sandhills on the other protected this zone of mesic vegetation. The fact that these are downslope seepage areas is also quite important in maintaining a damp floor Still, drought years do come and the fire interval can be assumed to be 15-40 years, Ed Komarek (pers. comm.). Longleaf pine-wiregrass communities (**submesic pine uplands**) adjacent to many of these hammocks burn with a natural frequency of 3-5 years. Komarek feels that the Indians may have fired these adjacent forests more frequently, perhaps annually, and that the hammocks burned more often with less damage. In fact, experimental burning of hardwood hammocks at Tall Timbers Research Station indicates that there is little damage to hammock trees, such as beech and magnolia, if fire is on an annual basis. Furthermore, fire appears to promote an increase in the numbers and kinds of beneficial fungi, important in recycling, Ed Komarek (pers. comm.).

Except for the absence of live oak, the composition of this forest is markedly similar to that listed by Pearson (1954) as mesic hammock on ridges along the Wascassassa River in Levy County, Florida.

Magnolia Bluff was visited by Duncan and the author, and a partial list of plants has been published by Duncan (1969). A southern magnolia was measured at 14' 5" CBH. Due to the many emergent springs and very moist conditions, seepage slope species, such as magnolia and spruce pine, occur alongside cypress, water hickory, planer tree, swamp privet, and cabbage palm, which are floodplain or high watertable tolerant species. In these bluffs one often finds branches running in ravines. Here one finds loblolly bay, holly, *Pinckneya*, and Virginia willow. These feeder streams, sometimes with small water falls, are important to the esthetic and recreational setting of the bluff forests. In considering the distribution of northern plants more or less confined to the Savannah and Chattahoochee drainages, we should bear in mind that these are our only Coastal Plain streams which head in the mountains and might carry mountain plant seeds by water. It will be interesting to explore other riverine bluffs in the Coastal Plain for evidence of northern affinities.

Blaisdell *et al* (1973) concluded that beech-magnolia dominated forests in SW Georgia (where the species overlap) can potentially develop as a climax forest type on any soil site free from periodic burning or periodic inundation. Ground fires do not apparently damage mature southern magnolias but some do seriously injure beech, half-girdling it and allowing fungus to establish. These authors cite evidence that the Indians burned vegetation extensively. Their evidence suggests that bluff forests represent the too-moist-to burn and to-steep-to cultivate climax forest that, without man and fire, would occupy much more terrain than at present, including some areas which are now extensive pine forests. This also explains why we find forest with magnolia and beech along river swamps and on occasional high areas in the floodplain as along the Flint River in Crawford County. This does not distract from the fact that this is a distinctive environment — in fact, these forests may be even more relictual than we had supposed and their fauna needs careful evaluation.

### Fauna

At Magnolia Bluff the southern dusky salamander and cricket frog are common to the seeps; pine woods tree frog and broad-headed skink were taken from the drier portions (Wharton and Wharton, 1969). The fauna is, by habitat, X with distribution, CP with some P-CP elements, Appendix VI. Most P-CP animals are wetland forms. However, in the snakes one finds some, such as the midland brown, southern ringneck, gray rat, scarlet king, and crowned snakes, that occupy bluff environments. Hardwood hammocks in the Tallahassee Hills region have as dominant snails, *Mesomphix* sp., *Anguispira alternata,* and *Mesodon thyroides*, Virginia Vail (pers. comm.).

### Natural and Cultural Values

This environment is protective against erosion and is botanically and zoologically rich, providing essential greenbelts for wildlife along streams and floodplains. Buffer zones maintain suitable temperatures, and seepage areas often have rare plants or animals. These are often forests of grandeur, as at Magnolia Bluff (selected for a natural area).

### Man's Impact

Due to logging, good examples with mature, old growth forest are rare. Riverside cabins and camps pose another threat to remaining samples.

b. MESIC RAVINE FORESTS

### Introduction

Microclimates in ravine forests are cooler and more moist than surrounding terrain, owing to a steep-walled gorge. There is usually a spring, branch, or stream at bottom. Beech and southern magnolia may form the dominant canopy. These forests could be considered variations of the preceding types [77] and [78].

(1) CHATTAHOOCHEE ESCARPMENT TYPE

## [79] CHATTAHOOCHEE RAVINES

### Location and Description

Found in gorges from Ft. Gaines (Clay Co.) south, largely in Clay and Early counties, these ravines are on bluffs which generally begin about three miles east of the Chattahoochee River. Streams provide some white water and afford exciting canoe trips. Examples are Kolomoki Creek and Coheelee gorges (Clay-Early counties), Photo A32, below the Highway 39 bridge and Town Creek gorge (Clay Co.). They appear as steep-walled ravines of fascinating blue-marl clays.

Photo A32. Near-vertical cliffs of laminated clay (Tuscahoma Formation) in the walls of Kolomoki Creek Gorge (Clay Co.) support Venus hair fern which is visible above the figure, environment [79]. Harper called this weird area the "blue marl region."

Kolomoki Creek has a remarkable gorge in thinly-laminated silt-clays of the Tuscahoma formation containing chert nodules up to wash tub size. All surfaces are extremely slippery and the stream has treacherously swift channels if one is afoot. The Town Creek gorge, 15 miles north of Kolomoki Creek, is in the Clayton Limestone. Town Creek is known for fossil leaves between clay layers. This gorge is practically within the city limits of Ft. Gaines. It contains late Paleocene fossils, including oyster reefs and abundant corals. According to Sam Pickering, one of the first scientists to investigate these ravines, there has been no work here on vertebrate paleontology.

The laminated series of silt-clays in this sector of Georgia and adjacent Alabama are largely subsurface and outcrop only in the gorges. The bluish clays are so unusual that Harper (1930) called this the "Blue Marl Region." These ravines apparently do not burn.

These rather bizarre gorges may or may not be one of a kind. Laurel oaks on the rims are quite old (300 years estimate), attesting a narrow strip of near-original forest. Basswood (*Tilia*) is occasional. A wet cliff yielded some rare ferns; this and the Torreya ravines are the only localities (known to me) for venus hair fern not on limestone cliffs. This entire area's creeks should be investigated. Canoe travel is feasible. There are only five streams in this area — the lower two miles of each should receive priority inventory. The famous **Lumpkin Erosion Gullies** (Stewart Co.) are not considered natural environments but are included here, Some contain huge beech trees, and two rare heaths, *Rhododendron prunifolium* and *R. chapmani* have been recorded there.

### Flora

**Trees:** southern magnolia, laurel oak (largely confined to the top of the ravine), sugarberry, sycamore, beech, box elder, black locust, mulberry, alder (along stream edge).

**Shrubs:** (D) oak leaf hydrangea, (D) titi, (D) Virginia willow, wild hydrangea, arrowwood viburnum (*Viburnum dentatum*), swamp palm (*Sabal minor*), mountain laurel.

**Herbs:** Christmas fern, cinnamon fern, cardinal flower (*Lobelia cardinalis*), venus hair fern (*Adiantum capillus-veneris*) (usually confined to near-vertical seeps).

### Fauna

The cottonmouth is present along streams, and salamanders are likely mountain forms. The fishes should be very interesting, and a study of water-dependent or ravine organisms should be made. Fauna largely habitat X but with elements of N; distribution CP with the possibility of mountain (MT) forms, Appendix VI.

### Natural and Cultural Values

These areas are geologically unique and their flora and fauna, when properly known, may prove to be very interesting to science. They are valuable for water and land trails, and are oases in otherwise cut-over pine-hardwood areas. **Man's impact** on these ravines is unknown.

## [80] TORREYA RAVINES

### Location and Description

Torreya ravines are found in the lower part of Pelham escarpment between Highway 97 and the Flint River arm of Lake Seminole, Decatur County. Some areas have steep-walled forested ravines called "steepheads"; northward they appear less steep and more like normal stream ravines. Most have small branches in them and a cool, moist microclimate quite different from that of the surrounding terrain. There are notable ravines north of Corps of Engineers' headquarters building at Chattahoochee, Florida, and northward.

### Flora

**Trees:** red maple, southern sugar maple (*Acer floridana*), southern magnolia, beech, umbrella magnolia (*Magnolia pyramidata*), basswood (*Tilia* sp.), bladdernut (*Ptelea*), sugarberry, red elm (*Ulmus rubra*), American elm, the rare torreya (*Torreya taxifolia*).

**Shrubs:** swamp palm (*Sabal minor*), oak leaf hydrangea, strawberry bush, red bud.

**Herbs and Vines:** bloodroot, green dragon, *Matelea suberosa*, spleenworts, tickclover (*Desmondium nudum*), wake-robins (*Trillium lanceolatum* and *T. underwoodii*), Virginia snakeroot (*Aristolochia serpentaria*), campion (*Silene polypetala*), round lobe hepatica (*Hepatica americana*), dutchman's pipe (*Aristolochia tomentosa*), black sanicle (*Sanicula marilandica*), sarsaparilla vine (*Smilax pumila*), leatherwood (*Dirca*), bluestar (*Amsonia ciliata*), cross-vine (*Bignonia capreolata*), and the grass, *Triplasis* sp. The dominant fern is maiden fern (*Thelypteris normalis*).

In the Faceville Ravine we found beech to be the dominant **tree,** with sourwood and American plum. The dominant **herbs** were leatherwood, american false hellebore, hepatica, lousewort, dogtooth violet (*Viola walteri*), climbing hydrangea, odorless wax myrtle, horse balm (*Collinsonia*), and green and gold (*Chrysogonum virginianus*). The venus hair fern, the southern lady fern, and the cinnamon fern appeared to be the dominant ferns.

### Fauna

The fauna is basically X, Appendix VI. Distribution is CP with MT forms present, such as Piedmont salamanders. There are also a few rare endemic forms according to Bruce Means (pers. comm.), such as *Amphiuma pholeter*. Dominant amphibians and reptiles are the Desmognathine salamanders *Desmognathus fuscus* and *D. auriculatus,* Means (1975), two and three-lined salamanders, red salamander (*Pseudotriton ruber ruber*), chorus frog (*Pseudacris nigrita triseriata*), and copperhead.

### Natural and Cultural Values

These are exceptionally rare environments with unusual plant and animal assemblages, spring water sources, and genetic pools of disjunct species. This area has served as a refugium for ice-age species which could survive only in these cool ravines and gradually develop heat tolerance. Unfortunately, both the torreya and the similar Florida yew (*Taxus floridanus*) are suffering from a blight and approaching extinction. The portions of these ravines which remain along the inundated Chattahoochee are valuable not only as refuges for rare floral elements, such as the stinking cedar (*Torreya*), but for the northern plants and animals that can live there. Among the notable plants generally restricted to the mountains and/or Piedmont that occur there are doll's eyes, hepatica (*Hepatica americanus*), wild hydrangea, bellwort, bloodroot, snakeroot (*Sanicula* sp.), false hellebore (*Veratrum parviflorum*), and louse wort. Means (1976) indicated that animals with strong northern affinities are the dusky salamander, four-toed salamander, and the red salamander. The yew-like *Torreya* still exists in Georgia (a few specimens), but it is very rare, These environments are exciting in school and general public education, owing to their natural values.

### Man's Impact

These areas are highly vulnerable to logging and dumping of all kinds. A pulp company which owns the northernmost ravines in Decatur County is logging them with disastrous results.

## [81] SOLUTION RAVINES AND SINKS

### Location and Description

These ravines occur near the crest of the Pelham escarpment in upper Decatur and Grady counties. A good example is Waterfall Sink ravine (Grady Co.), several miles west of Highway 112. Generally, these ravines are steep-walled, usually dry, sinkholes down to cavernous limestone. Located in forested terrain, the soil overburden above the limestone supports trees, with beech dominant. These environments may have water running into sink.

Photo A33. Climax Sink in Decatur County is a large dry sink hole connected to the undergound cavern system in the Pelham escarpment. Sink holes support a beech-magnolia hammock forest [81]. Sinks may conduct polluted surface drainage into the underground aquifer

### Flora

**Trees:** beech, southern magnolia, southern red oak, hickory (all growing on sink wall or edge of sink). Ravine leading to sink is beech-dominated.

**Shrubs:** red bud, burning bush, horse sugar.

**Herbs:** venus hair fern, liverworts, mosses, chinaroot (*Smilax taenifolia*) (only locality).

Waterfall Sink is a rare and beautiful limesink type fed or formed by a stream running in a ravine and pouring off as a waterfall into the sink which has perpendicular walls. The forest is a variant of the lowland evergreen broadleaf forest dominated by beech and magnolia in the ravine leading to it and around the sink itself. In the example given, the upstream owner has dammed the creek for a lake, and the stream runs only in the winter Winter or early spring is the suggested time for photography of all sinks. The sinks of the Pelham escarpment are often connected with extensive caves. Waterfall and Climax sinks (located about 100 yards north of Climax, Decatur Co., Ga.) are connected to extensive caves. These sinks allow access to the underground aquifers that extend under the Dougherty Plain, Fig. 29.

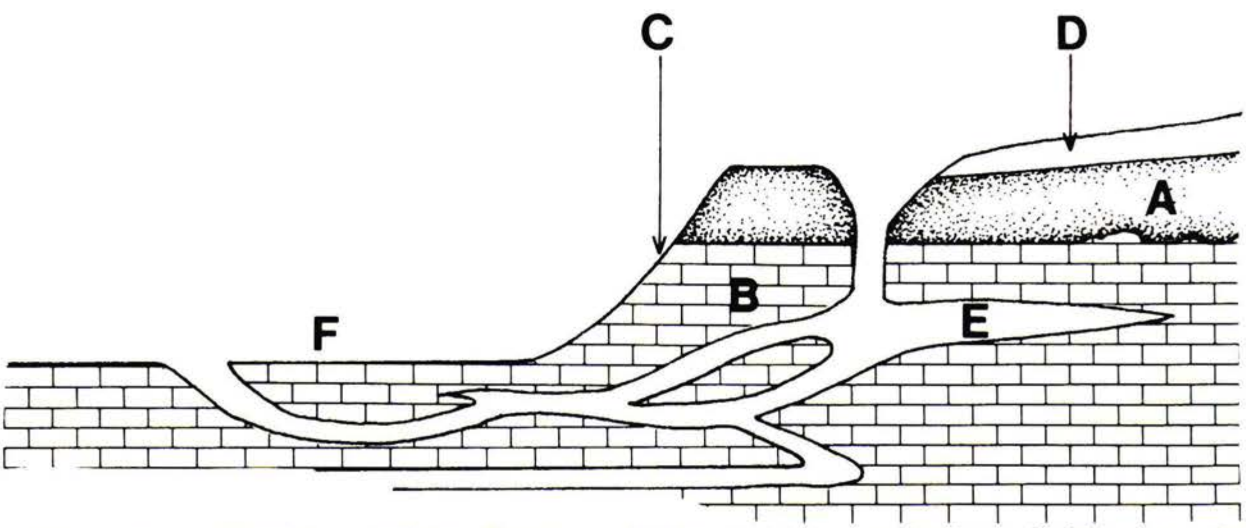



Fig. 29. Solution ravine and limesink on the Pelham Escarpment, SW Georgia. (A) Miocene Hawthorne clastics on the western edge of the Tifton Upland; (B) Miocene and Oligocene limestones; (C) Pelham scarp face; (D) ravine emptying into sink; (E) underground cavern such as Climax Cave; (F) Dougherty Plain (Limesink Region) surface. Steepness of scarp face is greatly exaggerated.

### Fauna

In the underground streams occurs the rare blind cave salamander (*Typhlotriton Wallaci*), described by Archie Carr from a specimen pumped up from a deep well near Albany. These rare salamanders can be captured in caves in northwest Florida not far from the junction of Alabama, Georgia, and Florida where the underground streams are accessible. A crayfish (*Cambarus cryptodytes*) and an isopod (*Asellus hobbsi*) are subterranean faunal members. Two normally surface-dwelling salamanders, the two-lined (*Eurycia bislineata*) and the three-lined (*E. longicauda*), have adapted to underground life in Climax Sink, Means (1976).

Photo A34. Waterfall Sink in Grady County connects with an underground cave system that is extensive in the Pelham escarpment limestones. A stream pours into this sink in the winter Ravines and sink holes support beech-magnolia hammock vegetation, environment [81].

### Natural and Cultural Values

These ravines are geologically and sometimes botanically unique, and are often one of a kind. Rare ferns may occur In the 1930's a number of ferns were added to the known flora of Florida's panhandle by investigating similar sinks, Steve Bowling (pers. comm.). Waterfall Sink is especially valuable, being isolated within a forested area, with a number of dry sinks nearby of various sizes. Most other sinks (Climax, Blowing Hole, Glory Hole) are in cornfields or adjacent to highways and not in desirable settings. Perhaps the best source of information for sink hole and cave inventory in the Pelham escarpment area is the Florida State Speleological Society in Tallahassee. Generally, sinks are highly recreational to climbers, cavers, and tourists.

### Man's Impact

Damming of streams, pesticide pollution, dumping, and cutting the surrounding forest are damaging.

(3) TIFTON UPLAND EROSION TYPE

## [82] TIFTON UPLAND RAVINES

### Location and Description

These are steep-walled, flat-bottomed ravines with numerous solution crevices as narrow as two feet with a depth of 10 feet ("rock city type"), with mesic hardwood forest in ravines, which are approximately three miles long. The best, and possibly the only, example is "The Rocks" in Coffee County, near Broxton. Here, ravines are incised into sandstone — adjacent canyon "rims" are xeric. Fracture-zone weathering produces steep-walled clefts, caves, and side walls.

### Flora

**Trees:** longleaf pine, blackjack oak, scrubby post oak (largely on rims), sweet gum. Trees in ravines not recorded.

**Shrubs:** winged sumac, persimmon (on rim), fringe tree, dwarf paw paw.

**Herbs:** Very rare dwarf filmy fern (*Trichomanes petersii*) occurs here in moist crevices (J. Bozeman, pers. comm.). According to Duncan, the wooly lipfern (*Cheilanthes lanosa*) is at the southern extension of its range here. I also found the following plants to be common: *Selaginella acanthanota*, green fly orchid (*Epidendron conopseum*), ebony spleenwort (*Asplenium platyneuron*), goldenrod (*Solidago graminifolia*), *Talinum teretifolium*, and false garlic (*Nothoscordum bivalve*).

### Fauna

Skinks, racerunners, and heat-loving reptiles are present on the xeric rim. The crevice and ravine floor fauna is unknown. Habitat X on the rim, and probably in the ravine; distribution is CP, Appendix VI.

### Natural and Cultural Values

This rare formation needs to be explored and acquired without delay. It is, as far as known, the only one of its kind. There are endless crevices, tunnels, caves, small waterfalls, and pools. The flora is largely undescribed and the fauna is unknown. The canyon rims are arid sandstone outcrops. As an esthetic or educational experience this ravine is unexcelled. It would make an ideal trail system.

### Man's Impact

The area is owned by a large pulp company. There is some solid waste pollution and misuse by local people. Direct threats are not known.

2. BROADLEAF DECIDUOUS-NEEDLELEAF EVERGREEN FORESTS

a. BROADLEAF DECIDUOUS-NEEDLELEAF EVERGREEN SUBMESIC FOREST

## [83] BROADLEAF DECIDUOUS-NEEDLELEAF EVERGREEN UPLAND FOREST

### Location and Description

This environment is found on heavier-textured soils on level or rolling uplands and confined largely to non-sandy, heavy clay soils of the Fall Line Sand Hills, Fall Line Red Hills, the Fort Valley Plateau, parts of the Dougherty Plain (upper Dooley and lower Houston Co.), and parts of the Miocene where the sand has eroded from the underlying clay, such as in the Tallahassee Hills. In these areas pines are loblolly and shortleaf. It is present rarely in the Tifton Plateau, where protected from fire (as the upper slopes of Troupville Woods). Examples are: upper slope of Troupville Woods (Highway 94, Lowndes Co.); Plot NB66, Tall Timbers Research Station; Highway 46 near Lotts Creek (Bulloch Co.); Veterans Memorial Park (Crisp Co.).

Soils are typically dense, with considerable silt and clay. Thorn (1954) indicated that the Red Hills and higher portions of the Dougherty Plain fall within the Greenville-Magnolia area of red soils. Upland areas possess loamy sands, sandy loams, and clay loams of the Greenville and Blakely series. Associated with these are soils of the Orangeburg, Ruston, Norfolk, Cuthbert, and Susquehanna series.

It appears as a dry hardwood forest with pines.

### Flora

Lane (1974) made a detailed study of the vegetation of the west central upper Coastal Plain, and discusses this environment.

Andy Clewell reports (pers. comm.) that the dominant trees in this environment in the Tallahassee Red Hills are shortleaf pine, mockernut hickory, red oak, black oak, post oak, and dogwood. A xeric bluff top along the Altamaha in Wayne County was dominated by loblolly pine, southern red oak, and mockernut hickory. Robert Lane (pers. comm.) reports that in the central upper Coastal Plain, as one goes northward out of the Tifton Upland into the Red Hills, the pines change from longleaf and slash to loblolly and shortleaf, and southern red oak (*Quercus falcata*), red oak (*Quercus rubra*), and winged elm become more prominent.

A mesic example of this type of forest exists around sink holes in western Crisp County, presumably in unfarmed terrain: **Trees:** (D) southern red oak, southern sugar maple, (D) slash pine, white oak, (D) sweet gum, slippery elm, white ash, mockernut hickory, dogwood; **Shrubs:** sassafras, sparkleberry, red buckeye, (D) rusty haw (*Viburnum rufidulum*), sugarberry (*Celtis georgiana*), possum haw (*Ilex decidua*), swamp dogwood (*Cornus foemina*), dwarf buckeye, sassafras, and sparkleberry.

One of the best studied examples has been used by Valdosta State College faculty for many years. Wayne Faircloth calls it Troupville Woods and the upper xeric slopes provide a good example of this forest, although possessing some elements (laurel oak, live oak) of the UPLAND BROADLEAF EVERGREEN FOREST:

**Trees:** (D) shortleaf pine, (D) southern red oak, (D) mockernut, (D) basswood, (D) laurel oak, white oak, sweet gum, American holly, water oak, (D) post oak, live oak.

**Shrubs and Vines:** chinkquapin (*Castanea floridana*), (D) rusty black haw (*Viburnum rufidulum*), dogwood, horse sugar, buckthorn (*Bumelia* sp.), witch hazel, sarsaparilla vine (*Smilax pumila*), Virginia creeper, poison ivy, yellow jessamine.

This a dry subtype of the Southern Mixed Hardwood Forest of Quarterman and Keever (1962); Monk (1965), and Faircloth (1971) and is obviously similar to many Piedmont upland forests. It is identified by the presence of some or all of the following trees: southern red oak, post oak, black oak, mockernut hickory, and shortleaf pine with shrubs, such as horse sugar, french mulberry, witch hazel, and dwarf paw paw in the shrub layer. The woody vine, *Smilax pumila*, is characteristic in the herb layer. Formerly it capped the hill summits and upper slopes, while the bluff edge or slope direclty adjacent to floodplains was occupied by the beech-magnolia bluff forest. In spite of their selectivity, Quarterman and Keever chose study areas in both dry and mesic sites, i.e., Oglethorpe Bluff (Wayne Co.) and Troupville Woods (Lowndes Co.). Perhaps these forests should be separated. Clewell (pers. comm.) calls this forest "pine-oak-hickory." Harper (1906) listed this type forest as "hammocks" but did not distinguish between bluff forests and drier upland types. He made statements that these forests antedated the Miocene and that they were the only example in the Grit Region (Tifton Upland) "of typical mesophytic forests which are so characteristic of the older parts of the continent." Plummer (1974) stated that this formation was widespread but, owing to size of individual tracts, could not be separately categorized.

Andre Clewell (pers. comm.) indicates that in Grady and Thomas counties in the Tallahassee Hills only isolated remnants of this forest exist. Secondary forests on old field sites may come back in water oak, sweet gum, loblolly pine (and live oak according to Clewell), and the most likely site is below sand caps on Miocene ridges of the Tifton Plateau. Clewell indicates that such a secondary forest is often on badly eroded loams or where sands are eroded to clay subsoils. What was originally a drier oak-hickory forest (as evidenced by mockernut hickory, red oak, and post oak) may on clay soils receive more water, thus enabling certain species (water oak and sweet gum) to thrive — perhaps more properly classified as a seepage subtype. The sand cap may be deposited downslope as colluvium, according to Clewell. If the horizon of a downslope exceeds 8 to 10 cm. in thickness, in all probability, it is a colluvial deposit from the Miocene sand cap upslope, Fig. 30.

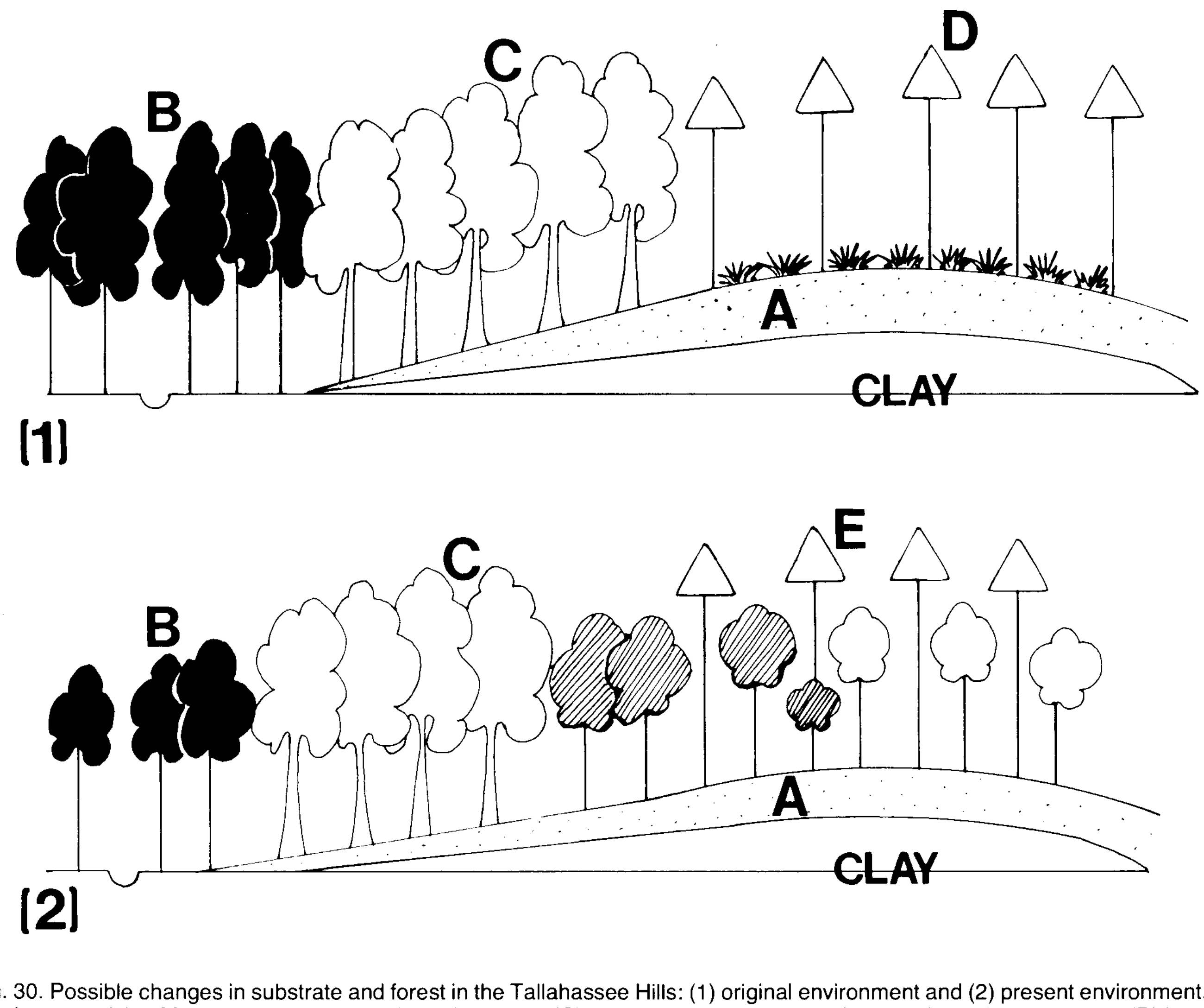



Fig. 30. Possible changes in substrate and forest in the Tallahassee Hills: (1) original environment and (2) present environment. (A) sand cap overlying Miocene clay subsoil; (B) creek swamp; (C) beech-magnolia seepage hammock, environment [78]; (D) longleaf pine-wiregrass [95]; (E) loblolly-shortleaf [96] with invasion of submesic to mesic broadleaf hardwoods [83], depending on depth to clay subsoil (invading mesic species hatched).

There are several areas near or on the Fort Valley Plateau (pre-Miocene) that are classified as "black lands" similar to the blackland strip in central Alabama (which may have supported prairie vegetation there); almost all of Georgia's blacklands are now in pasture or agriculture. Near Tarverville (Twiggs Co.), the surface A-1 was very dark but only several inches thick; the area was badly eroding. The subsoil had a peculiar character. The Carolina buckthorn (*Rhamnus caroliniana*) was the dominant shrub in this area. The former forest type is unknown.

The effect of Indian agriculture on the upland forests of Georgia is not known. Clewell (pers. comm.) has studied it close to the Georgia line. Apparently the Georgia-Florida line area was a no-man's land between the Apalachees and Creeks (Rogers, 1963). According to Clewell, the Tallahassee Hills below the Georgia line were the site of one of the greatest Indian agricultural centers in the southeast, and one which supplied the Spanish missions with corn as far as St. Augustine. Clewell believes that the Indians farmed only the hilltops where clearing the longleaf pine would have been simple, The soil is Norfolk fine sand. Clewell (1971) concedes that today most of the Tallahassee Hills are now covered with pine-mesic hardwood forests with laurel, live and red oaks on drier sites. He classifies these as ruderal communities, following the intensive Indian and Eurasian agriculture or logging, followed by fire suppression.

### Fauna

The distribution is CP; the habitat X, Appendix VI.

### Natural and Cultural Values

Formerly this extensive forest was very important as a timber resource in the maintenance of a fertile land surface, and in forming a receptive, spongy organic topsoil for water conservation. This forest was rich in plant and animal species and harbored much game; a diverse and stable ecosystem.

Preserved samples are urgently needed as living museums of the original forest vegetation over large areas of the northern Coastal Plain. It is shocking to find so little of this forest remaining. A small remnant is used by Georgia Southern, and Troupville Woods is heavily used by Valdosta State.

### Man's Impact

The soils that underlie this forest are among the most fertile and productive in the Coastal Plain — hence most forests have long been removed. Lane states that 20 years ago there was 200% more of this forest than now. All types of forest are, in 1975, giving way in many areas to increased acreage for cropland, largely for soybeans, corn, and cotton. This is especially noticeable in Dooly, Crisp, Pulaski, and Houston counties. Southern red oak is possibly an indicator species for good agricultural land.

Agriculture has eliminated this forest. Robert Lane (pers. comm.) has closely observed changes in the 12-county area between Macon and Cordele. Since 1970 more land has gone into agriculture than at any time since the Indians. Small farmers are selling out to big farmers who are cutting fence row remnants, draining wetlands, especially bogs, branch heads, and intermittent creeks. Lane estimates ¾ of his 12-county area is agricultural and indicates that many pine tree farms are being reconverted into cropland. Twenty years ago the federal "tree bank" program furnished pines and paid to set them out. Most of the less productive lands were set out in pines, especially in the Tifton Upland and Dougherty Plain. In the past five years since these trees have reached pulp size, these plantings have been clearcut and brought back into cultivation (federal tree bank payments stopped after twenty years). Crops are soybeans and corn, with some peanuts and cotton. On the sand-capped hills in the Limesink Region (western sector of Dooly and Crisp counties) one sees numerous irrigation rigs to apply water and fertilizer. These pivot on wheels around a well (approximately 150 ft. deep) pump operated by a diesel motor; up to 200 acres can be watered at one time.

b. NEEDLELEAF EVERGREEN-BROADLEAF DECIDUOUS SUBCANOPY XERIC FORESTS

### Introduction

These forests seem to correspond with Harper's (1960) "dry pine barrens." Longleaf pine appears to be the original tall overstory tree. The amount of clay in the soil or the nearness of the clay subsoil to the surface seems to determine which of the following types dominate, although intergradations are to be expected. With the great longleaf pines for the most part removed, the dominant trees now appear to be dwarf oaks (turkey oak, *Quercus laevis*) mixed with blackjack, bluejack, and dwarf post oak. Bozeman (1971) classifies this environment as a deciduous type, and to the eye with the slow-growing longleaf pines gone, it is so; but, originally, the pine canopy was probably more conspicuous and may have also been called pine barrens by the early travelers, it is considered to be **xeric pine uplands.**

(1) CLAY RIDGE TYPE

## [84] CLAY RIDGE FOREST

### Location and Description

These forests are found on Miocene ridges in the Tifton Plateau where clay subsoils are close to the surface, and described by Bozeman (1971). An example is found on Highway 121 five miles south of Altamaha River (Appling Co.).

These areas may have a mantle of relatively thin sand capping a clay ridge of Miocene age. The thickest sand caps (up to 12 feet) I have seen were east of Cordele (Wilcox Co.) where the underlying clay layer can be seen in road cuts (U.S. 280). Here, the sand is thick enough to classify as a **Sand Ridge Type,** and the vegetation is described under the next heading (DWARF OAK FOREST). This environment is characterized by the presence of blackjack oak.

### Flora

Bozeman (1971) calls this the Blackjack Oak-Milk Pea Association, characterized by the blackjack oak, milk pea (*Galactia erecta*), and by *Dyschoriste oblongifolia*, a bluet (*Houstonia longifolia*), and a rosin weed (*Silphium compositum*).

An Appling County site visited with John Bozeman had the following vegetation:

**Trees:** longleaf pine, blackjack oak, turkey oak, live oak (occ.), bluejack oak.

**Shrubs:** *Quercus incana,* blueberry (*Vaccinium stamineum*), haw (*Crataegus flava*), winged sumac (*Rhus copallina*).

**Herbs and Vines:** panic grass (*Panicum virgatum*), rattlesnake master (*Eryngium yuccifolium*), broomgrasses (*Andropogons* 3 spp.), (D) gopher apple (*Geobalanus*), (D) wiregrass (*Aristida stricta*), (D) bracken fern, dogtongue or wild buckwheat (*Eriogonum tomentosum*), queen's delight (*Stillingia sylvatica*), *Smilax pumila*, muscadine, nolina lily (*Nolina georgiana*), rosinweed (*Silphium compositum*), (D) sensitive brier, sunflower (*Helianthus radula*), *Croton* sp., and the dwarf blueberry (*Vaccinium myrsinites*).

Fire frequency approximates that of DWARF OAK FOREST (7-10 years), John Bozeman (pers. comm.).

The deeper sands have well-adapted plants, such as the lupines and some interesting endemics, such as *Solidago (Chrysoma) pauciflosculosa,* a woody goldenrod. According to John Bozeman, the clay-based sandhills are characterized by the milkweed, *Asclepias tuberosa,* the sensitive brier (*Schrankia microphylla*), and goat's rue (*Tephrosia virginiana*). Bozeman indicates that the bracken fern is also a good indicator species, where dominant.

### Fauna

Distribution CP with some P-CP, Appendix VI. Habitat — if the sand cap is too thin, the fauna will be largely a depauperate X. If the sand cap is thick, the fauna will be SX — with W.

### Natural and Cultural Values

This xeric environment has a singular beauty of its own. The intact vegetation prevents erosion of the thin sand caps on the Miocene clay ridges. The large leaves of the blackjack oak give the community a distinctive appearance.

### Man's Impact

This forest is damaged largely through logging of the longleaf pine overstory, and severely modified by bulldozing efforts to remove the "undesirable" oaks in order to plant slash pine.

(2) SAND RIDGE TYPE

## [85] DWARF OAK FOREST (LONGLEAF PINE-TURKEY OAK)

### Location and Description

This is an open canopy forest usually on conspicuous sandhills and deep sands on ridge tops. It is an extremely dry forest of small deciduous oaks seldom over 15' high, with or without longleaf pine overstory — much open sand, litter absent, often with conspicuous ground lichens, cactus, yucca, and other xeric plants, Photo A35. These forests occur on deep sand ridges parallel to and east of major streams in the Coastal Plain, especially on the Tifton Plateau. They also occur on top of sand ridges throughout the Miocene (referred to by Harper, 1906, as dry pine barrens) and on deep residual sands of the Cretaceous Fall Line Sand Hills.

Examples are found in the Miocene three miles east of Pitts, Highway 280, Wilcox County; Buckhorn Bluff, Pulaski County; Sandhill along Highway 137, Whitewater Creek, Taylor County between Geneva and Junction City; Highway 96, Talbot County; South of Junction City on Highway 90 until the Taylor County line, Talbot County.

Bozeman (1964) indicates that most of the sand ridge paralleling the Altamaha consists of Kershaw (Lakeland) sand as much as 30' deep, with a thin A-1 horizon from one to three inches thick. Monk (1960) found calcium and magnesium markedly lower in Lakeland soils in northern Florida sandhills. Phosphorus and potassium were lower but not markedly so. Faust (1973) found a soil pH of 4.0-5.6 for Cretaceous Norfolk coarse sands, and indicated that the soils contained less than 2.0% organic matter and less than 10% silt and clay. LaMoreaux (1946) indicates that the fall line sandhills correspond on the map to the Tuscaloosa (Cretaceous) formation. Duke (1961), who studied the sandhill flora along the Fall Line in North Carolina, described the Norfolk sands as follows: A-1 horizon, organic-stained, grey sands a few inches thick; B horizon, yellow or faintly yellow friable sandy clay three feet thick; C horizon, a mottled red, yellow and grey sandy clay. Bozeman (pers. comm.) suggests that a soil development or succession takes place in sandhills over perhaps a 100 year period.

Faust (pers. comm.) indicates that in Talbot County, the depth of the nearly pure sand is unknown, although Bozeman (pers. comm.) indicates that 20 to 30 feet is extreme. Faust also compared mesic hammock and sandhill for the amount of clay (4.7% versus 1.9%) and organic matter (2.5% versus 0.9%). These factors help create a sharp moisture gradient between these habitats and increase the fire probability on the sandhills.

The Cretaceous area is not completely sandy; it is sandy loam and coarse sandy loam. In the northern half of Stewart County, Sam Pickering reports excellent late Cretaceous fossil localities with oysters, shark's teeth, and the bones of the aquatic mosasaur, a dinosaurian reptile.

Some sandhills in Talbot County are 700 feet above sea level.

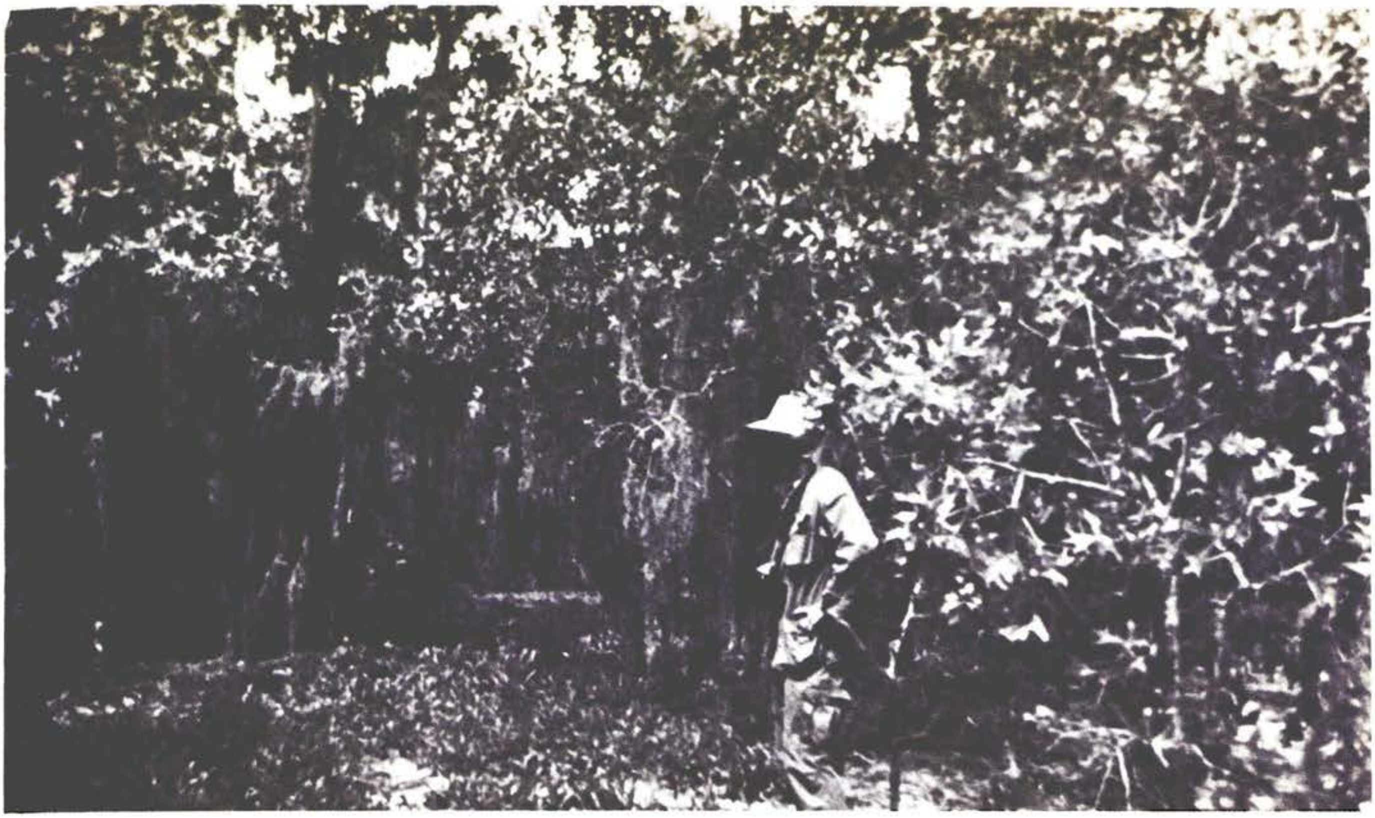


Photo A35. DWARF OAK FOREST [85], a sandhill community commonly called "longleaf pine-turkey oak." Most of the trees visible here are dwarf oaks called turkey oaks (*Quercus laevis*). The longleaf pine overstory has been removed but a young longleaf can be seen in the center of the photo.

**Flora**

Bozeman (1971) states that this association can be identified by two plants, the turkey oak and *Stipulicida setacea,* and also by *Galactia regularis, Bulbostylis ciliatifolia, Aristida purpurasens, Paronychia herniarioides,* and *Arenaria caroliniana* Additional characteristic species have limited geographical distributions.

A forest of this type on a 12-foot deep sand cap in the Tifton Plateau in Wilcox County had the following dominant plants:

**Trees:** Turkey oak, bluejack oak, dwarf post oak, longleaf pine.

**Herbs:** gopher apple (*Chrysobalanus oblongifolius*), (D) *Vaccinium* sp., (D) wiregrass (*Aristida*), (D) *Hypericum gentianoides,* (D) sticky foxglove (*Aureolaria pectinata*), sandhill lupine (*Lupinus villosus*), dog tongue (*Eriogonum tomentosum*), (D) sandhill milkweed (*Asclepias humistrata*).

In a more xeric portion of the Phillip's tract visited with John Bozeman, the following vegetation appeared most obvious:

**Trees:** longleaf pine, turkey oak, scrub post oak, bluejack oak.

**Shrubs:** haws (*Crataegus flava, C. uniflora*), winged sumac (*Rhus copallina*), poison sumac (*Rhus toxicodendron*), (D) sparkleberry, (D) deerberry (*Vaccinium stamineum*), blueberry (*Vaccinium tenellum*).

**Herbs:** Gopher apple, woody goldenrod *Chrysoma (Solidago) pauciflosculosa;* reindeer lichen (*Cladonia* sp.), sand spikemoss (*Selaginella arenicola*), wiregrass, broomgrass (*Andropogon* sp.), panic grass (*Panicum* sp.), fleabane (*Erigeron* sp.), dwarf dandelion (*Krigia virginica*), blazing star (*Liatris* sp.), tephrosia (*Tephrosia virginiana*), risky treadsoftly (*Cnidoscolus stimulosus*), adam's needle yucca (*Yucca filamentosa*), pineweed (*Hypericum gentianoides*), (D) sandhill milkweed, Carolina gromwell (*Lithospermum caroliniense*).

In the Cretaceous sandhills of Talbot and Taylor County one notices more senna (*Cassia* sp.), pennyroyal mint (*Pycnothymus rigidus*), and wild indigo (*Baptisia* sp.). The subcanopy is still dominated by turkey oak and bluejack oak with, seemingly, more hawthorn (*Crataegus* sp.) and persimmon. One plant that is endemic to the Fall Line Sand Hills is *Heterotheca pinifolia* according to Bozeman. At Iron Mine Bluff on the Ocmulgee, on a sandhill bluff on the Savannah River at Bear Island, and on the sandhills adjacent to Big Sandy Creek (Highway 29 Bridge, Wilkinson Co.), the devilwood (*Osmanthus*) is quite common. At Buckhorn Bluff (Altamaha River between U.S. 1 and 121) the vegetation was dominated by bluejack oak, sticky foxglöve, sandhill tephrosia, gopher apple, and *Rhynchosia reniformis*. In the sandhills along Big Sandy, in addition to devilwood, one sees dwarfed laurel oaks (*Quercus hemispherica*), buckthorn (*Bumelia lanuginosa*), sparkleberry, and Carolina holly (*Ilex ambigua*). There are also noticeable plants which appear in the Cretaceous dunes seasonally I do not have a list, but examples are the striking *Polygonella americana* with its white floral heads in July, and several species of blazing stars (*Liatris*) which bloom in early fall.

This is a fire-adapted community. It burns with a frequency interval of 5-10 years, John Bozeman (pers. comm.). Buildup of flammable material is slow and accumulates outward radially from each plant.

Some authors (Faust, lit. cited) and foresters suggest that turkey oak and the other "scrub" oaks have invaded and replaced the original longleaf pine forests destroyed by lumbering — the scrub oaks are preventing the re-establishment of the pine overstory, owing to root competition and diminished light.

Photo A36. Winter aspect of longleaf pine-turkey oak (DWARF OAK FOREST [85]) on sandhills near Whitewater Creek in Taylor County. The longleaf pines, though young, are conspicuous. This is one of Georgia's most ancient environments and supports a remarkable community of plants and animals adapted to the deep, arid sands.

#### Fauna

The dominant vertebrates are the gopher tortoise (*Gopherus polyphemus*) and the pocket gopher (*Geomys pinetis*), a mammal.

A map by Auffenberg and Franz (1975) indicates that the gopher tortoise is generally limited to the central portion of the Tifton Plateau, with a secondaryd concentration in the Fall Line sandhills of Marion and Taylor counties. Their densities appear greater on certain Plio-pleistocene deposits of the middle and lower Coastal Plain. Literature on fauna of the gopher tortoise burrow (photo A49) is covered by Douglas (1975). Young and Goff (1939) indicate that these burrows have preserved a Pleistocene association of animals living as commensals. The fauna is distinctive, only two species are shared with the pocked gopher Commensal arthropods confined to the burrows are: a pseudoscorpion (*Chelanops affinis*), a daddy longlegs (*Phalangodes* sp.), a tick (*Amblyomma tuberculatum*), a fly (*Septocerca* sp.), a staphylinid beetle (*Philonthus gopheri*), the scarabeid beetles *Copris gopheri, Onthophagus polyphemi* and *Aphodius troglodytes.* The beetle *Trichopteryx* sp. is abundant. The lycosid spider *Sosilaus spiniger,* the anthomyid fly *Pegyomya gopheri*, and the beetle *Aphodius geomysi* occur in pocket gopher burrows. The red-tailed skink (*Eumeces egregius*) inhabits pocket gopher mounds, Mount (1963). Other tortoise burrow commensals are the gopher frog (*Rana areolata*) and the gopher mouse (*Peromyscus floridanus*), the latter restricted to Florida. Many animals, such as the 6-lined racerunner, a lizard (*Cnemidophorus*), and cotton mice, take refuge in the burrows. Opossum and rabbit may use them for refuge while the foxes may enlarge them for dens. Numerous snakes, including the diamondback rattlesnake, black racer and cottonmouth, hibernate in gopher holes, as does the rare indigo snake found in extreme southern Georgia.

In the sandhills there are burrowing scarabeid beetles (*Geotrupes*) and hole-dwelling lycosid spiders. According to J. B. Gentry (pers. comm.), the following ants are dominant: *Crematogaster punctulata, Pheidole dentata, Solenopsis texana,* and the Florida harverter ant (*Pogonomyrmex badius*). In winter and early spring large grasshoppers (*Schistocerca* sp.) congregate in Cretaceous dunes. The old field mouse (*Peromyscus polionotus*) occurs in colonies. The principal small snake appears to be the crowned snake (*Tantilla*). The 6-lined racerunner is common, as is the fence swift (*Sceloporus*) in certain areas. In the sandhills along Highway 204, east of the Ogeechee River (Chatham Co.) where cypress ponds are common, the following vertebrates have been recorded: oak toad, smooth earth snake, coral snake, pine snake, copperhead, and the green, squirrel, pine woods and barking tree frogs, as well as the canebrake rattlesnake and copperhead. Jenkins and Provost (1963) discussed populations of large vertebrates on Cretaceous sandhills and other terrain.

The fauna needs further study. Areas of deep sands supporting scrub pine-sandhill communities in Florida have had time to evolve a separate species of lizard (*Sceloporus*) and a bird (jay), as well as possessing a remarkable legless skink.

Distribution — CP; habitat SX-X, Appendix VI.

#### Natural and Cultural Values

Walter Auffenberg (pers. comm.) and others indicate that this ecosystem may be one of the oldest that we have in the Southeast. Bozeman and others feel that Cretaceous dunes may have been the place of origin of this distinctive environment. The antiquity of this balanced assemblage of fire-adapted plants and animals weighs against the view of Faust and others stated above.

This sandhill community is utterly fascinating to many. The vegetation is relatively simple (not diverse); there are many lichens, and flowering plants are not infrequent. The fauna is largely burrowing and remarkably adapted to the arid, deep sands. The antiquity and rarity alone make it worth protecting; this may be the oldest extant environment in the Coastal Plain. In spite of the arid and inhospitable aspect (especially in midsummer), this community is picturesque, scenic, and of considerable educational value because of the severe conditions of life imposed by the sandiness, aridity, low nutrient availability, and fire which combine to produce a fascinating, adaptive biota. Adaptation to the deep sands and their temperatures is probably more important ecologically than the frequency of fire. The finest example I have seen are the sandhills between and east and west forks of Whitewater Creek, Highway 137 (Taylor Co.). A park here would also preserve the unique bay swamps with white cedar along Whitewater Creek.

Photo A37 Two years before this was one of Georgia's best examples of longleaf pine-turkey oak forest [85] near Junction City in Talbot County. In spite of the fact that these low nutrient, dry soils tend to grow pulpwood slowly, such massive modifications are widespread, especially in the **fall line sandhills** of Cretaceous age.

#### Man's Impact

Logging the longleaf and using gasoline to extract the reptiles (largely diamondback rattlesnakes) from gopher holes has played havoc with many communities, but a greater threat is the commercial pulp company which systematically destroys the original, ancient vegetation (and the thin veneer of organic soil) and plants slash pine. This modification is especially obvious in the old Cretaceous dunes of Talbot and Taylor County and from infra-red aerials of the Altamaha dune systems in McIntosh and Long counties. This environment is rapidly disappearing. Sandhill preserves are a necessity.

### [ 86] DWARF OAK-EVERGREEN SHRUB FOREST

#### Location and Description

This enchanting environment occurs on deep coarse sands. It is a striking habitat with rare evergreens, such as rosemary (often widely scattered), and evergreen woody mints with colorful blooms as dominant ground cover Fig. 31 This environment has been called "The Ohoopee Dunes." It occurs on curious dunes lying east of the Ohoopee River The uniqueness of these dunes was first noted from ERTS high altitude imagery. The dunes are of a parabolic shape and unlike any others in Georgia. Their long axis is east-west and they measure about 4-½ by 1-½ miles. Sam Pickering indicates that they are of aeolian (wind) origin, formed of riverine alluvial sand, and probably of late Pleistocene age. Similar dunes occur east of the Canoochee River Thom (1967) and Whitehead (1973) present geomorphic evidence for the formation of parabolic dunes by strong southwest winds during full-glacial times.

The best example is found on the sandhills lying east of the Ohoopee River near Cobbtown, north of Highway 152 (Tattnall Co.) near the Candler County line, Photo A38. There are probably other examples that can be located from the air Soils are similar to those in DWARF OAK FOREST Trees can be quite old at small diameters. One oak (4 inch diameter) was about 60 years old, another (6 inch diameter) approximately 138 years.

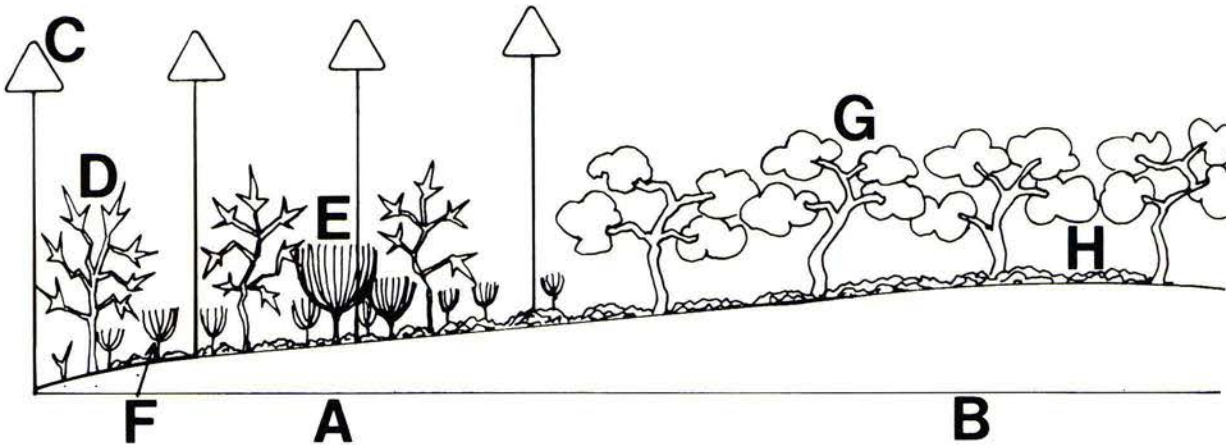



Fig. 31 Xeric environments on the Ohoopee dune sandhills. (A) dwarf oak-evergreen shrub forest, environment [86]: (B) evergreen scrub-lichen forest, environment [93]: (C) longleaf pine: (D) turkey oak; (E) rosemary (*Ceratiola*); (F) woody mint (*Calamintha*); (G) dwarfed live oak; (H) lichen ground cover


Photo A38. The famous "Ohoopee Dunes," here seen from an aerial view, were first thought to be unique sandhills by geologists looking at the 1974 band 5 Landsat satellite images. These dunes are elliptical structures up to five miles long occurring only on the east sides of the Ohoopee and Canoochee rivers. Thought to be of wind origin during the Pleistocene, they support several environments, such as variants of longleaf pine-turkey oak [86], dwarf and dwarfed oak communities [92] [93], and oak hammock [91] as well as cypress ponds [26], bay swamps [29], and shrub bogs [26]. Image courtesy S.M. Pickering, Geologic and Water Resources Division, Georgia Department of Natural Resources.

### Flora

This striking environment is identified by the following plants:

**Trees:** (D) turkey oak, longleaf pine.

**Shrubs:** Rosemary (*Ceratiola ericoides*), (D) red basil (a woody mint) (*Calamintha coccinea*), blue flowering woody mint (*Calamintha ashei*), shrub goldenrod (*Chrysoma pauciflosculosa*), jointweed (*Polygonella polygama*).

**Herbs:** sand spikemoss (*Selaginella arenicola*), nailwort (*Paronychia* sp.), sand chickweed (*Arenaria* sp.), *Balduina langustifolia*, and a lichen (commonly called British soldier).

Fire is frequent to infrequent. Hot fire appears to destroy some of the shrubs, especially rosemary. This environment apparently burns less frequently than the DWARF OAK FOREST

Photo A39. Sandhills on the east side of the Ohoopee River support a fascinating variation of the typical longleaf pine-turkey oak community. This variant [86] is identified by distinctive evergreen shrubs such as the dark green rosemary (*Ceratiola*) in the center, and a gound cover of several species of peculiar woody mints (*Calamintha*), with colorful blooms in red and purple. Gopher tortoise and old field mouse (*Peromyscus polionotus*) are common.

### Fauna

Distribution — CP; Habitat — SX with W, Appendix VI. The gopher turtle and old field mouse (*Peromyscus polionotus*) are particularly well-adapted to this environment, where there are suitable open spaces. See discussion under environment [ 85].

### Natural and Cultural Values

This is an exceptional habitat, and one badly in need of protection. The Ohoopee dunes appear to be among the best and largest of the riverine dune systems in the Tifton Upland. Rosemary is a rare and unusual shrub in Georgia. It is found from Tattnall as far north as Johnson County. The Beautiful red-flowing mint (*Calamintha coccinea*) has much the same range as rosemary, but the other woody mint (*Calamintha ashei*) is found only in Tattnall County.

To my mind this environment is one of Georgia's most exceptional, picturesque, and unique. Rosemary and woody mints are not only visually rewarding but olfactorily stimulating. The area has marked educational, scenic and scientific values.

### Man's Impact

Like other sandhills, the Ohoopee dunes are endangered by subdivision or random home building. The impact of pine monoculture is not known.

3. BROADLEAF EVERGREEN-NEEDLELEAF EVERGREEN FORESTS

## [ 87] LOWLAND MARITIME FOREST

### Location and Description

This forest appears as a luxuriant species-rich community, located in depressions and filled-in lowlands and drainage ways on coastal islands and in the maritime region bordered by the coastal marshes. Bozeman (1975) was the first to describe this environment and calls it the "lowland mixed hardwood forest community," and states that it represents "the most advanced successional stage on fresh-water aquatic sites." This forest is found on certain areas of Cumberland Island (Camden Co.).

Bozeman indicates that the dominance of evergreens in this forest type may be related to the lack of minerals in the drainage ways of the coastal islands.

#### Flora

**Trees:** (D) red bay, (D) loblolly bay, (D) sweet bay, (D) water oak, (D) red maple, (D) loblolly pine, (D) live oak, laurel oak, hackberry, black gum, cabbage palm, American elm.

**Shrubs:** fetterbush (*Lyonia lucida*), (D) wax myrtle, saw palmetto, bamboo cane (*Arundinaria tecta*), button bush.

**Herbs:** greenbrier (*Smilax laurifolia*), pepper vine, muscadine, lizard tail, beak rush (*Rhychospora decurrens*), cinnamon fern, chain fern (*Woodwardia virginica*), water pimpernel (*Samolus parvifloris*).

The presence of many species here tolerant of an elevated water table is diagnostic. Some species (live oak, red bay, cabbage palm are markedly maritime in their distribution patterns.

This environment shares a number of species (black gum, sugarberry, sweet bay, loblolly bay, water oak, red maple, elm, lizard's tail, and chain fern) with inland fresh water floodplain environments.

#### Natural and Cultural Values

This forest is of botanical and zoological interest — so few examples have been described.

Cultural values are largely those of the upland maritime forests.

#### Man's Impact

Chiefly logging and the grazing and browsing of livestock, and the rooting of swine.

## [ 88] MARITIME STRAND FOREST

#### Location and Description

This forest is found on coastal islands (usually on the marsh or inland side) and low areas adjacent to salt marshes on the mainland. Cabbage palms and red cedars are distinctive. A ground cover of dead palm fronds is occasionally found. Bozeman (1975), the first to describe this community in Georgia, calls it an "oak-juniper-palm forest community." It is largely a zonal strip just inland of the salt marsh, although it may cover small islands in the salt marsh. The community dominates large areas of the Cedar Key islands in Levy County, Florida; the cedars there at one time provided Faber Pencil Company with abundant wood for pencils and supported entire communities until exhausted. Indian kitchen middens of marine shells are frequent in this habitat. The herbaceous cover is limited, if present at all.

The water table may be high at high tide. Excess calcium in the soils, derived from shells, may be utilized by the calcium-loving red cedar.

#### Flora

**Trees:** (D) live oak, red cedar, cabbage palm (*Sabal palmetto*).

**Shrubs:** wax myrtle, yaupon (*Ilex vomitoria*), Florida privet (*Forestiera porulosa*), saw palmetto.

Laessle (pers. comm.) in Florida calls this a "hydrophytic coastal hammock." In Florida it is a distinctive coastal strip in the Gulf Hammock sector, which is usually dry for three months and has several feet of water on it at other periods, and which Wharton *et al* (1976) call "hydric hammock," considering it a wetland. It is distinguished from floodplain forest by being on non-alluvial soils and being inundated by local rainwater. The community is fire prone but not easily damaged by fire.

#### Fauna

Distribution — CP; Habitat — an impoverished X but used by salt marsh carnivores, such as mink and raccoon, as refuge. It sometimes provides a nesting area for wading birds. Normally, it is too dry and intermittently saline for a diverse fauna.

#### Natural and Cultural Values

This forest is protective, preventing erosion by high spring or flood tides. It also acts as a wind barrier. In Florida's coastal zone, it impedes rapid run-off of rainwater from storms, Wharton *et al* (1976). It is botanically unique and the fauna is poorly known. Some rare plants whose seeds wash ashore may be found here or at the strand edge. Historically, Indian middens are often located here. The presence of palm and cedar make this a unique scenic adjunct to coastal ecosystems.

#### Man's Impact

The cutting of cedar for pencils or other uses, and the cutting of palms for their edible "heart" are two destructive influences. Agriculture may have encroached on this community in the past. The large "hydric hammocks" of Florida's Gulf Coast are being bulldozed and planted to pine.

# [ 89] UPLAND MARITIME FOREST

## Location and Description

This is the evergreen-oak dominated climax forest of the coastal islands and higher zones back from the coastal salt marshes. Bozeman (1975) refers to it as the "mixed oak-hardwood forest community" and states that it "represents the most advanced successional stage of forest on upland soils." Much of the interior of the coastal islands falls in this category. Bozeman (ibid.) states that it occurs predominantly on Chipley soils. The oaks are gnarled and twisted with small, dark green leaves. They are often draped with spanish "moss" (*Tillandsia usneoides*), a non-parasitic bromeliad.

Photo A40. The UPLAND MARITIME FORESTS [89] is dominated by the picturesque, gnarled live and laurel oaks, often draped with Spanish "moss," a bromeliad (*Tillandsia usneoides*). Considered to be the end result of plant succession, these forests clothe much of Georgia's coastal islands. Fields on Cumberland once grew cotton and indigo where these young oaks and slash pines are now growing.

## Flora

**Trees:** (D) live oak, (D) laurel oak, American holly, southern magnolia, red bay (*Persea borbonia*), southern red cedar (*Juniperus silicicola*), water oak, pignut hickory, cabbage palm, slash pine.

**Shrubs:** staggerbush (*Lyonia ferruginea*), wild olive, wax myrtle, sparkleberry.

**Herbs:** panic grass (*Panicum* sp.), spike grass (*Uniola sessiliflora*), broomsedge, nut grass (*Cyperus* sp.), thoroughwort (*Eupatorium aromaticum*), nut rush (*Scleria triglomorata*), black oat grass (*Stipa avenacea*).

Bozeman (ibid) feels that these forests have not burned for decades. Live oak leaves are poor tinder On parts of the island where saw palmetto and other growth is dense, fire is more frequent.

Bozeman (1975) indicates that this community may be the end result of succession on Chipley-Lakeland soils, and that the area may pass through either pine-oak or oak-pine stages. He suggests that the pines originally ocurring in this forest or in other pre-climax forests may either be removed by logging or died sooner (l00-200 years) than the long-lived live oaks (400-600 years). On the Holocene islands of Wassaw, Little Cumberland, and Blackbeard, large slash pines are still common where selective logging has been restricted. They are considered the second most important trees in the maritime forest, Bozeman (1971). Bozeman (1975) interprets the mature forests of Cumberland Island as subtropical in nature, citing as evidence their dominance by broadleaf evergreens and their floristic affinities with tropical forests. He feels that these evergreen forests develop on dry-sterile sandy soils protected from fire and correspond to Monk's (1968) xeric phase of the southern mixed hardwoods of northern Florida.

Davenport and Brower (1974) studied a successional forest of 150 acres on Wormsloe Plantation on the Isle of Hope, Chatham County. The trees had been selectively cut. The ratio of hardwoods to pines was 2:1, and while importance values did not change between 1964-1973, stem counts indicated successful reproduction for hardwoods and none for pines, and basal area increases were greater for hardwoods. The dominant hardwoods were water oak, live oak, southern red oak, and sweet gum, with laurel oak, black gum, and southern magnolia sub-dominant. Slash was the dominant pine with loblolly and longleaf as co-dominants.

## Fauna

Leslie Davenport (pers. comm.) has trapped and observed the Wormsloe forest area. He reports the following fauna: broadhead skink (*Eumeces laticeps*), black racer, copperhead and diamondback rattlesnake, opossum, mole, short-tailed shrew, grey squirrel, deer, and flying squirrel. He took no mice. The mink, marsh rabbit, raccoon, and rice rat were ecotonal (edge) species adjacent to the salt marsh. Fox squirrels were only occasional. One wood rat (*Neotoma*) is probably also an ecotonal species. Distribution — CP; Habitat — a reduced X, Appendix VI.

## Natural and Curtural Values

This community provides shade, microclimate, food for animals and birds, protects the soil, and increases the organic content. It probably aids in preventing rapid run-off of rains.

These forests are of scenic and recreational value, ideal for parks, and trails, wildlife refuges, and wilderness areas. Many scientific studies on depauperate, introduced and waif fauna can be conducted. The ecology of our coastal islands is largely unknown.

## Man's Impact

The major impact has been by agriculture first, and logging second. On coastal islands the introduction of cattle, horses, and swine has had an undetermined influence on this forest. Much of the acorn mast is destroyed by the hogs. The normal fauna (such as rodents and turkeys) is curtailed to an unknown degree. Many attempts to introduce exotic birds and mammals have failed. Some, such as the chachalaca and fallow deer, have been successful.

4. BROADLEAF EVERGREEN FOREST

a. INLAND BROADLEAF EVERGREEN FORESTS

## Introduction

These forests are characterized by a higher water table brought about by proximity to surrounding flatwoods, cypress swamp or permanent fresh water, or by excessive ground water emerging on top of a resistant soil layer (seepage type). These forests normally do not burn, and a litter layer is usually present. The water table is usually high and species (water oak, cabbage palm) which prefer, or are tolerant of, this condition are usually present. A hammock is usually thought of as a hardwood forest, surrounded by lower terrain, such as pine flatwoods, or adjacent to coastal marshes.

According to Faircloth (pers. comm.), if Dudley's Hammock had live oak as dominant instead of water oak, along with cabbage palms, it would closely resemble hammocks in the Floridian flatwoods.

The "hydric hammock" as defined by Wharton *et al* (1976) for Florida is perhaps most comparable to [88] MARITIME STRAND FOREST in Georgia, considering tree composition, but if water table heights are considered, Florida's hydric hammocks are more comparable to Georgia's [90] LOWLAND BROADLEAF EVERGREEN FOREST (especially those in lower Chatham Co.). In these forests near Savannah, water and willow oaks are the dominant trees, and this environment could be called **hydric hammock**, but further study is needed.

# [ 90] LOWLAND BROADLEAF EVERGREEN FOREST

## Location and Description

This type is located on slightly higher ground surrounded by pine flatwoods or interconnected cypress ponds as in the Grand Bay region, Fig. 32, or on low flat areas adjacent to small streams in Chatham county.

An example is Dudley's Hammock in the Grand Bay section of Lowndes County, pictured by Meanley (1972). Kaiser Hammock on Highway 21 and other lowland forests in Chatham County are also examples. The forest has a sub-tropical luxuriance.

The water table is high. Soils have considerable organic matter and are desirable for agriculture.

## Flora (Dudley's Hammock)

**Trees:** (D) water oak, live oak, laurel oak, southern magnolia, pignut hickory, white oak, American holly, spruce pine (*Pinus glabra*).

**Shrubs:** (D) saw palmetto, (D) rusty black haw (*Lyonia ferruginea*), sparkleberry, wild olive, swamp palm (*Sabal minor*), (D) Elliott blueberry (*Vaccinium elliottii*), (D) downy blueberry (*Vaccinium atrococcum*), needlepalm (*Rhapidophyllum*).

**Herbs:** green fly orchid (*Epidendrum conopseum*), true wintergreen (*Gaultheria*).

Around Savannah there are extensive, very mesic hammocks. Some appear intermediate between higher portions of floodplains and more xeric upland forests. In "Kaiser Hammock" the dominant vegetation was willow oak, sweet gum, red bay, southern magnolia, Virginia willow (*Itea*), and cinnamon fern. It appears that these forests are approaching the composition of higher terrace forests of the floodplain.

## Fauna

Distribution — CP; habitat probably a mixture of forms from X with elements of N intruding peripherally, Appendix VI.

Photo A41 Dudley's Hammock in Lowndes County has an almost subtropical luxuriance. Most of these low oak-dominated hammock forests [90] were destroyed by agricultural efforts, and only a few examples remain. The environment is so moist that the arboreal green fly orchid (*Epidendrum conopseum*) occurs (it seldom lives after removal).

**Natural and Cultural Values**

The botany and zoology of this community is poorly known, probably because there are so few samples remaining. Usually they are very humid, with arboreal orchids common. An interesting description of Dudley's Hammock is to be found in Meanley (1972).

This is an exotic, almost subtropical environment, esthetically pleasing and of considerable educational and scientific value. The curious hydric hammocks near Savannah need further study. The wetland nature of the Chatham County hammocks has saved some of them from destruction.

**Man's Impact**

Most of these "islands" of higher ground were quickly converted into agriculture by the early settlers. Dudley's Hammock survived probably because it is ringed by cypress ponds. Only isolation by surrounding wetlands and small size have saved samples of this environment.

## [91] UPLAND BROADLEAF EVERGREEN FOREST

**Location and Description**

This forest is found scattered in the Pleistocene and Tifton Plateau, on the Tallahassee Hills, and covering the lower half of the limesink region (approximate range of the live oak), and originally in the Valdosta limesink region. It may occur on sandy hills in the Pleistocene (or pine flatwoods area); on high, broad flat-topped sandy hills of Pleistocene terraces; on broad level plains in the limesink region; around depressions, lakes, and limesinks: sometimes in shallow depressions; on some sandhills lying east of rivers (riverine sandhills); on Pleistocene relict dunes along ancient shore lines, and on deep sand ridges in the floodplains of the larger rivers.

These forests are dominated by an evergreen oak canopy. Laessle and Monk (1961) indicate that with elimination of fire, succession in **longleaf pine lowlands** may terminate in a forest dominated by live oak whose sclerophyllous (thick) leaves indicate adaptation to this more xeric habitat of the Pleistocene flatwoods. This forest was stated by Monk (1968) to be the drier, more sterile, portion of the southern mixed hardwoods. This forest is classified by Bozeman (1971) as a laurel oak-wild olive association under his laurel-live oak alliance.

Examples are: extensive forests in the southern half of Mitchell County; broad sandy hills type, Waycross (Ware Co.); lakeshore area of Grassy Pond 12 miles south of Valdosta, Lochloral Road (Lowndes Co.); riverine sandhills, Phillip's Tract (Tattnall Co.), Big Toolhouse Ridge (Long Co.), and Cooter Ridge, Boyle's Island (Wayne Co.), Altamaha floodplain. Bozeman (pers. comm.) reports extensive live oak-laurel oak hammocks along the Ohoopee River

Soils are drier and more sterile (Monk, 1968) than those supporting **lowland broadleaf evergreen** or **broadleaf deciduous-broadleaf evergreen forests.** Monk (1965) recorded that when evergreen trees were dominant, calcium, potassium, phosphorus, and moisture equivalent were low. He interpreted this to be a conservation mechanism where a more closed mineral cycle could be established. Bozeman (1964) considers that this community develops on Paola (Lakewood) coarse sand, possibly also on Galestown fine sand with a B horizon. Depths down to the water table range from 6-20 feet, and leaf litter is present. Because it grows under such a wide range of soil conditions, the factors controlling distribution of evergreen oak forest seem yet to be learned. In the limesink region, in western Mitchell County, the soils are either Norfolk sand or Norfolk sandy loam, USDA (1922).

Photo A42. Evergreen oak forest [91] caps Cooter Ridge on Boyle's Island in the Altamaha floodplain of Wayne County. These ridges apparently are high points in ancient dune systems, now surrounded and isolated by river swamp. They lend a pleasing variety to floodplains and serve as important high water refuges, and provide food and dens. Armadillos, surprisingly, are quite common here.

### Flora

**Trees:** (D) live oak, (D) laurel oak, pignut hickory; American holly, southern magnolia, spruce pine.

**Shrubs:** (D) wild olive, (D) sparkleberry, witch hazel, saw palmetto (*Serenoa repens*), fringe tree, horse sugar coastal chinquapin (*Castanea ashei*), (D) red bay, dwarf paw paw.

**Herbs:** resurrection fern, patridgeberry (*Mitchella repens*).

Fire is less frequent and intense than in more xeric environments and more frequent than in more mesic environments. Without fire, this environment adds species characteristic of mesic forests (magnolia, holly, pignut hickory). With fire to prevent encroachment of other mesic species, the forest changes to a pure live oak forest or a pure live oak-laurel oak forest. Once broadleaf evergreens reach a diameter of about five inches, fire is inhibited and they are not as easily damaged, Ed Komarek (pers. comm.).

Live oak grows rapidly, Clewell (1971), and does not seed under itself (Laessle, pers. comm.). A variant of this forest was observed on Big Tool House Ridge on the Altamaha floodplain (Long Co.) where live and laurel oak formed the dominant canopy, with some beech, holly, and southern magnolia present. Red bay dominated the understory and the major shrubs were French mulberry (*Callicarpa*) and sparkleberry.

It is postulated that the long-lived live oaks and laurel oaks simply outlive the other components of the forest and, with the help of man (fire and pasturage), the open grove aspect is maintained — a scene which greeted Bartram at the Great Alachua Sink and in other areas on his epic journey in 1774-1775. Laessle and Monk (1961) state that most of the inland live oak hammocks they studied in Florida were on slightly higher portions of pine flatwoods, and that the general sequence of succession is scrubby flatwoods - live oak hammock - mesic hammock, and that live oak stands "represent an extended sub-climax maintained through burning and longevity of the species." Once established, an evergreen oak hammock is difficult to destroy by fire, Monk (1960). By their position in the classification, I have indicated that the **Broadleaf Evergreen Forests** are more xeric than the **Broadleaf Deciduous-Broadleaf Evergreen Forests.** Monk (1968) recognizes this as a continuum between wet and dry extremes, "The dry sterile portion of the southern mixed hardwood environmental gradient is dominated by evergreens, whereas the mesic and wet portions are dominated by deciduous species."

A good example of this forest type with large surviving live and laurel oaks occurs at Grassy Pond (Lowndes Co.). According to Faircloth (pers. comm.), this was originally an oak-hickory forest, but the hickories and other components have died. The mature oaks appear to be reasonably fire-tolerant; the seedlings, however, are not. Infrequent fires, therefore, keep the ground relatively open. Some red bay does occur in the understory at Grassy Pond.

An interesting account is given by Stoddard (1955) of many magnificent live oaks in northern Florida and SW Georgia destroyed by several feet of water held for over one year following 27 inches of rain in the spring of 1948 which flooded a 50-county area of SW Georgia.

This is the typical "hammock" as defined by Harper (1905) and others. Laessle (1942) refers to the drier types which support more fire and have a dominance of live oak as "xeric hammocks." Harper (1911) was one of the first to define this type hammock as climax vegetation on deep sandy soils, with mild dry winters and wet summers. By observing that these hammock forests were the dominant vegetation on islands and peninsulas, he ascertained that they were due to the absence or near absence of fire.

The most extensive remaining evergreen oak hammocks that I have seen are in southern Mitchell County, especially near the Flint River. Evergreen oak forests may have dominated large areas of the Valdosta limesink region; groves of scattered trees are still visible. Dominant shrubs beneath a near-original Mitchell County remnant of live oak hammock in low terrain (higher ground in cultivation) proved to be persimmon, Walter's viburnum (*Viburnum obovatum*) and cockspur haw (*Crataegus crus-galli*).

Photo A43. In southern Mitchell County (Highway 112) vestiges of the original evergreen oak forest [91] can be seen. Almost all of the land in the Limesink Region is in agriculture. Most remaining examples exist on the larger landholdings, but abundant sub-surface water and rising food prices may spell the end of most forests in this area.

Bozeman (1971) describes an interesting related plant community which he calls the Laurel Oak-Wild Olive Association, characterized by the laurel oak, wild olive (*Osmanthus americanus*), southern magnolia and dwarf paw paw (*Asimina parviflora*). This association occurs "as a marginal strand on slopes of sand ridges between the turkey oak association and a swamp or bay forest " Bozeman (1971). A good example of this association occurs on the northwest side of Big Sandy Creek at the Highway 441 bridge (Wilkinson Co.) immediately adjacent to the swamp.

### Fauna

Noted for coral snakes and other burrowers. Gerald Williamson (pers. comm.) indicates that the fauna is limited compared to other environments. The following species are dominant: marbled salamander, red-spotted newt, king snake, scarlet kingsnake, black rat snake, corn snake, garter snake, hognose snake, copperhead, and canebrake rattlesnake.

Distribution — CP· Habitat — X, with some elements of SX, Appendix VI.

### Natural and Cultural Values

The precise nature of this biotic community is poorly known. It does, however, prevent erosion and builds an organic horizon. A burrowing fauna (with such notable members as the coral snake and scarlet kingsnake) is present.

The park-like aspect of the old growth forest is quite scenic, and ideal for parks, trails and, unfortunately, for residences also. The wildlife-feeding capacity of these acorn-producing forests is considerable.

### Man's Impact

Logging is destructive. Ringing the old oaks (or bulldozing them) is common to create pasture or pineland. In fact, most of the original evergreen oak forests in the limesink region have been eliminated. Apparently, larger land-holdings and plantations have preserved the best remaining examples in SW Georgia. This terrain makes ideal housing development and pasture, and agriculture is possible in some areas.

b. EVERGREEN SCRUB FORESTS

## [92] EVERGREEN SCRUB FOREST

### Location and Description

A dwarf forest of largely evergreen shrubs and dwarf (scrub) oaks on sandhills, Photo A44. It is classed by Bozeman (1971) as a myrtle oak-chapman oak (scrub oak) association. Harper (1906) spoke of the lack of shade and the conspicuous adaptation for reducing transpiration, such as thick, small leaves. Another similar category cited by Harper is the "sand hammock." This forest appears on sandhill terrain slightly drier than that supporting laurel oak-live oak forest. Inland it is essentially a scrub oak-evergreen shrub community generally always being invaded by members of the broadleaf evergreen forest. It resembles the **dune oak scrub** of the back dune of certain coastal areas, especially along Florida's Gulf Coast, except that it may burn less frequently and it is not wind-pruned.

Photo A44. EVERGREEN SCRUB FOREST [92] on the Phillips Tract (Tattnall Co.), a shrub community dominated by myrtle oak (*Quercus myrtifolia*) and heath plants such as the blueberries, and harboring the rare Georgia plume (*Elliottia*). This community is transitional to evergreen hammock [91] (**Broadleaf Evergreen Forest**).

According to Bozeman (pers. comm.), this is a successional type to hammock (**Broadleaf Evergreen Forest**) and, given enough time, will evolve to it. Laessle (1958) compared Florida scrub environments (fire infrequent, about one human generation) with sandhill environment (**sand ridge type**) which burns regularly. He indicated that scrub would change into broadleaf evergreen hammock, the climax forest. Portions of the Phillip's tract (Tattnall Co.) provide examples.

### Flora

Bozeman (1971) determined that the Myrtle oak-Chapman oak Association is characterized by, in addition to the two oaks, *Lyonia ferruginea* and a beaked rush *Rhynchospora megalocarpa* He indicates that this association frequently occurs in transition zones between turkey oak dominated areas and the Laurel Oak-Wild Olive Association.

### Phillip's Tract:

**Trees:** scrubby post oak, live oak, southern magnolia (scattered), mockernut hickory (*Carya tomentosa*).

**Shrubs:** (D) myrtle oak, (D) deerberry (*Vaccinium stamineum*), wild olive, (D) Georgia plume (*Elliottia racemosa*), (D) sparkleberry, highbush blueberry (*V corymbosum*), downy blueberry (*V atrococcum*), horse sugar (*Symplocus*), saw palmetto.

**Herbs:** beak rush (*Rynchospera megalocarpa*), reindeer lichen (*Cladonia* sp.), sand spikemoss (*Selaginella arenicola*).

Fire is infrequent (30-40 years), Bozeman (pers. comm.). The infrequency of fire allows the encroachment of species of the **Broadleaf Evergreen Forest.** While common in central Florida, this environment appears rare in Georgia. It is being rather rapidly destroyed by housing developments, some agriculture, and the planting of commercial pine species by pulp companies.

### Fauna

The fauna is fire-adapted and possibly fire dependent, with burrowing forms among reptiles and mammals.

Distribution — CP· Habitat — largely intermediate between SX and X, Appendix VI.

### Natural and Cultural Values

The botanical vistas are exciting. The fauna is largely burrowing. It is a source of food and cover for wildlife, and protection for the land, augmenting fertility The presence of rare plants, such as the Georgia plume (*Elliottia*), makes areas of this environment essential to protect.

This forest has important scenic, educational and scientific value, especially because of its scarcity. Scrub-dominated communities appear to be among the rarest in our Coastal Plain.

### Man's Impact

See remarks above.

## [93] EVERGREEN SCRUB-LICHEN FOREST

### Location and Description

This environment is found in areas as small as several acres in the sandhills east of rivers such as the Ohoopee. It is a remarkable fairyland of lichens with scattered clumps of dwarfed oaks, Fig. 31 A beautiful example is found between the I-16 bridge over U.S. 1 and the junction of Ga. Highway 46 with U.S. 1 (Emanual Co.) in the southeast quadrant, immediately south of a fine example of a bay swamp. It is found on coarse sands (Kershaw to Kureb; Bozeman, pers. comm.).

Photo A45. This intriguing elfin forest of dwarfed live oaks has a remarkable ground cover of lichens of several distinctive species. This environment [93] occupies zones, often several acres in extent, surrounded by typical longleaf pine-turkey oak [86] on the deep sand dunes lying along the east side of Coastal Plain rivers, such as the Ohoopee, Canoochee, and Ogeechee.

### Flora

**Trees:** (D) dwarfed live oak (*Quercus maritima*), dwarfed laurel oak, dwarfed red bay (*Persea borbonia*).
**Shrubs:** sparkleberry.
**Herbs:** Three dominant species of foliose lichens (*Cladonia* spp.) (one resembles a white sponge), woody goldenrod (*Solidago pauciflosculosa*), sand spikemoss (*Selaginella arenicola*), *Polygonella* spp.

### Fauna

Distribution — CP; Habitat — SX, Appendix VI. The fauna is unknown, probably only the most xeric-tolerant invertebrates and lizards are present.

### Natural and Cultural Values

The dwarfed live oaks are naturally bonsaied into twisted and weird shapes. They appear quite old. One 2.5 inch example had been growing about 136 years.

The abundance of ground lichens, spike moss, and moss in mats, carpets, and tussocks makes this a fascinating habitat. While of tremendous educational, scenic and scientific value, this environment is limited to small scattered areas in deep dune sands and is **very fragile**. A few careless individuals could destroy the work of decades by disturbing the lichens. Boardwalks would be an absolute necessity here. Unless they could be rigidly protected, these areas should be used chiefly in education and science.

### Man's Impact

Highways, homesites, clearing, reforestation, wheeled vehicles, and heavy foot traffic will destroy this environment.

5. NEEDLELEAF EVERGREEN FORESTS

### Introduction

These forests are either known as "pine flatwoods," usually with a shrub understory, or "longleaf pine-wiregrass" uplands lacking a prominent shrub understory. Fire plays an important role in these forests — they are considered as sub-climax or fire climax forests — if fire is kept out, they will revert in time to either lowland or upland hardwood forest. Fire has played a role in these forests so long that many of the plants (and animals) are fire-adapted; some also inhabit similar communities in xeric **broadleaf evergreen forests**. One of the blazing stars (*Liatris* sp.), which has underground corms with annual rings, is an example of a plant which is adapted to this environment. Other plants have huge, starchy underground roots, or hard seeds that endure for many years without germinating.

Natural lightning-caused fires formerly burned this environment in summer, prior to man's advent — controlled burning as a management tool is now widely used to prevent the successional stages (from shrubs to mesic hardwood forest) from occurring. This controlled burning is usually done in the winter and must be done at least every three years. Even yearly fires will not exclude the fire-tolerant saw palmetto and some other fire-adapted shrub species which can apparently be removed only by bulldozing.

Ploughing for agriculture also causes marked changes. On Springhill Plantation (Grady Co.) red clays are close to the surface, and in the event of ploughing up the wiregrass and logging out the longleaf pine, loblolly and shortleaf pines form the new canopy following typical old field succession. Once wiregrass turf is destroyed, wiregrass never returns. Even small pea patches planted for game birds are drastically changed and become an entirely different community. Conversely, if wiregrass is present, the area probably was never in agriculture.

Longleaf pine is markedly fire-adapted and fire-tolerant. Slash pine is not. Consequently, slash pine grows in flatwoods that burn less frequently (giving the seedlings time to reach a more fire-resistant stage).

a. MESIC PINE LOWLANDS

## [94] MESIC PINE LOWLAND FOREST (PINE FLATWOODS)

### Location and Description

This forest is largely confined to the Pleistocene of the lower Coastal Plain — the flat, former sea floor is level, and highways appear arrow straight. The transition from Tifton Plateau to Pleistocene can be noted a few miles south of Hazelhurst (Highway 341, Jeff Davis Co.). The aspect is one of a monotonous pineland with a heavy shrub ground cover — including much saw palmetto and ericaceous (heath) plants. Monk (1968) recognized three phases in Florida, two of them, longleaf (drier sites) and slash (wetter sites) Figure 32, occurring on soils more alkaline than pH 4.5, with pond pine on more acid, poorly drained soils. John Bozeman (pers. comm.) recognizes these three types in Georgia, but indicates that pond pine is uncommon except on Leon soils. He states that pond pine has been extensively logged out and replaced by slash pine with accompanying changes in the use of fire or fire prevention.

Faircloth (pers. comm.) regards the three phases as one large type, and states that he finds that longleaf pine generally occupies the long, gentle slopes of terrain; that slash pine is the most common of the three, and that most cypress ponds occur in the slash pine phase. Faircloth (1971) indicates that the conspicuous shrub stratum of ericaceous plants, such as the gallberry, is characteristic of the organic-rich flatwoods, while the poorer pine uplands tend to have wiregrass instead. Longleaf pine did not occur extensively and still occurs sporadically in the pine flatwoods. According to Faircloth, only one foot elevation may make the difference between longleaf and slash in the original forest — now, of course, the large companies are promoting slash everywhere.

Slash pine dominates perhaps 90% of the Pleistocene pine flatwoods. The best examples of longleaf pine flatwoods I have seen are along Highway 121 between Folkston and St. George (Charleton Co.) and along Highway 94, 6½ miles E of its junction with U.S. 441 at Fargo (Clinch Co.).

Flatwood sands are often underlain with an organic hardpan 18 to 24 inches beneath the surface. Where present, this structure causes surface soils to be saturated during wet seasons and quite dry during dry seasons. This forest occurs primarily on ground-water podzols of Leon, Bladen and Coxville soils (Walker and Perkins, 1958). According to Bozeman (1964), low pineland on the Pamlico terrace north of the Altamaha sand ridge occurs on the Bladen-Coxville fine sandy loams, whereas Leon soils are more prevalent south of the Altamaha drainage system.

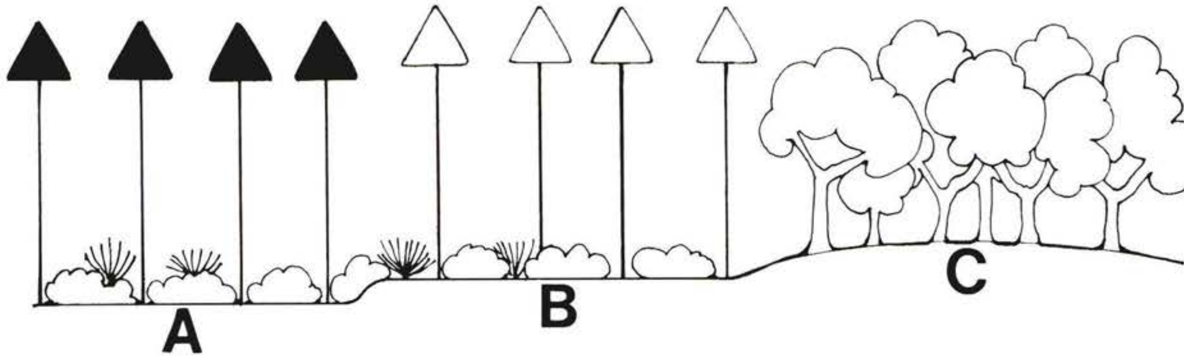



Fig. 32. Environments in the Pleistocene or pine flatwoods: (A) slash pine with gallberry-saw palmetto understory [94]; (B) longleaf pine [94] on slightly higher (12-14") level; (C) lowland hardwood hammock [90] on still slightly higher level.

Photo A46. Much of the Pleistocene region is a flat sea floor now covered with a slash pine dominated commercial forest, commonly called "pine flatwoods" [94]. The undergrowth is typically heath shrubs, such as gallberry, which produces an excellent honey, and the trunkless ground palm called saw-palmetto (*Serenoa repens*).

### Flora

The drier type has the following vegetation:

**Trees:** Longleaf Pine.

**Shrubs:** (D) gallberry, (D) saw palmetto, dwarf oaks (*Quercus minima*), *Quercus pumila,* poor grub (*Lyonia ferruginia*), blueberries (*Vaccinium* sp.), (D) buckberries (*Gaylussachia* sp.)

**Herbs:** Lilies, such as Atamasco, *Zephyranthes* (early spring); *Sabatia* spp. (mid-summer); *Compositae* (fall).

The wetter type has the following:

**Trees:** slash pine or pond pine.

**Shrubs:** wicky (*Kalmia hirsuta*), (D) wax myrtle, (D) wiregrass, and dwarf blueberry (*Vaccinium mercinites*) (a tiny-leaved variety).

Wells (1928) points out the historical fact that formerly slash pine was not prominent in the southern half of North Carolina's Coastal Plain, and that it colonized this area with the destruction of the longleaf pine. He stated that it cannot tolerate as long a hydroperiod as loblolly, but he thought the total range of tolerance was probably as great — "it can grow on 'crayfish land' as well as on perfectly drained coarse sand ridges."

Natural fire is frequent, on an average of 3-5 years. Fire prevents the establishment of hardwoods. These areas burn largely in late summer from natural or man-caused ignition.

### Fauna

In slash pine flatwoods of Bryan County the following reptiles are recorded: kingsnake, corn snake, rat snake, southern hognose, coachwhip, pine snake, copperhead, pygmy and diamondback rattlesnake. Earth snakes of the genus *Haldea* are known from this environment, as is the rare pine woods snake (*Rhadinaea flavilata*). Distribution is CP, habitat SH in the wetter portions, and SX in the drier, Appendix VI.

### Natural and Cultural Values

This is a relatively common environment which probably resembles the original forest cover closely, except for the presence now of more fast-growing slash pine instead of slow-growing longleaf pine on the drier sites. It has probably burned regularly for thousands of years (perhaps 5,000-10,000), either from lightning-caused or man-set fires. It was a gameland for wide-ranging herbivores, such as the bison, until about 1750. It is quite likely that the mammoths and the mastodons foraged on saw palmetto and other growth of the flatwoods before their extinction between 15,000 and 10,000 years ago. Mineral cycling in this habitat is largely unknown. Despite its uniformity of appearance, the flatwoods (and associated cypress and gum ponds, cypress savannah) support a surprisingly abundant fauna, much of it burrowing and fire-adapted. Grasses provide grazing and build organic soil.

This environment is largely suitable for hunting, especially deer and quail. In company with cypress ponds, it provides nesting and feeding grounds for a variety of birds. Old pine forests are esthetically pleasing. It is probable that the name "savannah" was derived from the former extent of this forest. It is generally thought that the old growth pine can be removed with little effect on the other vegetation.

### Man's Impact

This is the dominant community on the Pleistocene sea floor area of the lower Coastal Plain. The pines have been turpentined and used for lumber and pulpwood. The "yellow pine" of the historical reports was the great longleaf pine of the lowlands and uplands that was rafted down the Altamaha and its tributaries to make Darien the greatest lumber port in eastern America. Owing to the fluctuating water table, perhaps, this area has escaped the destructive impact of agriculture. Large industries tree farm this environment, first bulldozing the shrubs and saw palmettos (the latter with giant underground rhizomes) into rows and then replanting with slash pine, since longleaf grows much more slowly. Before the stock laws were passed, hogs ("piney wood rooters") and cattle ranged freely through this extensive environment. Some plants, such as deer tongue (*Trilisa odoratissima*), which is mixed with tobacco in the manufacture of cigarettes, are still collected and dried for sale, for example, at Mayday, east of Valdosta. As stated elsewhere, the breaking of the wiregrass sod allows a different ground community to develop on the drier flatwoods.

The honey yield from the extensive gallberries and other heath plants is one of the commercial products of the pine flatwoods.

b. SUBMESIC PINE UPLANDS

## [95] LONGLEAF PINE UPLAND FOREST

### Location and Description

This environment is the typical "longleaf pine-wiregrass" community, Photo A47. It is frequent on the Tifton Upland and the Tallahassee Hills. Without fire, it would revert to upland hardwood. This is the intermediate pine barren of Harper (1906) and Plummer (1963). Plummer's (1975) survey of old records suggests 7% of Tift County was in pines. Pine trees were widely spaced (30-50 ft.), so that 25% of the corners had to be marked with stakes. This author also concluded that the pine forests in Dougherty County occurred on fine, loamy, silicaceous soils, while the oak-pine-sweet gum forests occupied the clayey, kaolinitic soils "particularly from the Ocala limestone formation." Upland pine forests were said to have occurred over 17,000 square miles.

Photo A47 Virgin longleaf pine (age 200-250 years). A tree of this age has a circumference of about 78 inches, Greenwood Plantation (Thomas Co.). This is the scene that greeted the early pioneers through much of the "pine barrens" of southern Georgia. This environment (**Longleaf Pine Upland Forest** [95]) is burned annually.

Fortunately, two virgin stands have been preserved. These outstanding examples are 800 acres on Greenwood, Photo A47 and 800 acres on Millpond Plantation near Thomasville (Thomas Co.). Other mature stands are preserved on large plantations in Brooks, Thomas and Grady counties particularly. Younger stands were examined on Highway 319, four miles south of Thomasville and on the Barber property (Colquitt Co.).

This forest is found largely on Tifton and Norfolk fine sandy loams but depth to subsurface Miocene clays is less than in drier habitats, according to Faircloth (1971). Best development is found on the better-drained soils of the Norfolk, Orangeburg, Ruston and associated soil series. These soils are low in organic content, light-colored, and acidic with heavy clay subsoil below a sandy surface layer At Greenwood, soil pH in virgin longleaf pine (200-250 years) was 5.6.

### Flora

**Trees:** Canopy dominants are longleaf pine up to 250 years old.

**Shrubs and Vines:** Runner oak (*Quercus pumila*) is often present with some gallberry.

**Herbs:** The dominant ground cover varies, but includes wiregrass (*Aristida stricta*), *Eupatorium rotundifolium* marsh flea-bane (*Pluchea rosea*), deer tongue, gold aster (*Heterotheca* sp.), sunrose (*Helianthemum* sp.), wiregrass (*Sporobolus* sp.), pencil flower (*Stylosanthes biflora*), wild indigo (*Baptisia lanceolata*), gopher apple (*Geobalanus oblongifolius*), cone flower (*Rudbeckia hirta*), queen's delight (*Stillingia sylvatica*); and heterotheca (*Heterotheca gossypina, H. mariana*).

In a very moist but virgin sample on the east side of the Savannah River where water stands after heavy rains there were patches of sweet gum seedlings, and the following herbs were prominent: Gerardia (*Agalinus* sp.), blazing star (*Liatris* sp.), thoroughwort (*Eupatorium undulatum*).

Fire is regular on a natural frequency of 3-5 years, Ed Komarek (pers. comm.). The biotic community is fire-adapted. If one burns more often than 2-3 years (annually), reproduction of longleaf pine and turkey oak is inhibited.

Muscogee and Chattahoochee counties are closest to having original longleaf and loblolly pine in the northern Coastal Plain (Robert Lane, pers. comm.). Harper (1930) indicates that the original vegetation of much of the Dougherty Plain limesink region was "open forests of longleaf pine, carpeted with wiregrass and other perennial herbs " With fire exclusion, hardwood forest seedlings invade within six to eight years and succession is rapid. If burned regularly, there are many legumes (including eight species of lespedeza) and grasses. Ed Komarek (pers comm.) indicates that most of this portion of the Coastal Plain was originally cleared for corn, not cotton. Man apparently changed the environment by overburning, and burning at the wrong season.

The ground oaks (*Quercus minima, Q. pumila*) may be, according to the Komareks, 100 years old, with root systems 300 years old. Fires also burn the pitcher plant bogs found here and there in this environment. Seven species of orchids have been found in such bogs on Greenwood Plantation. The quail authority, Herbert Stoddard, was brought to this area in 1924 because of a dwindling quail population, largely due to fire exclusion.

### Fauna

The fossorial niche is essentially dominated by ambystomid salamanders, such as the mole, frosted flatwoods and marbled, and travelled through by a variety of snakes, such as king, corn, ribbon, garter, black racer, and diamondback rattlesnake. See GUM

PONDS as focal points for life in this environment. The least shrew (*Cryptotis*) is common. The rodents are poorly known. Distribution is CP and habitat is SX, Appendix VI.

If burned regularly, this environment can support up to one quail per acre. According to Ed Komarek (pers. comm.), the dominant conspicuous vertebrates are the red-cockaded woodpecker (which nests only in a live pine with a dead heart and will leave the area if fire is excluded for five years), Pine Woods Sparrow, Brown-headed Nuthatch, harvest mouse, and fox squirrel.

#### Natural and Cultural Values

Although longleaf pines do not attain the massive proportions of loblolly pines, a virgin stand is very impressive. It carries a considerable fauna and is similar to the drier portions of the flatwoods in this respect. Again, the open nature of the regularly burned pine uplands makes it ideal for hunting quail, deer and turkey.

Many of the large plantations maintain this environment and are winter-burned to prevent plant succession. Historically, Bartram indicated that the spacing of the pines (in this habitat and the drier flatwoods) would allow a wagon to be driven across roadless southern Georgia with ease. Wiregrass is the major fuel which is needed to maintain this environment by frequent fire.

#### Man's Impact

Lumbering, breaking the wiregrass sod, and agriculture led to the devastation and disappearance of most of this environment. It is neither as dry as environments [84] [85] and [86] nor as wet as the **mesic pine lowlands**, consequently it has been exploited agriculturally. It has been put into pasture in areas and slash pines have replaced the original longleaf canopy. Although Plummer (1975) states that longleaf pines were reserved for the crown, Kings George II and III stripped coastal Georgia (15 miles wide) by the late 1800's. Plummer reviews historical evidence from the **Darien Timber Gazette** indicating that in 1880, 272 million board feet were cut and 16.8 billion board feet remained in the Coastal Plain. These longleaf grew to a diameter of 20-24 inches in 200 years. By 1895 apparently the virgin longleaf forests were largely exhausted through the combined efforts of log rafting, steam sawmills, and railroads. Stoddard (1955) indicates that overgrazing can eradicate the perennial legumes, but that the lack of frequent fire eliminates them faster

## [96] LOBLOLLY-SHORTLEAF PINE UPLAND FOREST

#### Location and Description

Loblolly-shortleaf pine uplands are found where dry soils predominate in the Dougherty Plain, Fort Valley Plateau, Fall Line Red Hills, and Fall Line Sand Hills regions. They are apparently a product of **secondary succession,** following destruction of the original forest. Loblolly pine-shortleaf pine uplands are also secondary succession stages in longleaf pine forests of the Tifton Upland and Tallahassee Hills as at Tall Timbers Research Station. Soils will be similar to those of **mesic broadleaf deciduous-needleleaf evergreen**, and some **xeric pine uplands**. Fire frequency will be similar to this latter category.

Photo A48. This LOBLOLLY-SHORTLEAF PINE UPLAND FOREST [96] at Tall Timbers Research Station near Thomasville has replaced the original longleaf pine-wiregrass community following both Indian (corn) and Caucasian (cotton) agriculture. The gopher tortoise and its associates, such as the diamondback rattlesnake, are able to survive the vegetational changes.

## Flora

**Trees:** Loblolly and shortleaf pines with some southern red oak.

**Shrubs:** persimmon, spathulate haw (*Crataegus spathulata*), sparkleberry (*Vaccinium arboreum*), and blueberry.

**Herbs and Vines:** bracken fern, blackseed needlegrass (*Stipa avenacea*), flowering spurge (*Euphorbia corollata*), elephant's foot (*Elephantopus carolinianus*), Gerardia (*Agalinus fasciculata*), thoroughwort (*Eupatorium semiserratum*), muscadine, and yellow jessamine.

This community may follow either hardwoods or longleaf pine uplands (if the wiregrass sod is broken) but may be a relatively permanent stage of succession, especially if fire is frequent enough.

## Fauna

The fauna largely consists of some members of the prior community (such as the short-tailed shrew), following destruction of the deciduous forest, but *Cryptotis* shrews may replace *Sorex* shrews and harvest mice (*Reithrodontomys*) may replace white-footed mice (*Peromyscus*). Gopher-hole communities may persist if this forest follows longleaf pine uplands, and the associated fauna, such as diamondback rattlesnakes, will continue to inhabit the area, snake diversity being dependent upon the abundance of various species of rodents (and rabbits) which are in turn are dependent upon fire-frequency.

Distribution CP with P-CP elements. Habitat largely X, Appendix VI.

Photo A49. The gopher tortoise burrow provides a home for many creatures, including the endangered indigo snake (*Drymarchon*). This ancient Pleistocene assemblage of life occurs wherever sands capping Miocene clay hills are deep enough, here in environment [95].

**Natural and Cultural Values and Man's Impact**

Not treated, but can have recreational value; primarily hunting.

6. MARITIME DUNE COMMUNITIES

## [ 97] INTERDUNE TYPE

**Location and Description**

These are meadows, shrub thickets, and forests located between the foredunes and rear dunes. Such communities are common on the coastal islands, which possess a fore dune-rear dune system like the southern end of Sapelo and Cumberland Islands. Bozeman (1975) recognizes three distinct interdune communities on Cumberland: (1) canopy-less, shrub-less meadow community where the duration of standing water delimits both a low and a high meadow, (2) a shrub thicket which may be very dense and appear impenetrable, and which Bozeman feels is in a stage of succession towards (3) a pine hardwood or lowland

Photo A50. On Georgia's coastal islands the region between the foredunes back of the beach and the oak-capped rear dunes supports shrub, meadow or tree-dominated communities [97]. Saw palmetto and yucca are obvious in dry areas, while wax myrtle and willow dominate the wetter swales. Wind-pruned live oaks have overgrown the dunes in the background.

mixed hardwood forest, which is apparently distinguished from the more mesic interior forests by having pines as the dominant canopy. *Note:* The low meadow and pine-hardwood forest might be classified as mesic environments but are retained here for convenience. Examples are common on most of the older and larger islands possessing a dual dune system.

Soils may be water-logged for varying periods of time. This community rarely burns.

### Flora

**Trees:** Trees are present only in the pine-hardwood phase. (D) slash pine, (D) loblolly pine, cabbage palm, hackberry (*Celtis laevigata*), live oak, red cedar, sweet bay, black gum.

**Shrubs:** Some wax myrtle and saw palmetto is found in the forest stage. In the shrub stage wax myrtle dominates with some yaupon, and in moist places there is willow (*Salix carolinana*), Hercules'-club (*Zanthoxylum clava-herculis*), and saw palmetto. In the meadow phase there is, according to Bozeman, an evening primrose (*Oenothera humifusa*), marsh elder (*Iva imbricata*), Spanish bayonet, and wax myrtle.

**Herbs:** capeweed (*Lippia modiflora*), pennywort (*Hydrocotyl bonariensis*), seashore paspalum (*Paspalum vaginatum*), centipede grass (*Eremochloa ophiuroides*), hair grass (*Muhlenbergia capillaris*) (high meadow); (*Fimbristylis spandicea*), marsh gentian (*Sabatia stellaris*), love grass (*Eragrostis refracta*), star rush (*Dichromena colorata*), rush (*Juncus bufonius*) (all low meadow); nut grass (*Cyperus* spp.) (low meadow and forest); dog fennel (*Eupatorium capillifolium*), marsh flea-bane (*Pluchea* sp.), rush (*Juncus* sp.) (all forest); and false nettle (*Boehmeria cylindrica*).

### Fauna

Depending on the successional stage, the fauna would have elements from the dune-meadow, the rear dunes, and interior forested areas.

Distribution — CP; habitat — highly depauperate, invaded by X elements, such as short-tailed shrews and cotton mice, Appendix VI.

### Natural and Cultural Values

The biota of this environment provide soil stabilization, food and shelter for wildlife, protection for the rear dunes, and the land forms provide sources of temporary water for animals, This environment is esthetically pleasing, especially the wax myrtle thickets which also hinder vehicular travel in the interdune area.

### Man's Impact

Less vulnerable than the dunes.

## [98] DUNE MEADOW TYPE

### Location and Description

Dune meadows occur on low foredunes and much of the interdune area. They are largely confined to recent or Holocene dunes just back of the present beaches. Plants are salt-tolerant grasses and herbs.

The substrate is strongly washed sand. Beach ridges at high tide serve as sand sources for dunes, especially in summer. Sand salinity is not significant because of leaching by rain.

### Flora

**Trees and Shrubs:** None (Rarely Spanish bayonet, *Yucca* spp.)

**Herbs:** (D) sea oats (*Uniola paniculata*), beach panic grass (*Panicum armarum*), seashore paspalum (*Paspalum vaginatum*)., (D) pennywort (*Hydrocotyl bonariensis*), sandspur (*Cenchrus tribuloides*), railroad vine (*Ipomoea pes-caprae*), sea spurge (*Euphorbia polygonifolia*), sea rocket (*Cakile* spp.), glasswort (*Salsola kali*), drop seed grass (*Sporobolus virginicus*), cape weed (*Lippia nodiflora*), little bluestem (*Andropogon scoparius*).

### Fauna

The fauna is extremely impoverished — the ghost crab (*Ocypode quadrata*) is a dominant component. Seasonally, nesting birds include American Oyster-Catcher, Least Tern, Royal Tern, Willet, Wilson's Plover, Black Skimmer, and Gull-billed Tern, Johnson **et al** (1971). According to these authors, songbirds, particularly sparrows and red-winged blackbirds, consume sea oat seeds. Raccoons are nocturnal visitors to the beach and dunes where they primarily seek dead fish and crabs, and may raid the nests of marine turtles. The following are notes on mammals of importance: Marsh Rabbit (*Sylvilagus palustris*) (all islands except Little Tybee); Eastern Mole (*Scalopus aquaticus*) (recorded only from Ossabaw, St. Catherine's, Blackbeard, Sapelo, St. Simons, Jekyll, Little Cumberland, Cumberland); Cotton Mouse (*Peromyscus gossypinus*) (recorded only from Ossabaw, Blackbeard, Sapelo, Jekyll, Little Cumberland, Cumberland); Old Field Mouse (*Peromyscus polionotus*) (recorded only from Cumberland Island).

Distribution — CP; Habitat — a few highly motile forms from X, Appendix VI.

### Natural and Cultural Values

The following are significant values: sand storage, initial absorption of wind and some wave energy, island protection, nesting sites for marine turtles, food source for granivorous birds and rodents. This environment provides a substrate for pioneer plant communities, — vegetation necessary to establish the dunes-interdune area. This area furnishes nesting sites for a number of species of shore birds, gulls, terns, etc. The environment offers esthetic beauty and wildness, the educational values of pioneer communities, and marine invertebrate collecting grounds. Recreational values are high.

### Man's Impact

Introduction of livestock has been very damaging by overgrazing and physical damage by hooves to root bind. Hogs feed heavily on pennywort (*Hydrocotyl*) and are the main destroyers of marine turtle nests. Dunebuggies and motorized vehicles destroy vegetation, allowing wind to move sand inward to create moving dunes that overwhelm forest and enabling blowouts and foredune loss to occur. Johnson *et al* (1971) depict an over-grazed beach front with subsequent loss of foredunes. Man has been a serious predator on the eggs of marine turtles — eggs are sold in Savannah and are said to be superior to hen eggs in making cakes. (Two other sources of death to marine turtles are drowning in shrimp boat nets and ingestion of plastic bags which resemble jellyfish, a natural food.

## [99] DUNE OAK-EVERGREEN SHRUB TYPE

### Location and Descritption

The biota, dominated by trees, normally occupies the rear dunes — the upper front half of the dunes appears to be largely a shrub community. Bozeman (1975) recognizes two distinct communities: (1) the "dune shrub thicket community" with canopy absent and tree species juvenile, confined to the front upper portion of the rear dunes and (2) the "dune oak-buckthorn scrub forest community" with a tree canopy covering the top and hind slope of the rear dunes.

These communities are found wherever there are high rear dunes as on most of the islands with Pleistocene surface. They do not burn.

Soils are wind blown sands. Rear dune sands on Jekyll Island contained considerably more organic matter than did foredunes. On Sapelo and parts of Cumberland the rear dunes are probably of Silver Bluff age (when the sea stood five feet higher, aged by Hoyt to be circa 30,000 years old). On Cumberland, due largely to the destructive influence of livestock, dunebuggies, and similar abuse, the ancient dunes of the Silver Bluff formation are being overtopped by an advancing wall of wind blown sand up to 45 feet in height. These moving dunes are steadily destroying both the original dune forest, the rear dune forest, and the fresh water ponds that fill the depressions behind the Silver Bluff formation.

### Flora

**Trees:** On the hind slope live oak, tough buckthorn, loblolly pine, or slash pine. On the foreslope, small red bay and live oak.

**Shrubs:** saw palmetto, Spanish bayonet (foreslope), tough buckthorn (*Bumelia tenax*), yaupon (*Ilex vomitoria*), wax myrtle, stagger-bush (rearslope), (*Lyonia ferruginea*).

**Herbs:** A few uncommon grasses and rushes, some greenbrier and prickly pear, cactus (*Opuntia drummondii*).

### Fauna

On the rear dunes one finds abundant tracks of cotton mice. Among the lizards, the six-lined race runner (*Cnemidophous sexlineatus*) is common on Blackbeard, Sapelo, and Cumberland. Both the blackracer (*Coluber constrictor*), on the larger islands, and the coachwhip (*Masticophis flagellum*), on Sapelo and Cumberland, may make diurnal forays on the rear dunes before the sand gets too hot. Occasionally, cottonmouths (*Agkistrodon piscivoris*) cross the rear dunes seeking cotton mice. One expects the old field mouse here, but it appears absent from most of Georgia's coastal islands except Cumberland. Distribution — CP; Habitat — a very depauperate X, Appendix VI.

### Natural and Cultural Values

It is important that both fore and rear dunes be anchored by plant roots and rhizomes, otherwise onshore storm winds move sand faster than the capacity of the vegetative community to re-establish itself and anchor the sand. Thus the dunes are a barrier against wind energy that can damage and destroy island structure. Botanically, these communities are fascinating for studying primary succession, plant adaptation, and wind and spray pruning. The adaptation of animals is equally interesting. Stable rear dunes form a barrier against high spring and storm tides that might flood the island interior.

Esthetically, dunes are as interesting as the beach itself. One of the most exciting environments I have ever seen is the creek from Lake Whitney penetrating the rear dunes on Cumberland's north end. The gnarled and wind-pruned oaks have huge patches of pink lichen contrasting with the grey of the spanish moss and the dark green of the saw palmetto.

### Man's Impact

The hooves, grazing, and rooting of domestic livestock (cattle, horses, pigs) have destroyed dune areas of the coastal islands. Jeeps, dunebuggies, and other motorized vehicles must be barred from the dune areas. These are fragile environments because of the limited plant food and water. Plants colonize the sands with difficulty under the best conditions. Sand fences have been helpful on Hatteras to prevent excessive dune movement following human or storm damage, but they detract from the esthetic vistas.

7. ROCK OUTCROPS

## [100] SANDSTONE OUTCROPS

### Location and Description

This environment is confined to limited places in Tifton Upland, Fig. 33, where obvious weathered rock outcrops are found, with stunted oak trees and xeric plants, such as yucca and cactus. There are usually some pines in the overstory. The vegetation is somewhat similar to the sand ridge type, but trees are sparse. Outcrops occur as bluffs, near the edge of streams or ravines, or as flat outcrops in the Tifton Upland in a belt extending from Johnson County through Coffee County. The Broxton Rocks are incised into this zone of sandstone (see SOLUTION RAVINES, **Tifton Upland Type**).

A good example is an outcrop on I-75 near Ashburn — two miles north of exit 159 (Turner Co.) Photo A51; the grounds of Mt. Bethel Free Will Baptist Youth Camp would also be an example.

Soils are thin and sandy, with weathered bedrock exposed. Obviously, this is a fire-prone community.

### Flora

**Trees:** (bluff type outcrop only) longleaf pine, blackjack oak, dwarf post oak.

**Shrubs:** (in and around the bluff-type outcrop) winged sumac (*Rhus copallina*), persimmon, yellow jessamine (*Gelsemium sempervirens*), deerberry (*Vaccineum stamineum*). The rare Georgia plume was discovered (*Elliottia racemosa*) on sandstone bluffs in Turner County by Wayne Faircloth, according to John Bozeman (pers. comm.).

**Herbs:** trumpet creeper, yucca (*Yucca filamentosa*), agave (*Agave virginica*), wild onion (*Allium cuthbertii*). At the Ashburn outcrops I found blazing star (*Liatris* sp.), beardtongue (*Penstemon dissectus*), and coreopsis (*Coreopsis major*) to be dominant herbs. John Bozeman (pers. comm.) indicates that some dominant herbs on the flat outcrops are shared with Piedmont granite outcrops. The following rather complete list of herbs occurring on sandstone outcrops was furnished by Wayne Faircloth: feather leaf penstemon (*Penstemon dissectus*), rock portulacca (*Talinum teretifolium*), candyweed (*Polygala chapmani*), resurrection fern (*Polypodium polypodioides*), bracken fern (*Pteridium aquilinum*), cymose beakrush (*Rhynchospora cymosa*), croton (*Crotonopsis linearis*), downy danthonia grass (*Danthonia sericia*), aster (*Aster surculosus*), button snakeroot (*Eryngium yuccafolium*), Virginia tephrosia (*Tephrosia virginiana*), slender bluestem grass (*Andropogon tener*), Florida dropseed (*Sporobolius floridanus*), wiregrass (*Aristida stricta*), selaginella (*Selaginella spp.*), nuttall golden weed (*Bigloweia nuttallii*). *Bigloweia, Liatris squarrosa, Penstemon dissectus,* and *Hypericum lloydii* are said to be characteristic of south Georgia sandstone outcrops, Raleigh Bryans (pers. comm.).

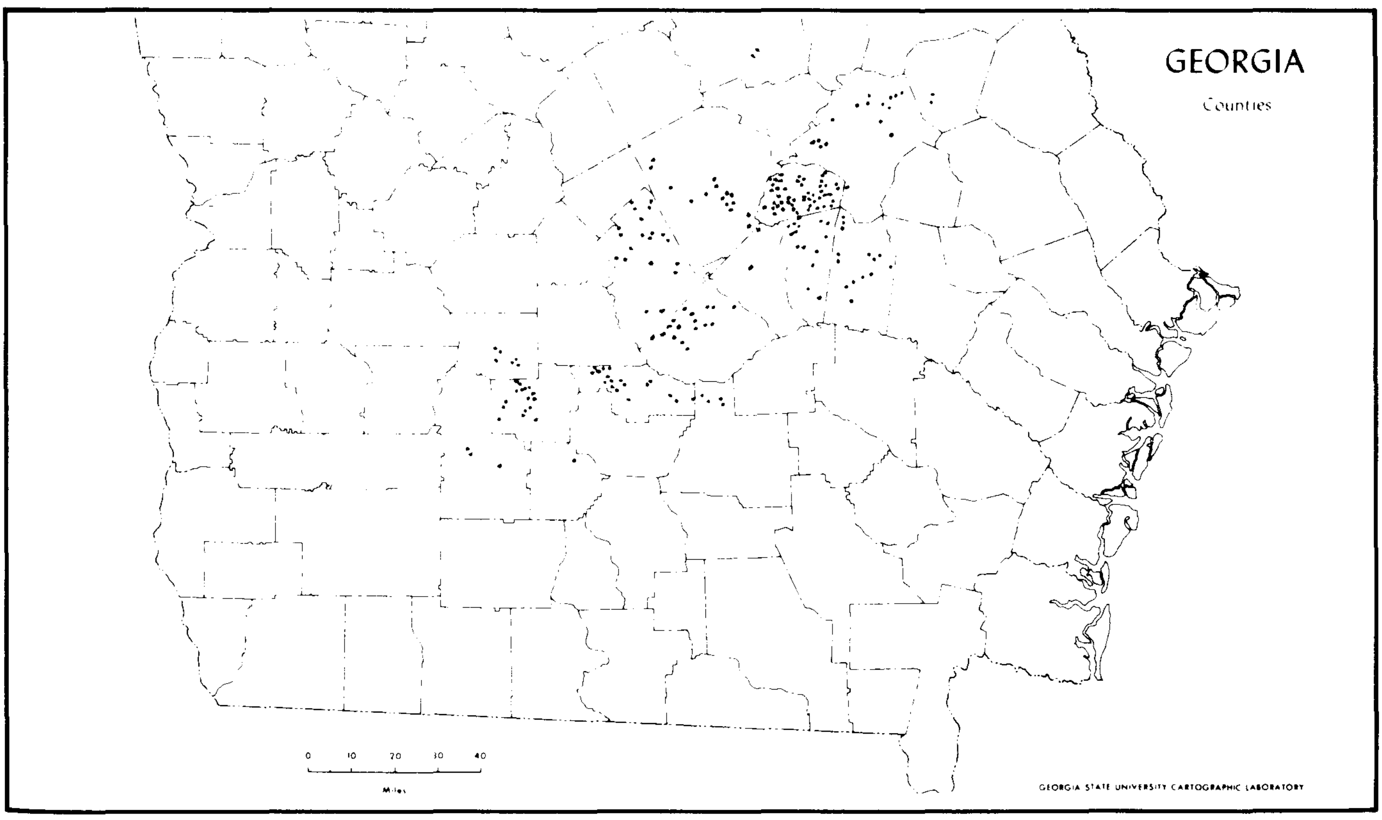



Fig. 33. Distribution of "Ashburn type" sandstone outcrops (solid dots) in Georgia. Data from 1976 Geologic Map of Georgia.

Photo A51 SANDSTONE OUTCROP [100] on I-75 near Ashburn (Turner Co.) with a canopy of blackjack and dwarf post oak, a very arid environment sharing some plants with the granite outcrops of the **Piedmont**.

### Fauna

Distribution: CP Habitat, usually mobile elments from SX, and occasionally X, Appendix VI.

### Natural and Cultural Values

This environment is botanically and zoologically depauperate but unique. It is geologically important in Coastal Plain history, being often mentioned by early travellers. These are esthetically pleasing and unusual scenic communities with xeric-tolerant plants and animals, and of considerable educational and scientific interest. Beardtongue is on the proposed Federal Endangered and Threatened List.

### Man's Impact

The outcrops are probably mined in places. They are used as dumping areas (see locality above, I-75) or considered useless.

# APPENDIX I

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# APPENDIX II

## PLANT GLOSSARY

agrimony–*Agrimonia gryposepala*
air plant–*Tillandsia tenuifolia*
alder–*Alnus*
alder, common–*Alnus serrulata*
alder, tag–*Alnus rugosa*
alumroot, American–*Heuchera americana*
alumroot, hairy–*Heuchera villosa*
alumroot, littleleaf–*Heuchera parviflora*
amorpha–*Amorpha fruticosa*
anemone, rue–*Anemonella thalictroides*
anemone, Virginia–*Anemone virginiana*
anemonella–*Anemonella thalictroides*
angelica–*Angelica triquinata; Angelica venenosa*
arbutus, trailing–*Epigaea repens*
arrowarum, Virginia–*Peltandra virginica*
arrowhead, bull tongue–*Sagittaria lancifolia*
arrowhead, grassy–*Sagittaria graminea*
arum–*Asarum ariflora*
ash, Carolina–*Fraxinus caroliniana*
ash, green–*Fraxinus pennsylvanica*
ash, mountain–*Sorbus arbutifolia*
ash, prickly–*Zanthoxylum clava-herculis*
ash, pumpkin–*Fraxinus tomentosa*
ash, red–*Fraxinus pennsylvanica*
ash, water–*Fraxinus caroliniana*
ash, white–*Fraxinus americana*
aster–*Aster* sp.
aster–*Aster surculosus; Aster synarrosus*
aster, acuminate–*Aster acuminatus*
aster, bushy–*Aster dumosus*
aster, calico–*Aster lateriflorus*
aster, gold–*Chrysopsis* sp.
aster, heath–*Aster ericoides*
aster, Maryland gold–*Chrysopsis mariana*
aster, ragged–*Seriocarpus asteriodes; S. linifolius*
aster, skydrop–*Aster patens*
aster, wave–*Aster undulatus*
aster, white topped–*Seriocarpus asteriodes; S. linifolius*
azalea, flame–*Rhododendron calendulaceum; Azalea calendulacea*
azalea, piedmont–*Rhododendron canescens*
azalea, swamp–*Rhododendron viscosum*
azalea, sweet–*Rhododendron arborescens*
baldrush–*Psilocarya* sp.
Barbara's buttons–*Balduina; Marshallia graminifolium*
basswood–*Tilia americana*
bay, loblolly–*Gordonia lasianthus*
bay, red–*Persea borbonia*
bay, swamp red–*Persea palustris; Tamala pubescens*
bay, sweet–*Magnolia virginiana*
bay, Virginia–*Magnolia virginiana*
bay, white–*Magnolia virginiana*
bayberry, southern–*Myrica pennsylvanica*
beadlily, yellow–*Clintonia borealis*
beadruby, Canana–*Maianthemum canadense*
beakrusk, cymosa–*Rhynchospora cymosa*
bear lettuce—*Saxifraga micranthidifolia*
bedstraw—*Galium circaezens*
bedstraw, hairy–*Galium pilosum*
beech–*Fagus*
bellflower, Allegheny–*Campanula divaricata*
bellflower, American–*Campanula americana*
bellwort–*Uvularia sessilifolia*
berry, service–*Amelanchier* sp.
birch, black–*Betula lenta*
birch, river–*Betula nigra*
birch, yellow–*Betula lutea*
bittermint–*Hyptis radiata*
blackberry, cutleaf–*Rubus lacinatus*
blackberry, thornless–*Rubus canadensis*
bladderpod–*Glottidium vesicarium*
bladderwort–*Utricularia biflora*
bladderwort, awn–*Utricularia subulata*
bladderwort, fiber–*Utricularia fibrosa*
bladderwort, purple–*Utricularia purpurea*
bladderwort, rush–*Utricularia juncea*
blazingstar–*Liatris* sp.
bloodroot–*Sanguinaria canadensis*
blueberry–*Polycodium vaccinium; Vaccinium (Cyanococcus) constablaei*
blueberry, blueridge–*Vaccinium pallidum*
blueberry, Downy–*Vaccinium atrococcum*
blueberry, dwarf–*Vaccinium myrsinites*
blueberry, Elliott's–*Vaccinium (Cyanococcus) elliottii*
blueberry, ground–*Vaccinium myrsinites*
blueberry, highbush–*Vaccinium corymbosum; V. constablaei*
bluet, common–*Houstonia caerulea*
bluet, creeping–*Houstonia serpyllifolia*
bluet, longleaf–*Houstonia longifolia*
bluet, purple–*Houstonia purpurea*
brier, bamboo–*Smilax laurifolia*
brier, sensitive–*Schrankia microphylla*
bristlefern–*Trichomanes boschianum*
broomsedge–*Angropogon virginicus*
buckberry–*Gaylusaccia ursina*
buckeye, dwarf–*Aesculus pavia*
buckeye, red–*Aesculus pavia*
buckeye, yellow–*Aesculus octandra*
buckthorn–*Rhamnus* sp.
buckthorn, tough–*Bumelia tenax*
buckwheat, wild—*Erigonum tomentosum*
bugbane—*Cimicifuga racemosa*
bugleweed–*Lycopus* sp.
bulrush, woolgrass–*Scirpus cyprinus*
bumelia, tough–*Bumelia tenax*
bush, burning–*Euonymus americanus*
bush, button–*Cephalanthus occidentalis*
bush, indigo–*Amorpha fruticosa*
bush, sweet pepper–*Cethra alnifolia*
buttercup–*Ranunculus* sp.
butterwort–*Utricularia radiata; Pinguicula* sp.
calceolaria–*Hybanthus concolor*
campion, catchfly–*Silene* sp.
campion, starry–*Silene stellata*
candyweed, Chapman's–*Polygala chapmani*
cane, giant–*Arundinaria gigantea*
cattail, broadleaf–*Typha latifolia*
cedar–*Juniperus* sp.
cedar, red–*Juniperus virginiana*
cedar, stinking–*Torreya taxifolia*
cedar, white–*Chamaecyparis thyoides*
chainfern, netvein–*Lorinseria areolata*
chainfern, Virginia–*Anchistes virginica*
cherry, black–*Prunus serotina*
cherry, fire–*Prunus pennsylvanica*
cherry, wild–*Prunus pennsylvanica*
chestnut, American–*Castanea dentata*
chickweed–*Stellaria media*
chinkapin, Ashe's–*Castanea ashei*
chinkapin, dwarf–*Castanea pumila*
chinkapin, Florida–*Castanea alnifolia floridana*
chokeberry–*Prunus cuthbertii*
chokeberry, red–*Sorbus (Aronia) arbutifolia*

cinquefoil-*Potentilla simplex*
clethra, cinnamon-*Clethra acuminata*
clethra, summersweet-*Clethra alnifolia*
clubmoss-*Lycopodium flabelliforme*
clubmoss, Carolina-*Lycopodium carolinanum*
clubmoss, carpet-*Lycopodium prostratum*
clubmoss, shining-*Lycopodium lucidulum*
cohosh, black-*Cimicifuga racemosa*
coltsfoot-*Brasenia schreberi; Galax aphylla; Tussilago farfara*
columbine, wild-*Aquilegia canadensis*
coneflower-*Rudbeckia merta*
coneflower, cutleaf-*Rudbeckia laciniata*
coralroot-*Corallorhiza odontorhiza*
cordgrass, big-*Spartina cynosuroides*
cordgrass, marshhay-*Spartina patens*
coreopsis-*Coreopsis major; Coreopsis trefoil*
corydalis, pale-*Corydalis sempervirens*
cottonwood-*Populus deltoides*
crabgrass-*Digitaria* sp.
creeper, trumpet-*Campsis radicans*
creeper, Virginia-*Parthenocissus quinquefolia*
crossvine-*Bignonia capreolata*
cucumber, indian-*Medeola virginiana*
cupscale, American-*Sacciolepsis striata*
cutgrass, giant-*Zizaniopsis miliacea*
cutgrass, rice-*Leersia oryzoides*
cyperus, redroot-*Cyperus erythrorhizos*
cypress, bald-*Taxodium distichum*
cypress, pond-*Taxodium ascendens; T. nutans*
cypress, river-*Taxodium distichum*
cyrilla, American-*Cyrilla racemiflora*
dahoon-*Ilex cassine*
dandelion, mountain dwarf-*Krigia montana*
dandelion, Virginia dwarf-*Krigia virginica*
danthonia, downy-*Danthonia sericea*
dayflower, marsh-*Aneilema keisax*
decumaria, southeast-*Decumaria barbara*
deerberry, common-*Vaccinium stamineum*
deertongue-*Trilisa carphephorus; T. odoratissima*
devil's bit-*Chamaelirion* sp.
devil's walkingstick-*Aralia spinosa*
devilwood-*Osmanthus americana*
dingleberry-*Vaccinium erythrocarpum*
doghobble-*Leucothoe axillaris; L. catesbaei*
dogtongue—*Erigonum tomentosum*
dogwood, pagoda—*Cornus alternifolia*
dogwood, silky-*Cornus amomum*
dogwood, stiff-*Cornus stricta*
dogwood, stiffcornel-*Cornus foemina*
dogwood, swamp-*Cornus stricta*
doll's eyes-*Actaea alba; Actaea pachypoda*
dragon, green-*Arisaema dracontium*
dropseed, Florida-*Sporobolus floridanum*
duckweed-*Lemna minor*
duckweed, big-*Spirodela polyrhiza*
Dutchman's breeches-*Dicentra cucullaria*
Dutchman's pipe-*Aristolochia macrophylla; Aristolochia tomentosa*
dyersweed-*Solidago nemoralis*
elder, box-*Acer negundo*
elder, marsh-*Iva imbricata*
elephantfoot-*Elephantopus* sp.
elf-orpines-*Diamorpha cymosa*
elliotia-*Elliotia racemosa*
elm, America-*Ulmus americana*
elm, Florida-*Ulmus floridanus*
elm, slippery-*Ulmus rubra*
elm, water-*Ulmus americana*
elm, winged-*Ulmus alata*
eupatorium-*Eupatorium rotundifolium*
euphorbia-*Euphorbia corollata*
fairybells-*Disporum* sp.
fanwort-*Cabomba* sp.
farkleberry-*Vaccinium arboreum*
fawnlily, common-*Erythronium americanum*
fern, American maidenhair-*Adiantum pedatum*
fern, bracken-*Pteridium aquilinum*
fern, broad beech-*Thelypteris hexagonoptera*
fern, Christmas-*Polystichum acrostichoides*
fern, cinnamon-*Osmunda cinnamomea*
fern, common grape-*Botrychium obliquum*
fern, filmy-*Trichomanes petersii*
fern, hay scented-*Dennstaedtia punctilobula*
fern, netted chain-*Woodwardia areolata*
fern, New York-*Thelypteris noveboracensis*
fern, rattlesnake-*Botrychium virginianum*
fern, royal-*Osmunda regalis*
fern, sensitive-*Onoclea sensibilis*
fern, sword-*Nephrolepsis* sp.
fern, maidenhair-*Adiantum pedetum*
fern, venus-hair-*Adiantum capillus-veneris*
fern, Virginia chain-*Woodwardia virginica*
fern, water-*Azolla caroliniana*
fern, western bracken-*Pteridium aquilinum*
fetterbush-*Lyonia lucida*
firegrass-*Drosera longifolia*
fireweed-*Erechtites hieracifolia*
flag, blue-*Iris versicolor*
flag, sweet-*Acorus calamus*
fleabane-*Erigeron* sp.
fleabane, marsh-*Pluchea rosea*
floating heart-*Nymphoides* sp.
flower, cardinal-*Lobelia cardinalis*
flower, leather-*Clematis crispa*
flower, October-*Polygonella polygama*
flower, pencil-*Stylosanthes* sp.
fly poison-*Amianthium muscaetoxicum*
foamflower-*Tiarella cordifolia* (MT)
forestiera, privet-*Forestiera ligustrina*
forkmoss-*Dicranum condensatum*
forkmoss, broom-*Dicranum scoparium*
foxglove-*Aureolaria flavia; Aureolaria pectinata*
foxtail, giant-*Setaria magna*
fringetree-*Chionanthus virginica*
frogbit-*Limnobium spongia*
galax-*Galax aphylla*
gallberry-*Ilex glabra*
gallberry, large-*Ilex coriacea*
garlic, striped-*Allium cuthbertii*
gayfeather-*Liatris* sp.
gentian-*Gentiana catesbei; Gentiana clausa*
gentian, bottle-*Gentiana saponaria*
gerardia-*Agalinus (Gerardia) fasciculata*
ginger, Canadian wild-*Asarum canadense*
ginger, Virginia wild-*Asarum virginicum*
ginger, wild-*Hexastylus ariflora; H. heterophylla; H. shuttleworthii*
ginseng, dwarf-*Panax trifolium*
glasswort-*Salicornia* sp.
goldenclub-*Orontium aquaticum*
golden-eye, Porter-*Viguiera porteri*
goldenrod-*Solidago* sp.
goldenrod, rayless-*Chondrophora nudata*
goldenrod, woody-*Chrysoma (Solidago) pauciflosculosa*
goldenstar-*Chrysogonum virginianus*
goldenweed, nuttail-*Bigelowia nuttalli*
gooseberry, pasture-*Ribes cynosbati*
gopher apple-*Geobalanus oblongifolius*
grape, muscadine-*Vitis rotundifolia*
grape, summer-*Vitis aestivalis*
grass, beach panic-*Panicum amarulum*
grass, blue-eyed-*Sisyrinchium augustifolium*
grass, bluestem-*Andropogon* sp.
grass, coastal love-*Eragrostis refractra*
grass, goldstar-*Hypoxis hirsuta*
grass, little bluestem-*Andropogon scoparius*
grass, orange-*Ctenium aromaticum*
grass, pineland threeawn-*Aristida stricta*
grass, slender bluestem-*Andropogon tener*
grass, swamp-*Microstegium vimineum*
grass, toothache-*Ctenium aromaticum*
grass,yelloweye-*Xyris* sp.
grass, broomsedge-*Andropogon virginicus*
grass of Parnassus-*Parnassia* sp.
greenbrier-*Smilax tamnifolia*
greenbrier, cat-*Smilax glauca*
greenbrier, common-*Smilax rotundifolia*
greenbrier, laurel-*Smilax laurifolia*

greenbrier, Walter's–*Smilax walteri*
greenbrier, saw–*Smilax bona nox*
gromwell, Carolina–*Lithospermum carolinense*
groundsel–*Senecio millefolium*
gum, black–*Nyssa sylvatica*
gum, swamp black–*Nyssa biflora*
gum, water–*Nyssa aquatica*
habernaria, snowy (orchid)–*Habenaria nivea*
hackberry–*Celtis occidentalis*
hackberry, Georgia–*Celtis georgiana*
hackberry, sugar–*Celtis laevigata*
hairyseed–*Calamagrostis cinnoides*
hardhead–*Xyris* sp.
hatpins–*Eriocaulon compressum*
haw, possum–*Ilex decidua*
haw, rusty black–*Lyonia ferruginea*
hawkweed–*Hieracium gronovit*
hawkweed, panicled–*Hieracium paniculatum*
hawkweed, poor robins–*Hieracium venosum*
hawthorn, dotted–*Crataegus punctata*
hawthorn, fanleaf–*Crataegus flabellata*
hawthorn, littlehip–*Crataegus spathulata*
hawthorn, oneflower–*Crataegus uniflora*
hawthorn, parsley–*Crataegus marshallii*
hawthorn, spathulate–*Crataegus spathulata*
hawthorn, yellow–*Crataegus flava*
hazelnut–*Corylus americana*
heal-all–*Prunella vulgaris*
hellebore, American false–*Veratrum viride*
hellebore, false–*Veratrum parviflorum*
hemlock, Canada–*Tsuga canadensis*
hemlock, Carolina–*Tsuga caroliniana*
hemp, water–*Acnida cannabina*
hepatica, roundlobe–*Hepatica americana*
hepatica, sharplobe–*Hepatica acutiloba*
Hercules club–*Zanthoxylum clava-herculis*
hickory, bitternut–*Carya cordiformis*
hickory, mockernut–*Carya tomentosa*
hickory, pignut–*Carya glabra*
hickory, red–*Carya ovalis*
hickory, shagbark–*Carya ovata*
hickory, water–*Carya aquatica*
hickory, white–*Carya alba*
hobblebush–*Viburnum alnifolium*
holly–*Ilex ambigua; Ilex coriacea*
holly, American–*Ilex opaca*
holly, myrtle–*Ilex myrtifolia*
honewort–*Cryptotaenia canadensis*
honeysuckle–*Lonicera* sp.
honeysuckle, Japanese–*Lonicera japonica*
hophornbeam, American–*Ostrya virginica*
hoptree–*Ptelea* sp.
hornbeam–*Carpinus* sp.
hornwort–*Ceratophyllum* sp.
horsebalm–*Collinsonia canadensis*
horsemint–*Collinsonia candensis; Mentha longifolia*
horsesugar–*Symplocus tinctoria*
horseweed–*Erigeron (Leptilion) canadense*
huckleberry–*Gaylusaccia* sp.
huckleberry, he-–*Lyonia ligustrina*
huckleberry, squaw–*Vaccinium stamineum*
hybanthus–*Hybanthus concolor*
hydrangea, climbing–*Decumaria barbara*
hydrangea, oak leaf–*Hydrangea quercifolia*
hydrangea, smooth–*Hydrangea arborescens*
hydrangea, wild–*Hydrangea arborescens*
indian physic–*Gillenia stipulata; Gillenia trifoliata* (MT)
indian pipe–*Monotropa uniflora*
indigo, blue wild–*Baptisia australis*
indigo, Georgia wild–*Baptisia perfoliata*
indigo, wild–*Baptisia lanceolata*
inkberry–*Ilex glabra*
iris, vernal–*Iris verna*
ironwood–*Carpinus caroliniana*
ivy, poison–*Rhus (Toxicodendron) radicans*
Jack-in-the-Pulpit–*Arisaema atrorubens*
jessamine, Carolina–*Gelsemium sempervirens*
jessamine,yellow–*Gelsemium sempervirens*
joint-tail, wrinkled–*Manisuris rugosa*
jointweed–*Polygonella polygonum; P.* sp.
kalmia–*Kalmia latifolia*
kalmia, sandhill–*Kalmia hirsuta*
knotweed–*Polygonella polygonum; Polygonum* sp.
ladies' tresses–*Spiranthes* sp.
ladyfern–*Athyrium felix-femina*
ladyfern, southern–*Athyrium asplenoides*
ladyslipper, European–*Cypripedium calceolus*
ladyslipper, large yellow–*Cypripedium parviflorum pubescens*
ladyslipper, pink–*Cypripedium acaule*
ladyslipper, small yellow–*Cypripedium parviflorum*
ladyslipper, yellow–*Cypripedium calceolus*
larkspur, Carolina–*Delphinium carolinianum*
latherleaf–*Clethra alnifolia*
laurel, cherry–*Laurocerasus caroliniana*
laurel, dwarf–*Kalmia hirsuta*
laurel, mountain–*Kalmia latifolia*
leafcup–*Polyminia* sp.
leatherwood–*Dirca palustris*
lespedeza, creeping–*Lespedeza repens*
leucothoe, sweetbells–*Leucothoe racemosa*
lily, American water–*Nymphaea odorata*
lily, Catesby's–*Lilium catesbaei*
lily, nolina–*Nolina georgiana*
lily, speckled wood–*Clintonia umbellulata; Lilium philadelphicum*
lily, spider–*Hymenocallis crassifolia*
lily, trumpet–*Zephyranthes* sp.
lily, white water–*Castalia (Nymphaea) odorata*
lily, yellow pond–*Nuphar (Nymphaea) advena*
lily of the valley, false–*Maianthemum canadense*
lime, Ogeechee–*Nyssa ogeche*
linden, American–*Tilia americana*
linden, highlands–*Tilia (monticola) heterophylla*
listera, Small's–*Listera smalli*
lizard's tail–*Saururus cernuus*
locust, black–*Robinia pseudoacacia*
locust, honey–*Gleditsia* sp.
locust, roseacacia–*Robinia hispida*
loosestrife, fourleaf–*Lysimachia quadrifolia*
loosestrife, whorled–*Lysimachia quadrifolia*
lopseed–*Phryma* sp.
lotus–*Nelumbo lutea; Nelumbo* sp.
lousewort–*Pedicularis canadensis*
lyonia–*Lyonia phillyreifolia*
lyonia, fetterbush–*Lyonia lucida; Lyonia nitida*
magnolia, bigleaf–*Magnolia macrophylla*
magnolia, Fraser–*Magnolia fraseri*
magnolia, Southern–*Magnolia grandiflora*
magnolia, umbrella–*Magnolia tripetela*
maidencane–*Panicum hemitomum*
mannagrass, pale–*Glyceria pallida*
maple, ash leaf–*Acer negundo*
maple, Florida–*Acer floridanum*
maple, mountain–*Acer spicatum*
maple, red–*Acer rubrum*
maple, silver–*Acer saccharinum*
maple, southern sugar–*Acer saccharum*
maple, striped–*Acer pensylvanicum*
mayapple, common–*Podophyllum peltatum*
mayflower, Canana–*Maianthemum canadense*
meadow beauty–*Rhexia alaphanus; Rhexia virginica*
meadow beauty, yellow–*Rhexia lutea*
mermaidweed, marsh–*Proserpinaca palustris*
merrybells, little–*Uvularia sessilifolia*
milkweed, sandhill–*Asclepias humistrata*
millet, Walter's–*Echinochloa walteri*
millet, wild–*Echinochloa crus galli*
mint, blue flowering woody–*Calamintha (Satureja) ashei*
mint, red flowering woody–*Calamintha (Satureja) coccinea*
mistletoe–*Phoradendron serotinum*
mock orange, scentless–*Philadelphis inodoris*
monkshood, clambering–*Aconitum uncinatum*
moosewood–*Viburnum alnifolium*
moss, common haircap–*Polytrichum commune*
moss, reindeer–*Cladonia rangifera (rangiferina)*
moss, rock–*Grimmia* sp.
moss, sphagnum–*Sphagnum* sp.

mountainmint, Atlantic-*Pycnanthemum incanum*
mountainmint, slender-*Pycnanthemum flexuosum*
mulberry-*Morus* spp.
mulberry, French-*Callicarpa americana*
mustard, turkey-*Cardimine (Dentaria) diphylla*
myrtle, odorless wax-*Myrica inodora*
myrtle, wax-*Myrica (Cerothamnus) ceriferus*
naiad, southern-*Najas guadalupensis*
nailwort-*Paronychia* sp.
needlegrass, blackseed-*Stipa avenacia*
nettle, false-*Boehmeria cylindrica*
nettle, stinging-*Urtica dioica*
nettle, swamp-*Boehmeria cylindrica*
nightshade, enchanter's-*Circaea alpina*
nut, buffalo-*Pyrularia pubera*
oak, black-*Quercus velutina*
oak, blackjack-*Quercus marilandica*
oak, bluejack-*Quercus incana; Quercus cinerea*
oak, Chapman-*Quercus chapmani*
oak, cherrybark-*Quercus falcata pagodaefolia*
oak, chestnut-*Quercus prinus; Quercus montana*
oak, dwarf live-*Quercus minima*
oak, dwarf post-*Quercus margaretta*
oak, laurel-*Quercus laurifolia*
oak, live-*Quercus virginiana*
oak, myrtle-*Quercus myrtifolia*
oak, northern red-*Quercus borealis*
oak, overcup-*Quercus lyrata*
oak, poison-*Toxicodendron quercifolium; Rhus toxicodendron*
oak, post-*Quercus stellata*
oak, red-*Quercus rubra*
oak, runner-*Quercus pumila*
oak, sand live-*Quercus geminata (virginiana)*
oak, scarlet-*Quercus coccinea*
oak, scrub-*Quercus minima*
oak, scrubby post-*Quercus margaretta*
oak, Shumard-*Quercus shumardii*
oak, southern red-*Quercus falcata*
oak, Spanish-*Quercus rubra*
oak, swamp chestnut-*Quercus michauxii*
oak, turkey-*Quercus laevis*
oak, water-*Quercus nigra*
oak, white-*Quercus alba*
oak, willow-*Quercus phellos*
oakleech-*Aureolaria flavia; Aureolaria pectinata*
oilnut-*Pyrularia pubera*
olive, wild-*Osmanthus americana*
onion-*Allium cuthbertii*
orchid, grasspink-*Calopogon pulchellus*
orchid, green fly-*Epidendrum conopseum*
orchid, rose-*Cleistes divaricata*
orchid, showy-*Orchis spectabilis*
orchid, small green wood-*Habenaria clavellata*
orchid, spur-*Habenaria repens*
orchid, yellow fringed-*Habenaria ciliata*
osage orange-*Toxylon pomiferum*
oxalis-*Oxalis montana*
ox-eye, bushy sea-*Borrichia frutescens*
palm, cabbage-*Sabal palmetto*
palm, needle-*Rhapidophyllum hystrix*
palm, swamp-*Sabal minor*
palmetto, bluestem-*Sabal minor*
palmetto, dwarf-*Sabal minor*
palmetto, saw-*Serenoa repens*
palmetto, swamp-*Sabal minor*
panicum, ash-*Panicum ashei*
panicum, Asiatic-*Panicum bisuleatum*
panicum, fall-*Panicum dichotomiflorum*
parmelia-*Parmelia* sp.
parrot's feather-*Myriophyllum* sp.
partridgeberry-*Mitchella repens*
pawpaw, common-*Asimina triloba*
pawpaw, dwarf-*Asimina parviflora*
pawpaw, smallflower-*Asimina parviflora*
pear, prickly-*Opuntia* sp.
pedicularis, early-*Pedicularis canadensis*
pennyroyal-*Pycnothymus rigidis*
pennywort, largeleaf-*Hydrocotyle bonariensis*
penstemon, featherleaf-*Penstemon dissectus*
persea-*Persea borbonia*
persimmon-*Diospyros virginiana*
phacelia, fringed-*Phacelia fimbriata*
phacelia, loose flowered-*Phacelia bipinnatifida*
phlox, meadow-*Phlox maculata*
pinckneya-*Pinckneya pubens*
pine, Caribbean-*Pinus caribaea*
pine, loblolly-*Pinus taeda*
pine, longleaf-*Pinus palustris*
pine, pone-*Pinus serotina*
pine, shortleaf-*Pinus echinata*
pine, slash-*Pinus elliottii*
pine, spruce-*Pinus glabra*
pine, Virginia-*Pinus virginiana*
pineweed-*Hypericum gentianoides*
pinxterflower-*Rhododendron nudiflorum*
pipevine-*Aristolochia tomentosa*
pipewort-*Eriocaulon compressum*
pipsissewa, striped-*Chimaphila maculata*
pitcher plant, hooded-*Sarracenia minor*
pitcher plant, parrot-*Sarracenia psittacina*
pitcher plant, trumpet-*Sarracenia flava*
plantain, rattlesnake-*Goodyera pubescens*
plum, American-*Prunus americana*
plumegrass-*Erianthus strictus*
plumegrass, giant-*Erianthus giganteus*
plumegrass, sugarcane-*Erianthus giganteus*
pogonia, drooping-*Pogonia (Triphora) trianthophora*
pogonia, rose-*Pogonia ophioglossoides*
poke-*Phytolacca* sp.
pondweed-*Potamogeton* sp.
pondweed, snailseed-*Potamogeton diversifolius*
poplar, tulip-*Liriodendron tulipifera*
poplar, yellow-*Liriodendron tulipifera*
privet-*Ligustrum* sp.
privet, Florida-*Forestiera acuminata*
privet, swamp-*Forestiera acuminata; Forestiera* sp.
queen's delight-*Stillingia sylvatica*
quillwort-*Isoetes melanopoda*
raspberry, flowering-*Rubus odoratus*
redbud-*Cercis canadensis*
reedgrass-*Calamagrostis cinnoides*
rhododendron, Carolina-*Rhododendron minus*
rhododendron, catawba-*Rhododendron catawbiense*
rhododendron, piedmont-*Rhododendron minus*
rhododendron, rosebay-*Rhododendron maximum*
rice, southern wild-*Zizaniopsis miliacea*
rice, wild-*Zizania aquatica*
richweed-*Collinsonia canadensis*
risky treadsoftly-*Cnidoscolus stimulosus*
riverweed-*Podostemum ceratophyllum*
riverweed, hornleaf-*Podostemum ceratophyllum*
rockrose-*Cistus* sp.
root, black-*Pterocaulon undulatum*
root, cancer-*Conopholis americana*
root, cucumber-*Cucumis sativus*
root, rattlesnake-*Prenanthes serpenteria*
root, squaw-*Conopholis americana*
rose, sun-*Helianthemum* sp.
rosegentian-*Sabatia macrophylla; Sabatia* sp.
rosemary-*Ceratiola ericoides*
rosinweed-*Silphium compositum*
rue, meadow-*Thalictrum clavatum*
rue, tall meadow-*Thalictrum polygamum*
rush-*Cyperus* sp.
rush, common-*Juncus effusus*
rush, needlegrass-*Juncus roemerianus*
rush, soft-*Juncus effusus*
rush, star-*Dichromena colorata*
rush, toad-*Juncus bufonius*
sabatia, pink-*Sabatia dodecandra*
sabatia, white-*Sabatia* sp.
St. Andrew's cross-*Ascyrum hypericoides*
saltgrass, seashore-*Distichlis spicata*
sandbush-*Hypericum fasciculatum*
sandwort-*Arenaria serpyllifolia; A.* sp.
sanicle, black-*Sanicula marilandica*

sassafras–*Sassafras albidum*
savory–*Clinopodium (Satureja)* sp.
sawgrass, seashore–*Distichlis spicata*
saxifrage, Allegheny–*Saxifraga micranthidifolia*
scratchgrass–*Polygonum arifolium*
sea rocket–*Cakile* sp.
sedge–*Carex spp.*
sedge, beaked–*Carex rostrata*
sedge, flat–*Cyperus spp.*
sedge, razor–*Scleria spp.*
sedge, white-top–*Dichromena colorata*
seedbox–*Ludwigia pilosa*
selaginella–*Selaginella acanthariola; Selaginella tortipilla*
selaginella, basket–*Selaginella apoda*
senna–*Cassia* sp.
sesban–*Sesbania exaltata*
shrub, sweet–*Calycanthus floridus*
silverbell, Carolina–*Halesia caroliniana*
silverbell, two-wing–*Halesia diptera*
skullcap–*Scutellaria ovata; Scutellaria* sp.
skunkbush, Alleghany–*Menziesia pilosa*
smartweed–*Polygonum punctatum*
smartweed, swamp–*Polygonum hydropiperoides*
smartweed, tearthumb–*Polygonum sagittatum*
smilacina, feather–*Smilacina racemosa*
snakeroot, black–*Cimicifuga racemosa; Sanicula marilandica*
snakeroot, button–*Eryngium yuccafolium*
snakeroot, Virginia–*Aristolochia serpentaria*
snakeroot, white–*Eupatorium rugosum*
sneezeweed–*Helenium autumnale*
snowbell–*Styrax* sp.
snowbell, bigleaf–*Styrax grandifolia*
Solomon's seal–*Polygonatum pubescens*
Solomon's seal, false–*Smilacina racemosa*
Solomon's seal, small–*Polygonatum biflorum*
sourwood–*Oxydendrum arboreum*
Spanish bayonet–*Yucca* sp.
sparkleberry–*Batodendron (Vaccinium) arboreum*
spatterdock–*Nuphar (Nymphaea) advena*
spicebush–*Lindera benzoin*
spikegrass–*Dezmazeria* sp.
spikerush–*Eleocharis obtusa*
spikesedge–*Eleocharis* spp.
spleenwort, ebony–*Asplenium platyneuron*
spleenwort, maidenhair–*Asplenium trichomanes*
spleenwort, mountain–*Asplenium montanum*
spring beauty–*Claytonia virginica*
spruce, black–*Picea mariana*
spruce, red–*Picea rubens*
spurge, flowering–*Euphorbia corollata*
spurge, mottled–*Euphorbia polyonifolia*
stargrass–*Aletris aurea (lutea, obovata)*
starwort, great–*Stellaria puberia*
stenanthium, grassleaf–*Stenanthium gramineum*
stewartia, mountain–*Stewartia ovata*
sticktite–*Meibomia* sp.
stillingia–*Stillingia sylvatica*
stonecrop–*Sedum pusillum*
stonemint, Maryland–*Cunila origanoides*
storax–*Styrax spp.*
sugarberry–*Celtis* sp.
sumac, flameleaf–*Rhus copallina*
sumac, winged–*Rhus copallina*
sumpweed–*Iva imbricata*
sundew, narrowleaf–*Drosera longifolia*
sundew, roundleaf–*Drosera rotundifolia*
sundew, threadleaf–*Drosera filiformis*
sunflower–*Helianthus radula*
supplejack–*Berchemia scandens*
swallowwort–*Cynanchum palustre*
sweetbeth–*Trillium vaseyi*
sweetfern–*Comptonia peregrina*
sweetgum–*Liquidambar styraciflua*
sweetleaf, common–*Symplocus tinctoria*
sweetspire, Virginia–*Itea virginica*
switchcane–*Panicum haematomon*
switchgrass–*Panicum viratum*
sycamore–*Platanus occidentalis*
tea, Jersey–*Ceanothus americanus*
tea, Oswego–*Monarda didyma*
tephrosia, Virginia–*Tephrosia virginiana*
thimbleweed–*Anemone virginiana*
thistle, swamp–*Cirsium carolinianum*
thoroughwort–*Eupatorium semiserratum*
tickclover–*Desmodium nudum*
tickclover, bare stem–*Desmodium nudiflorum*
tickclover, dillen–*Desmodium dillenii*
tickclover, littleleaf–*Desmodium obtusum (ciliare)*
tickclover, roundleaf–*Desmodium rotundifolium*
tickclover, smooth–*Desmodium laevigatum*
tillandsia–*Tillandsia tenuifolia*
titi–*Cyrilla racemiflora*
titi, black–*Cliftonia monophylla*
tofieldia, sticky–*Tofieldia racemosa*
toothwort–*Cardamine (Dentaria) heterophylla; C. diphylla*
torreya–*Torreya taxifolia*
tree, buckwheat–*Cliftonia monophylla*
tree, Georgia fever–*Pinckneya pubens*
tree, groundsel–*Baccharis halimifolia*
tree, planer–*Planera aquatica*
trillium, Catesby's–*Trillium catesbei*
trillium, nodding–*Trillium cernuum*
trillium, sweet–*Trillium vaseyi*
troutlily–*Erythronium americanum*
tupelo, swamp–*Nyssa aquatica*
uniola, longleaf–*Uniola sessiliflora*
viburnum, arrowwood–*Viburnum dentatum*
viburnum, blackhaw–*Viburnum prunifolium*
viburnum, maple-leaf–*Viburnum acerifolium*
viburnum, possum haw–*Viburnum nudum*
viburnum, rusty black haw–*Virburnum rufidulum*
viburnum, Walter's–*Viburnum obovatum*
viburnum, witherrod–*Viburnum cassinoides*
vine, groundnut–*Apios glycine*
vine, pepper–*Ampelopsis arborea*
vine, rattan–*Berchemia scandens*
vine, sarsaparilla–*Smilax pumila*
violet, Canada–*Viola canadensis*
wakerobin–*Trillium cernuum*
wakerobin, snow–*Trillium grandiflorum*
walnut, black–*Juglans nigra*
wampee–*Peltandra virginica*
waterelm–*Planera aquatica*
watershield–*Brasenia schreberi*
waterwillow–*Decodon verticillata*
weatherway–*Hydrochloa carolinensis*
weed, alligator–*Alternanthera philoxeroides*
weed, pickerel–*Pontederia cordata*
whiteflower–*Clintonia umbellulata*
wicky–*Kalmia hirsuta*
wildbean, pink–*Strophostyles unbellata*
willow, black–*Salix nigra*
willow, Carolina–*Salix carolinianum*
willow, primrose–*Jussiaea leptocarpa*
willow, sand bar–*Salix interior*
willow, swamp water–*Justicia ovata*
willow, Virginia–*Salix virginica*
willow, water–*Justicia americana*
windflower–*Anemone quinquefolia; A. virginiana; A. thalictroides*
winterberry, mountain–*Ilex montana*
wintergreen–*Gaultheria* sp.
wintergreen, spotted–*Chimaphila maculata*
wiregrass–*Aristida stricta*
witchgrass–*Panicum armamum*
witchhazel–*Hamamelis virginiana*
woodfern–*Thelypteris normalis*
woodfern, common–*Thelypteris intermedia*
woodfern, Goldie's–*Thelypteris goldiana*
woodfern, leather–*Thelypteris marginalis*
woodfern, Louisiana–*Thelypteris ludoviciana*
woodfern, Virginia–*Thelypteris virginica*
woodsia, common–*Woodsia obtusa*
woodsorrel, American–*Oxalis montana*
wort, St. John's–*Hypericum fasciculatum; H. gentianoides; H. suffridicosum*
yam, Atlantic–*Dioscorea villosa*

yam, wild–*Dioscorea* sp.
yaupon–*Ilex vomitoria*
yellowroot–*Xanthorrhiza simplicissima*
yucca, Adam's needle–*Yucca filamentosa*
zenobia–*Zenobia* sp.

# APPENDIX III

## FRESHWATER MOLLUSCS AND CRUSTACEA

| | | | |
|---|---|---|---|
| A Tennessee | E Ochlockonee | I St. Mary's | M Altamaha |
| B Alabama | F Little | J Satilla | N Ogeechee |
| C Chattahoochee | G Alapaha | K Ocmulgee | O Savannah |
| D Flint | H Suwannee | L Oconee | (E) Endemic bivalves |

**GASTROPODA (Snails)**

cp *Campeloma floridense*
L, M
*Campeloma geniculum*
C, D, F, M, N, O
cp *Campeloma decisum*
O
cp *Vivipara georgianus*
D, K, L, M
cp *Euglandina rosacea*
O
cp *Mesodon thyroidus*
K
cp *Lioplax pilsbryi*
D, F
cp *Pomacea paludosa*
D
cp *Goniobasis floridensis*
D
p *Goniobasis boykiniana*
C, D
p *Goniobasis catenoides*
C
cp *Goniobasis viennaensis*
D
p, cp *Goniobasis curvicostata*
C, D
p, cp *Goniobasis albanyensis*
C, D
cp *Physa pumilia*
C, D
p, cp *Physa crocata*
C, D
cp *Physa heterostropha*
O
p, cp *Pseudosuccinea columella*
C, D, O
cp *Ferrissia dalli*
D
p *Ferrissia fragillus*
D
cp *Laevapex fuscus*
E
p *Somatogyrus substriatus*
D
cp *Somatogyrus virginicus*
O
cp *Amnicola limosa*
F, O
cp *Lymnaea humilis*
O
cp *Gyraulus parvus*
O
cp *Menetus dilatatus*
O

**PELECYPODA (Bivalves-Clams)**

p, cp *Villosa lienosa*
D, E, F
p, cp *Villosa vibex*
B, C, D, E, F, J, K, M, N, O
cp *Villosa villosa*
C, E, F, I
p *Villosa delumbis*
K, L, M, N, O
cp, (E) *Elliptio spinosa*
M
cp, (E) *Elliptio crassidens downiei*
B, C, J
p *Elliptio fraterna*
D, O
p, cp *Elliptio complanata*
C, D, G, K, L, N, O
p *Elliptio arctata*
B, D, O
p, cp *Elliptio strigosus*
C, D, E, F, H
cp *Elliptio congaraea*
N, O
cp, (E) *Elliptio hopetonensis*
K, L, M, O
p, cp *Elliptio lanceolata*
C, J, K, L, N, O
cp, (E) *Elliptio shepardiana*
K
p, cp *Elliptio icterina*
D, E, F, G, I, K, L, M, N, O
cp, (E) *Elliptio dariensis*
K. M
p, cp *Medionidus penicillatus*
C, D, E
cp, p *Lampsilis subangulata*
C, E, D
cp *Lampsilis anodontoides floridensis*
C, D, E, F
cp *Lampsilis claibornensis*
C, E
cp *Lampsilis cariosa*
N, O
cp, (E) *Lampsilis dolabraeformis*
K, M
cp *Lampsilis ochracea*
O
cp *Lampsilis splendida*
K, L, M, N, O
cp *Lampsilis ogeecheensis*
O
p, mts *Lampsilis excavata*
B
p, cp *Sphaerium stamineum*
C, D
p, cp *Pisidium dubium*
C, D

Spring
ck., cp *Byssanodonta singleyi*

cp *Pleurobema anasoni*
N, O

p, cp *Pleurobema pyriforme*
C, D, E

mts *Lasmigona subviridis*
O

mts *Alasmidonta laricosa*
O

p, cp *Alasmidonta triangulata*
C, D

p, (E) *Alasmidonta arcula*
K, M

cp *Carunculina pulla*
K, M, O

p *Carunculina paula*
D

p, cp *Carunculina parva*
C, D, E

p, cp *Quincuncina infuscata*
C, D, E, F, G

p, cp *Crenodonta boykiniana*
C, D, E

p *Crenodonta nelsleri*
C, D

p, cp *Uniomerus obesus*
C, D, E, F, N, O

cp *Uniomerus tetralasmus*
B, C, D, K, L, M, N, O

cp *Anodonta couperiana*
C, E, I, O

cp *Anodonta gibbosa*
C, D, E, K, M

mts, cp *Anodonta hallenbecki*
B, O

p, cp *Anodonta imbecilis*
B, C, D, E, K, M, N, O

p *Anodonta cataracta*
B, C, D, K, O

cp *Eupera cubensis*
C

cp *Eupera singleyi*
O

mts, p, cp*Corbicula manilensis*
A, B, C, D, E, H, K, N, L

**DECAPODA (Crayfish and Fresh Water Shrimp)**

p *Cambarus halli*
B

mts, p *Cambarus latimanus*
B, C, D, K, L

p *Cambarus howardi*
C

mts, p *Cambarus bartonii bartonii*
A, C, O

mts *Cambarus striatus*
B

mts *Cambarus longirostris*
A

p *Cambarus* nov. sp. B
B

p *Cambarus* nov. sp. A
B

mts *Cambarus girardianus*
A

mts *Cambarus extraneus*
A

mts *Cambarus sphenoides*
A

mts *Cambarus hiawasseensis*
A

mts, p, cp*Procambarus spiculifer*
B, C, D, E, F, G, H, J, K, L

p *Procambarus raneyi*
K

cp *Procambarus litosternum*
M

cp *Procambarus pubescens*
O

cp *Procambarus paeninsulanus*
E, F, H

cp *Procambarus seminolae*
F, H, J

cp *Procambarus pygmaeus*
H, J

mts *Procambarus acutus acutus*
A

cp *Palaemonetes paludosus*
M, O

cp *Palaemonetes kadiakensis*
C, D, E, F, H, I, J, N

cp *Macrobranchium ohione*
O

cp *Macrobranchium acanthurus*
O

mts *Orconectes spinosus*
B

mts *Orconectes erichsonianus*
A, B

mts *Orconectes rusticus forceps*
A

# APPENDIX IV

## FRESHWATER FISHES OF GEORGIA
## After Dahlberg and Scott (1971)

A Tennessee
B Alabama
C Chattahoochee
D Flint
E Ochlockonee
F Little
G Alapaha
H Suwannee
I St. Mary's
J Satilla
K Ocmulgee
L Oconee
M Altamaha
N Ogeechee
O Savannah

Chestnut Lamprey-*Ichthyomyzon castaneus*
B
Southern brook lamprey-*Ichthyomyzon gagei*
B, C, D
Mountain brook lamprey-*Icthyomyzon hubbsi*
A
Least brook lamprey-*Lampetra aepyptera*
B
Sea lamprey-*Petromyzon marinus*
K
Shortnose sturgeon-*Acipenser brevirostrum*
M
Lake sturgeon-*Acipenser fulvescens*
B
Atlantic sturgeon-*Acipenser oxyrhynchus*
M, N, O
Spotted gar-*Lepisosteus oculatus*
C, D
Longnose gar-*Lepisosteus osseus*
A, B, C, F, I, J, M, N, O
Florida gar-*Lepisosteus platyrhincus*
H, M, O
Bowfin-*Amia calva*
B, C, G, H, I, J, M, N, O
Blueback herring-*Alosa aestivalis*
M, O
Alabama shad-*Alosa alabamae*
B, F
Skipjack herring-*Alosa chrysochloris*
A, C
Hickory shad-*Alosa mediocris*
M, N, O
American shad-*Alosa sapidissima*
I, K, L, M, N, O
Gizzard shad-*Dorosoma cepedianum*
A, B, C, D, J, L, M, O
Threadfin shad-*Dorosoma petenense*
B, C, D, F, J, K, M, O
Mooneye-*Hiodon tergisus*
B
Brown trout-*Salmo trutta*
A, B, C, O
Rainbow trout-*Salmo gairdneri*
A, B, C, O
Brook trout-*Salvelinus fontinalis*
A, B, C, O
Eastern mudminnow-*Umbra pygmaea*
H, I, N, O
Redfin or grass pickerel-*Esox americanus*
B, C, D, E, F, G, H, I, J, K, L, M, N, O
Chain pickerel-*Esox niger*
B, C, D, F, G, H, I, J, K, L, M, N, O
Stoneroller-*Campostoma anomalum*
A, B, C, D, K, L, O
Goldfish-*Carassius auratus*
C, K, O

Rosyside dace-*Clinostomus funduloides*
A, O
Carp-*Cyprinus carpio*
A, C, L, M, O
Silverjaw minnow-*Ericymba buccata*
C, D
Flame chub-*Hemitremia flammea*
A
Silvery minnow-*Hybognathus nuchalis*
K, L, M, O
Speckled chub-*Hybopsis aestivalis*
B
Bigeye chub-*Hybopsis amblops*
A
Redeye chub-*Hybopsis harperi*
C, D, K, L
Blotched chub—*Hybopsis insignis*
A
*Hybopsis* sp. cf. *amblops*
C, D, E
*Hybopsis* sp. cf. *amblops*
B
Bluehead chub-*Nocomis leptocephalus*
B, C, K, L, N, O
River chub-*Nocomis micropogon*
A, B, O
Golden shiner-*Notemigonus crysoleucas*
A, B, C, D, E, F, G, J, K, L, M, N, O
Rosefin shiner-*Notropis ardens*
A
Popeye shiner-*Notropis ariommus*
A
Burrhead shiner-*Notropis asperifrons*
B
Emerald shiner-*Notropis atherinoides*
A
Rough shiner-*Notropis baileyi*
C
Blue shiner-*Notropis caerulens*
B
Ocmulgee shiner-*Notropis callisemi*
K, L, M
Alabama shiner-*Notropis callistius*
B
Bluestripe shiner-*Notropis callitaenia*
C, D
Ironcolor shiner-*Notropis chalybaeus*
D, F, G, I, J, K, M, N, O
Rainbow shiner-*Notropis chrosomus*
B
Striped shiner-*Notropis chrysocephalus*
A, B
Warpaint shiner-*Notropis coccogenis*
A, O
Dusky shiner-*Notropis cummingsae*
C, E, K, L, M, N, O

Pugnose minnow-*Notropis emiliae*
C, D, E, F, G, I, J, L, M, N, O
Broadstripe shiner-*Notropis euryzonus*
C
Whitetail shiner-*Notropis galacturus*
A, O
Tallapoosa shiner-*Notropis biggsi*
B
Spottail shiner-*Notropis hudsonius*
C, J, K, L, M, N
Sailfin shiner-*Notropis hypselopterus*
C, D, E, F, G, J, K, L, M, N, O
Highscale shiner-*Notropis hypsilepis*
C, D, O
Ohoopee shiner-*Notropis leedsi*
E, F, G, M, N, O
Tennessee shiner-*Notropis leuciodus*
A, O
Mountain shiner-*Notropis lirus*
B
Longnose shiner-*Notropis longirostris*
D, M
Yellowfin shiner-*Notropis lutipinnis*
C, K, L, M, N, O
Taillight shiner-*Notropis maculatus*
C, D, E, F, G, I, J, K, M, N, O
Whitefin shiner-*Notropis niveus*
O
Coastal shiner-*Notropis petersoni*
C, D, F, G, H, I, J, K, L, M, N, O
Silver shiner-*Notropis photogenis*
A
Sandbar shiner-*Notropis scepticus*
O
Mirror shiner-*Notropis spectrunculus*
A, O
Spotfin shiner-*Notropis spilopterus*
A
Silverstripe shiner-*Notropis stilbius*
B
Weed shiner-*Notropis texanus*
C, D, E, F, G
Tricolor shiner-*Notropis trichroistius*
B
Blacktail shiner-*Notropis venustus*
B, C, D, F, G
Mimic shiner-*Notropis volucellus*
A, B
Coosa shiner-*Notropis xaenocephalus*
B, C
Altamaha shiner-*Notropis xaenurus*
K, L
Bandfin shiner-*Notropis zonistius*
B, C, D, L, O
*Notropis* sp. cf. *bellus*
C, D
Riffle minnow-*Phanacobius catostomus*
B
Fatlips minnow-*Phenacobius crassilabrum*
A
Bluntnose minnow-*Pimephales notatus*
A, B
Fathead minnow-*Pimephales promelas*
M
Bullhead minnow-*Pimephales vigilax*
A, B
Blacknose dace-*Rhinichthys atratulus*
A, B
Longnose dace-*Rhinichthys cataractae*
A
Creek chub-*Semotilus atromaculatus*
A, B, C, D, L, O
Quillback-*Carpiodes cyprinus*
B, C
*Carpiodes* sp. cf. *cyprinus*
M, O
*Carpiodes* sp. cf. *velifer*
M, O

White sucker-*Catostomus commersoni*
A
Creek chubsucker-*Erimyzon oblongus*
D, K, M, N, O
Lake chubsucker-*Erimyzon sucetta*
C, D, E, F, G, H, I, J, K, M, N, O
Alabama hogsucker-*Hypentelium etowanum*
B, C
Northern hogsucker-*Hypentelium nigricans*
A, L, O
Smallmouth buffalo-*Ictiobus bubalus*
B
Spotted sucker-*Minytrema melanops*
A, B, C, D, F, G, J, K, M, N, O
Silver redhorse-*Moxostoma anisurum*
K, L, M, O
Black redhorse-*Moxostoma duquesnei*
A, B
Golden redhorse-*Moxostoma erythrurum*
A, B
Greater jumprock-*Moxostoma lachneri*
C, D
Blacktail redhorse-*Moxostoma poecilurum*
B
Smallfin redhorse-*Moxostoma robustum*
L, O
Striped jumprock-*Moxostoma rupiscartes*
C, K, L, O
Grayfin redhorse-*Moxostoma* sp. cf. *poecilurum*
C, D
Snail bullhead-*Ictalurus brunneus*
C, D, K, L, M, N, O
White catfish-*Ictalurus catus*
C, H, I, L, M, N, O
Black bullhead-*Ictalurus melas*
B
Yellow bullhead-*Ictalurus natalis*
A, B, C, D, E, F, G, H, I, J, K, L, M, N, O
Brown bullhead-*Ictalurus nebulosus*
B, C, D, F, G, H, I, J, K, L, M, N, O
Flatbullhead-*Ictalurus platycephalus*
K, L, M, N, O
Channel catfish-*Ictalurus punctatus*
A, B, C, D, F, G, I, J, K, L, M, N, O
Spotted bullhead-*Ictalurus serracanthus*
C, D, F, G
Mountain madtom-*Noturus eleutherus*
A
Yellowfin madtom-*Noturus flavipinnis*
A
Black madtom-*Noturus funebris*
B
Tadpole madtom-*Noturus gyrinus*
C, D, E, F, G, H, I, J, K, L, M, N, O
Margined madtom-*Noturus insignis*
L, O
Speckled madtom-*Noturus leptacanthus*
B, C, D, E, F, G, I, J, K, L, M, N, O
Flathead catfish-*Pylodictis olivaris*
A, B, D, O
Swampfish-*Chologaster cornuta*
K, M, N, O
Pirate perch-*Aphredoderus sayanus*
C, D, E, F, G, H, I, J, K, L, M, N, O
Northern studfish-*Fundulus catenatus*
A
Golden topminnow-*Fundulus chrysotus*
D, G, H, I, K, M, N, O
Banded topminnow-*Fundulus angulatus*
H, I, J
Starhead minnow-*Fundulus notti*
C, D, E, F, G, H, I, J, K, M, N, O
Blackspotted minnow-*Fundulus olivaceus*
A, B, C
Southern studfish-*Fundulus stellifer*
A, B, C
Pygmy killifish-*Leptolucania ommata*
F, G, H, I, J, M, N

Bluefin killifish–*Lucania goodei*
M, N
Mosquitofish–*Gambusia affinis*
A, B, C, D, E, F, G, H, I, J, K, L, M, N, O
Least killifish–*Heterandria formosa*
D, F, G, I, J, M, N, O
Brook silverside–*Labidesthes sicculus*
A, C, D, E, F, G, H, I, J, K, M, N, O
White bass–*Morone chrysops*
A, B, C, D, K, L, M, O
Striped bass–*Morone saxatilis*
C, D, J, K, L, M, N, O
Mud sunfish–*Acantharchus pomotis*
E, F, G, H, J, K, M, N, O
Rock bass–*Amboloplites rupestris*
A, B, C, D
Flier–*Centrarchus macropterus*
C, D, E, F, G, H, I, J, K, M, N, O
Everglades pygmy sunfish–*Elassoma evergladei*
D, F, G, H, I, J, K, L, M, O
Okefenokee pygmy sunfish–*Elassoma okefenokee*
F, G, H, I, J, M
Banded pygmy sunfish–*Elassoma zonatum*
C, D, F, G, I, J, K, L, M, N, O
Blackbanded sunfish–*Enneacanthus chaetodon*
H, O
Bluespotted sunfish–*Ennaecanthus gloriosus*
D, E, F, G, H, I, J, K, M, N, O
Banded sunfish–*Enneacanthus obesus*
G, H, I, J, M, N, O
Redbreast sunfish–*Lepomis auritus*
A, B, C, D, E, F, G, H, I, J, K, L, M, N, O
Green sunfish–*Lepomis cyanellus*
A, B, C, L, O
Pumpkinseed–*Lepomis gibbosus*
O
Warmouth–*Lepomis gulosus*
A, B, C, D, E, F, G, H, I, J, K, L, M, N, O
Orangespotted sunfish–*Lepomis humilis*
C
Bluegill–*Lepomis macrochirus*
A, B, C, D, E, F, G, H, I, J, K, L, M, N, O
Dollar sunfish–*Lepomis marginatus*
B, C, D, E, F, G, H, I, J, K, L, M, N, O
Longear sunfish–*Lepomis megalotis*
A, B, C
Redear sunfish–*Lepomis microlophus*
A, B, C, D, F, I, J, K, L, M, N, O
Spotted sunfish, stumpknocker–*Lepomis punctatus*
A, B, C, D, E, F, G, H, I, J, K, L, M, N, O
Redeye bass–*Micropterus coosae*
A, B, C, D, K, L, O
Smallmouth bass–*Micropterus dolomieui*
A, B, C, O
Spotted bass–*Micropterus punctulatus*
A, B, C, L
Largemouth bass–*Micropterus salmoides*
A, B, C, D, E, F, G, H, I, J, K, L, M, N, O
White crappie–*Pomoxis annularis*
A, B, C, D, K, L, O
Black crappie–*Pomoxis nigromaculatus*
A, B, C, D, E, F, G, I, J, K, L, M, N, O
Greenside darter–*Etheostoma blennioides*
A
Rainbow darter–*Etheostoma caeruleum*
A
Ashy darter–*Etheostoma cinereum*
A
Coosa darter–*Etheostoma coosae*
B
Coldwater darter–*Etheostoma ditrema*
B
Brown darter–*Etheostoma edwini*
C, D, E
Savannah darter–*Etheostoma fricksium*
O
Swamp darter–*Etheostoma fusiforme*
C, D, E, F, G, H, I, J, K, M, N, O
Christmas darter–*Etheostoma hopkinsi*
K, L, M, N, O
Turquoise darter–*Etheostoma inscriptum*
K, L, N, O
Blueside darter–*Etheostoma jessiae*
A
Greenbreast darter–*Etheostoma jordani*
B
Tessellated darter–*Etheostoma olmstedi*
K, L, M, N, O
Goldstripe darter–*Etheostoma parvipinne*
C, D, K
Redline darter–*Ethostoma rufilineatum*
A
Rock darter–*Etheostoma rupestre*
B
Sawcheek darter–*Etheostoma serriferum*
N, O
Tennessee snubnose darter–*Etheostoma simoterum*
A
Speckled darter–*Etheostoma stigmaeum*
B
Gulf darter–*Etheostoma swaini*
C, D, E
Trispot darter–*Etheostoma trisella*
B
Banded darter–*Etheostoma zonale*
A
*Etheostoma* sp. cf. *camurum*
A
*Etheostoma* sp. cf. *coosae*
B
*Etheostoma* sp. cf. *coosae*
B
Yellow perch–*Perca flavescens*
A, C, K, M, O
Tangerine darter–*Percina aurantiaca*
A
Goldline darter–*Percina aurolineata*
B
Logperch–*Percina caprodes*
A, B
Gilt darter–*Percina evides*
A
Freckled darter–*Percina lenticula*
B
Blackside darter–*Percina maculata*
A
Blackbanded darter–*Percina nigrofasciata*
B, C, D, E, F, G, K, L, M, N, O
Bronze darter–*Percina palmaris*
B
Olive darter–*Percina squamata*
A
Bridled darter–*Percina* sp. cf. *maculata*
B
*Percina* sp. cf. *uranidea*
B
Sauger–*Stizostedion canadense*
A, C, O
Walleye–*Stizostedion vitreum*
A, B, C, L, O
Freshwater drum–*Aplodinotus grunniens*
A, B
Mottled sculpin–*Cottus bairdi*
A, B, C, N
Banded sculpin–*Cottus carolinae*
A, B, C

# APPENDIX V

## BIRDS WHICH BREED AT HIGH ELEVATIONS IN THE BLUE RIDGE SECTOR After Hubbard (1971)

*Buteonidae*
- Golden Eagle

*Scolopacidae*
- Common Snipe

*Strigidae*
- Saw-whet Owl

*Picidae*
- Yellow-bellied Sapsucker

*Tyrannidae* (flycatchers)
- Trail Flycatcher
- Least Flycatcher
- Olive-sided Flycatcher

*Corvidae*
- Common Raven

*Paridae*
- Black-capped Chickadee

*Sittidae*
- Red-breasted Nuthatch

*Certhiidae*
- Brown Creeper

*Troglodytidae*
- Winter Wren

*Turdidae* (thrushes)
- Hermit Thrush
- Swainson Thrush
- Veery

*Sylviidae*
- Golden-crowned Kinglet

*Vireoniidae*
- Solitary Vireo

*Parulidae* (warblers)
- Golden-winged Warbler
- Nashville Warbler
- Magnolia Warbler
- Blackburnian Warbler
- Black-throated blue Warbler
- Chestnut-sided Warbler
- Northern Water Thrush
- Mourning Warbler
- Canada Warbler

*Icteridae*
- Bobolink

*Fringillidae* (finches)
- Rose-breasted Grosbeak
- Purple Finch
- Pine Siskin
- Red Crossbill
- Savannah Sparrow
- Slate-colored Junco
- White-throated Sparrow
- Swamp Sparrow

# APPENDIX VI

## VERTEBRATES OF GEORGIA, EXCLUSIVE OF FISH AND BIRDS

**KEY TO FAUNA:**

| | |
|---|---|
| CP | Coastal Plain |
| P | Piedmont |
| MT | Mountains |
| CV | Coosa Valley |
| GV | Great Valley |
| RV | Ridge and Valley |

**Habitat**

| | |
|---|---|
| H | **Hydric and lower floodplain** (gum-cypress association), aquatic or amphibious or streams (MT and Piedmont). |
| M | **Very mesic forest** — bottomland hardwoods, drier floodplain terraces, creek swamps, bay swamps, etc. |
| X | **Mesic to xeric forests** — higher hammocks and upland forests. |
| XB | **Boreal forest extensions** — high altitude deciduous forests. |
| SX | **Xeric** — well-drained sandy soils (as in sandhills) with pine **uplands** dominant canopy; fire-adapted; non-carnivores arboreal or fossorial. |
| SH | **Xeric** — poorly drained sandy soils (Pleistocene flatwoods, pond edges and higher but moist pine forests). |

**SALAMANDERS**

| | |
|---|---|
| MT/H | hellbender–*Cryptobranchus alleganiensis alleganiensis* |
| MT/H | common mudpuppy–*Necturus maculosus maculosus* |
| MT/H | Cherokee–*Desmognathus aeneus aeneus* |
| MT/H | Chermock's pigmy–*Desmognathus aeneus chermocki* |
| MT/H | seal–*Desmognathus monticola* |
| MT/H | black-bellied–*Desmognathus quadramaculatus* |
| MT/H | shovel-nosed–*Leurognathus marmoratus* |
| MT/H | Blue Ridge two-lined–*Eurycea bislineata wilderae* |
| MT/H | Carolina mountain spring–*Gyrinophilus porphyriticus dunni* |
| MT/H/M | black-chinned red–*Pseudotriton ruber schencki* |
| MT/H/M | long-tailed–*Eurycea longicauda longicauda* |
| MT/H/XB | mountain dusky–*Desmognathus ochrophaeus* |
| MT/X | green–*Aneides aeneus* |
| MT/X/XB | Appalachian woodland–*Plethodon jordani* |
| P/M | small-mouthed–*Ambystoma texanum* |
| P/M | eastern four-toed–*Hemidactylium scutatum* |
| P/X | Georgia red-backed–*Plethodon cinereus polycentratus* |
| P/H/M | eastern mud–*Pseudotriton montanus montanus* |
| P/H/M | southern two-lined–*Eurycea bislineata cirrigera* |
| P/H/M | three-lined–*Eurycea longicauda guttolineata* |
| P/H/M/X | northern red–*Pseudotriton ruber ruber* |
| CP/H | dwarf water dog (upper NE CP)–*Necturus punctatus* |
| CP/H | mobile water dog (upper SW CP)–*Necturus punctatus lodingi* |
| CP/H | Alabama water dog–*Necturus alabamensis* |
| CP/H | greater siren–*Siren lacertina* |
| CP/H | eastern lesser siren–*Siren intermedia intermedia* |
| CP/H | broad-striped siren (S.E.)–*Pseudobranchus striatus striatus* |
| CP/H | narrow-striped mud (Okefenokee) siren–*Pseudobranchus striatus axanthus* |
| CP/H | slender dwarf siren (S.W.)–*Pseudobranchus striatus spheniscus* |
| CP/H | one-toed amphiuma–*Amphiuma pholeter* |
| CP/H | two-toed amphiuma–*Amphiuma means* |
| CP/H | three-toed amphiuma–*Amphiuma tridactylum* |
| CP/H | margined–*Stereochilus marginatus* |
| CP/H | Georgia blind–*Haideotriton wallacei* |
| CP/H | southern red (SW and mid CP)–*Pseudotriton ruber vioscai* |
| CP/H | dwarf four-toed–*Eurycea quadridigitata* |
| CP/H/M | southern dusky–*Desmognathus auriculatus* |
| CP/H/M | Brimley's dusky–*Desmognathus brimleyorum* |
| CP/H/M | gulf coast mud–*Pseudotriton montanus flavissimus* |
| CP/H/M | rusty mud (extreme S. CP)–*Pseudotriton montanus floridanus* |
| CP/M/X | tiger–*Ambystoma tigrinum tigrinum* |
| CP/SH | frosted flatwoods–*Ambystoma cingulatum* |
| CP/SH | western reticulated–*Ambystoma cingulatum bishopi* |
| CP/SH | Mabee's–*Ambystoma mabeei* |
| CP/H/SH | striped newt–*Notophthalmus perstriatus* |
| CP/H/M/SH | central newt–*Notophthalmus viridescens louisianensis* |
| RV/H | northeast purple–*Gyrinophilus porphyriticus porphyriticus* |
| RV/H | northern two-lined–*Eurycea bislineata bislineata* |
| RV | cave–*Eurycea lucifuga* |
| RV/H/X | zig-zag–*Plethodon dorsalis dorsalis* |
| MT/H/XB | mountain dusky–*Desmognathus ochrophaeus* |
| MT/P/X | red-backed–*Plethodon cinereus cinereus* |
| MT/P/X/XB | red-spotted newt–*Notophthalmus viridescens viridescens* |
| MT/P/M/H | northern dusky–*Desmognthus fuscus fuscus* |
| CP/P/M | mole–*Ambystoma talpoideum* |
| CP/P/M/H | marbled–*Ambystoma opacum* |
| MT/P/CP/X | slimy–*Plethodon glutinosus glutinosus* |
| MT/P/CP/X/M | spotted (upper CP)–*Ambystoma maculatum* |
| MT/P/CP/H | spotted dusky–*Desmognathus fuscus conanti* |

**FROGS AND TOADS**

| | |
|---|---|
| MT/X | mountain chorus frog–*Pseudacris brachyphona* |
| MT/X | northern leopard frog–*Rana pipiens* |
| MT/X/XB | wood frog–*Rana sylvatica* |
| P/X | eastern chorus frog–*Pseudacris nigrita feriarum* |
| CP | southern spring peeper–*Hyla crucifer bartramiana* |
| CP/H | pig frog–*Rana grylio* |
| CP/H | river frog–*Rana heckscheri* |

| | |
|---|---|
| CP/H/M | Florida cricket frog–*Acris gryllus dorsalis* |
| CP/H/M | southern cricket frog–*Acris gryllus gryllus* |
| CP/H/M | carpenter frog–*Rana virgatipes* |
| CP/SH/M | Brimley's chorus frog (extreme E. CP)–*Pseudacris brimleyi* |
| CP/SH/M | southern chorus frog–*Pseudacris nigrita nigrita* |
| CP/M/SH | little grass frog–*Limnaoedus ocularis* |
| CP/X/SH | southern toad–*Bufo terrestris* |
| CP/SH/X | squirrel tree frog–*Hyla squirella* |
| CP/SX | Anderson's tree frog–*Hyla andersoni* |
| CP/SX | gopher frog–*Rana areolata aesopus* (Fla); *Rana areolata capito* (Car.) |
| CP/SX | dusky gopher frog–*Rana areolata sevosa* |
| CP/SH | ornate chorus frog–*Pseudacris ornata* |
| CP/SH | pine woods tree frog–*Hyla femoralis* |
| CP/SX/SH | oak toad–*Bufo quercicus* |
| CP/CX/SH | barking tree frog–*Hyla gratiosa* |
| CP/RV/P/X/SX | eastern spadefoot toad–*Scaphiopus holbrooki holbrooki* |
| MT/P/X | northern cricket frog–*Acris crepitans crepitans* |
| MT/P/X | northern spring peeper–*Hyla crucifer crucifer* |
| MT/P/X | northern green frog–*Rana clamitans melanota* |
| MT/P/X | pickerel frog–*Rana palustris* |
| MT/P/M/X | American toad–*Bufo americanus americanus* |
| CP/P/H/M | green tree frog–*Hyla cinerea* |
| CP/P/H/M | bird-voiced tree frog–*Hyla avivoca avivoca* |
| CP/P/H/M | eastern bird-voiced tree frog–*Hyla avivoca ogechiensis* |
| CP/P/H/M | bronze frog–*Rana clamitans clamitans* |
| CP/P/H/M | southern leopard frog–*Rana utricularia* |
| CP/P/SH/M | upland chorus frog–*Pseudacris triseriata feriarum* |
| CP/P/CV/M | eastern narrow-mouthed toad–*Gastrophryne carolinensis* |
| MT/CP/P/H | bullfrog–*Rana catesbeiana* |
| MT/CP/P/M/X | gray tree frog–*Hyla versicolor* |
| MT/CP/P/X/SH/W | Fowler's toad (S.W. and upper CP)–*Bufo woodhousei fowleri* |

**TURTLES**

| | |
|---|---|
| MT/XB | Muhlenberg's (bog)–*Clemmys muhlenbergi* |
| P/M/X | three-toed box–*Terrapene carolina triunguis* |
| CP | diamondback terrapin (coastal)–*Malaclemys terrapin centrata* |
| CP | Atlantic green–*Chelonia mydas mydas* |
| CP | Atlantic hawkbill–*Eretmochelys imbricata imbricata* |
| CP | Atlantic ridley–*Lepidochelys kempi* |
| CP | Atlantic loggerhead–*Caretta caretta caretta* |
| CP | Atlantic leatherback–*Dermochelys coriacea coriacea* |
| CP/H | alligator snapper (Gulf drain E. to Suwanee)–*Macroclemys temmincki* |
| CP/H | stinkpot–*Sternotherus odoratus* |
| CP/H | striped mud (extreme S. CP)–*Kinosternon bauri palmarum* |
| CP/H | eastern mud–*Kinosternon subrubrum subrubrum* |
| CP/H | southern painted–*Chrysemys picta dorsalis* |
| CP/H | Florida cooter–*Chrysemys floridana floridana* |
| CP/H | mobile cooter (S.W. Ga.)–*Chrysemys concinna mobilensis* |
| CP/H | red-eared (extreme S.W. Ga.)–*Chrysemys scripta elegans* |
| CP/H | chicken–*Deirochelys reticularia reticularia* |
| CP/H | Florida softshell–*Trionyx ferox* |
| CP/H/M | spotted–*Clemmys guttata* |
| CP/M/X | eastern box–*Terrapene carolina carolina* |
| CP/M/X | Florida box–*Terrapene carolina bauri* |
| CP/M/X | Gulf coast box–*Terrapene carolina major* |
| CP/SX | gopher–*Gopherus polyphemus* |
| CV/H | stripe-necked musk–*Sternotherus minor peltifer* |
| CV/H | map–*Graptemys geographica* |
| CV/H | midland painted–*Chrysemys picta marginata* |
| RV/CV/H | Cumberland–*Chrysemys scripta troosti* |
| MT/P/H | eastern painted–*Chrysemys picta picta* |
| CP/P/H | loggerhead musk (Flint)–*Sternotherus minor nor* |
| CP/P/H | Barbour's map–*Graptemys barbouri* |
| CP/P/H | river cooter–*Chrysemys concinna concinna* |
| CP/P/H | yellow-bellied–*Chrysemys scripta scripta* |
| CP/P/H | Gulf coast spiny softshell–*Trionyx spiniferus asperus* |
| MT/CP/P/H | snapper–*Chelydra serpentina serpentina* |
| MT/CP/P/H | Florida snapper–*Chelydra serpentina osceola* |
| MT/CP/P/H | Gulf coast smooth softshell–*Trionyx muticus calvatus* |

**LIZARDS**

| | |
|---|---|
| MT/XB/X | northern coal skink–*Eumeces anthracinus anthracinus* |
| MT/XB/X | southern coal skink–*Eumeces anthracinus pluvialis* |
| CP/X | eastern glass–*Ophisaurus ventralis* |
| CP/X | island glass–*Ophisaurus compressus* |
| CP/SX | striped red-tailed (c)–*Eumeces egregius egregius* |
| CP/SX | red-tailed skink (c)–*Eumeces egregius similis* |
| CP/X/SX | southern fence–*Sceloporus undulatus undulatus* |
| MT/P/X | northern fence–*Sceloporus undulatus hyacinthinus* |
| CP/P/X | slender glass–*Ophisaurus attenuatus longicaudus* |
| MT/CP/P/M | green anole (a)–*Anolis carolinensis carolinensis* |
| MT/CP/P/M | five-lined skink–*Eumeces fasciatus* |
| MT/CP/P/X | ground skink (e)–*Leiolopisma laterale* |
| MT/CP/P/X | broad-headed skink (a)–*Eumeces laticeps* |
| MT/CP/P/X | S.E. five-lined skink–*Eumeces inexpectatus* |
| MT/CP/P/SX | 6-lined race runner–*Cnemidophorus sexlineatus* |

**SNAKES**

| | |
|---|---|
| MT/H | northern banded water–*Natrix sipedon sipedon* |
| MT/X | northern ringneck–*Diadophis punctatus edwardsi* |
| MT/X | black rat–*Elaphe obsoleta obsoleta* |
| MT/X | eastern milk–*Lampropeltis triangulum triangulum* |
| P/H | yellow-bellied water–*Natrix erythrogaster flavigaster* |
| P/H | midland banded water–*Natrix sipedon pleuralis* |
| P/X | Carolina pygmy rattlesnake–*Sistrurus miliarius miliarius* |
| P/X | midwest worm–*Carphophis amoenus helenae* |
| CP/H | glossy water–*Natrix rigida rigida* |
| CP/H | green water–*Natrix cyclopion cyclopion* |
| CP/H | Florida green water–*Natrix cyclopion floridana* |
| CP/H | southern banded water–*Natrix fasciata fasciata* |
| CP/H | Florida banded water–*Natrix fasciata pictiventris* |
| CP/H | Gulf glossy water–*Natrix rigida sinicola* |
| CP/H | black swamp–*Seminatrix pygaea pygaea* |
| CP/H | striped swamp (extreme S. CP)–*Liodytes alleni* |
| CP/H | rainbow–*Farancia erythrogramma erythrogramma* |
| CP/H | eastern mud–*Farancia abacura abacura* |
| CP/H | Florida cottonmouth–*Agkistrodon piscivorus conanti* |
| CP/M | canebrake rattlesnake–*Crotalus horridus atricaudatus* |
| CP/X | Florida brown–*Storeria dekayi victa* |
| CP/X | Florida red-bellied–*Storeria occipitomaculata obscura* |
| CP/X | southern hognose–*Heterodon simus* |
| CP/X | yellow rat–*Elaphe obsoleta quadrivittata* |
| CP/X | southern copperhead–*Agkistrodon contortrix contortrix* |
| CP/X | dusky pygmy rattlesnake–*Sistrurus miliarius barbouri* |
| CP/SX | southern black racer–*Coluber constrictor priapus* |
| CP/SX | indigo–*Drymarchon corais couperi* |
| CP/SX/X | Florida pine–*Pituophis melanoleucas mugitus* |
| CP/SX/X | coral–*Micrurus fulvius fulvius* |
| CP/SX/X | E. diamondback rattlesnake–*Crotalus adamanteus* |
| CP/SH | yellow-lipped–*Rhadinaea flavilata* |
| MT/RV/X | DeKay's brown–*Storeria dekayi dekayi* |
| MT/P/H | queen–*Natrix septemvittata* |

| | |
|---|---|
| MT/P/X | eastern worm–*Carphophis amoenus amoenus* |
| MT/P/X | northern black racer–*Coluber constrictor constrictor* |
| MT/P/X | black king–*Lampropeltis getulus niger* |
| MT/P/X | northern pine–*Pituophis melanoleucas melanoleucas* |
| MT/P/X | northern copperhead–*Agkistrodon contortrix mokason* |
| CP/P/H | red-bellied water–*Natrix erythrogaster erythrogaster* |
| CP/P/H | brown water–*Natrix taxispilota* |
| CP/P/X | midland brown–*Storeria dekayi wrightorum* |
| CP/P/X | southern ringneck–*Diadophis punctatus punctatus* |
| CP/P/M/X | gray rat–*Elaphe obsoleta spiloides* |
| CP/P/SH/X | scarlet king–*Lampropeltis triangulum elapsoides* |
| CP/P/H | eastern cottonmouth–*Agkistrodon piscivorus piscivorus* |
| CV/MT/RV/P/X | timber rattlesnake–*Crotalus horridus horridus* |
| MT/P/CP | southern ground–*Virginia striatula* |
| MT/P/CP | king–*Lampropeltis getulus getulus* |
| MT/P/CP/M | eastern ribbon–*Thamnophis sauritus sauritus* |
| MT/P/CP/M | southern ribbon–*Thamnophis sauritus sackeni* |
| MT/P/CP/X | red-bellied–*Storeria occipitomaculata occipitomaculata* |
| MT/P/CP/X | eastern hognose–*Heterodon platyrhinos* |
| MT/P/CP/X | rough green (keeled green)–*Opheodrys aestivus* |
| MT/P/CP/X | mole–*Lampropeltis calligaster rhombomaculata* |
| MT/P/CP/M/X | corn–*Elaphe guttata guttata* |
| MT/P/CP/SX | coachwhip–*Masticophis flagellum flagellum* |
| MT/P/CP/SX | northern scarlet–*Cemophora coccinea copei* |
| MT/P/CP/SX | crowned–*Tantilla coronata* |
| MT/P/CP/M/X/SH | garter–*Thamnophis sirtalis sirtalis* |
| MT/P/CP/X/SH | smooth earth–*Virginia valeriae valeriae* |
| RV/GV/H | western cottonmouth–*Agkistrodon piscivorus leucostoma* |

**MAMMALS OF GEORGIA**

| | |
|---|---|
| MT | *Myotis sodalis*–Indiana myotis |
| MT/XB | *Sorex cinereus*–Masked shrew |
| MT/XB | *Microsorex hoyi*–Pigmy shrew |
| MT/XB | *Tamiasciurus hudsonicus*–Red squirrel |
| MT/XB | *Peromyscus maniculatus*–Deer mouse |
| MT/XB | *Clethrionomys gapperi*–Red-backed vole |
| MT/X/XB | *Sorex fumeus*–Smoky shrew |
| MT/X/XB | *Sylvilagus transitionalis*–Wood rabbit |
| MT/X/XB | *Napeozapus insignis*–Woodland jumping mouse |
| P | *Lasionycteris noctivagans*–Silver haired bat |
| CP | *Myotis austroriparius*–S. E. myotis |
| CP | *Dasypterus floridanus*–Florida yellow bat |
| CP | *Tadarida brasiliensis*–Brazilian free-tailed bat |
| CP/H | *Condylura cristata*–Star-nosed mole |
| CP/H | *Neofiber alleni* (lower coastal plain)–Round-tailed muskrat |
| CP/M | *Sylvilagus palustris* (lower CP)–Marsh rabbit |
| CP/SX | *Geomys pinetis*–S.E. pocket gopher |
| CP/SX | *Geomys colonus*–Colonial pocket gopher |
| CP/SX | *Geomys fontanelus*–Sherman's pocket gopher |
| CP/SX | *Geomys cumberlandius*–Cumberland Island pocket gopher |
| CP/SX/SH | *Dasypus novemcinctus*–Nine-banded armadillo |
| MT/P | *Myotis keenii*–Keen's myotis |
| MT/P | *Reithrodontomys humulis*–Harvest mouse |
| MT/P | *Microtus pennsylvanicus*–Meadow vole |
| MT/P/M | *Zapus hudsonius*–Meadow jumping mouse |
| MT/P/X | *Marmota monax*–Ground hog |
| MT/P/X | *Tamias striatus*–Eastern chipmunk |
| MT/P/M/X | *Peromyscus leucopus*–White-footed mouse |
| MT/CP | *Corynorhinus macrotis*–Big eared bat |
| MT/CP/M | *Neotoma floridana*–Eastern wood rat |
| MT/CP/M | *Felis concolor*–Mountain lion, cougar, puma |
| P/CP | *Lasiurus seminolus*–Seminole, Mahogany bat |
| P/CP/H | *Castor canadensis*–Beaver |
| P/CP/H | *Lutra canadensis*–River otter |
| P/CP/M | *Sorex longirostris*–S.E. shrew |
| P/CP/M/X | *Lasiurus cinereus*–Hoary bat |
| P/CP/X/SH | *Peromyscus gossypinus*–Cotton mouse |
| MT/P/CP | *Cryptotis parva*–Least shrew |
| MT/P/CP | *Myotis lucifugus*–Little brown myotis |
| MT/P/CP | *Pipistrellus subflavus*–Eastern pipistrelle |
| MT/P/CP | *Eptesicus fuscus*–Big brown bat |
| MT/P/CP | *Lasiurus borealis*–Red bat |
| MT/P/CP | *Nycticeius humeralis*–Evening bat |
| MT/P/CP | *Sigmodon hispidus*–Cotton rat |
| MT/P/CP/H | *Oryzomys palustris*–Rice rat |
| MT/P/CP/H | *Ondatra zibethicus* (upper CP)–Muskrat |
| MT/P/CP/H | *Mustela vison*–Mink |
| MT/P/CP/M | *Peromyscus nuttalli*–Golden mouse |
| MT/P/CP/M | *Ursus americanus*–Black bear |
| MT/P/CP/X | *Didelphis marsupialis*–Opossum |
| MT/CP/P/H/M | *Sylvilagus aquaticus* (upper CP)–Swamp rabbit, cane cutter |
| MT/CP/P/H/M | *Procyon lotor*–Raccoon |
| MT/P/CP/M/X | *Blarina brevicauda*–Short-tailed shrew |
| MT/P/CP/M/X | *Scalopus aquaticus*–Eastern mole |
| MT/P/CP/M/X | *Sciurus carolinensis*–Gray squirrel |
| MT/P/CP/M/X | *Glaucomys volans*–Southern flying squirrel |
| MT/P/CP/M/X | *Pitymys pinetorum*–Pine vole |
| MT/P/CP/M/X | *Mustela frenata*–Long-tailed weasel |
| MT/P/CP/M/X | *Lynx rufus*–Bobcat |
| MT/P/CP/M/X | *Odocoileus virginianus*–White-tailed deer |
| MT/P/CP/SX | *Peromyscus polionotus*–Old-field mouse |
| MT/P/CP/SX/X | *Sciurus niger*–Fox squirrel |
| MT/P/CP/SX/X | *Vulpes fulva*–Red fox |
| MT/P/CP/SX/X | *Urocyon cinereoargenteus*–Gray fox |
| MT/P/CP/SX/X | *Spilogale putorius*–East. spotted skunk, polecat |
| MT/P/CP/SX/X | *Mephitis mephitis*–Striped skunk |
| MT/P/CP/SX/SH | *Sylvilagus floridanus*–Cottontail rabbit |

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