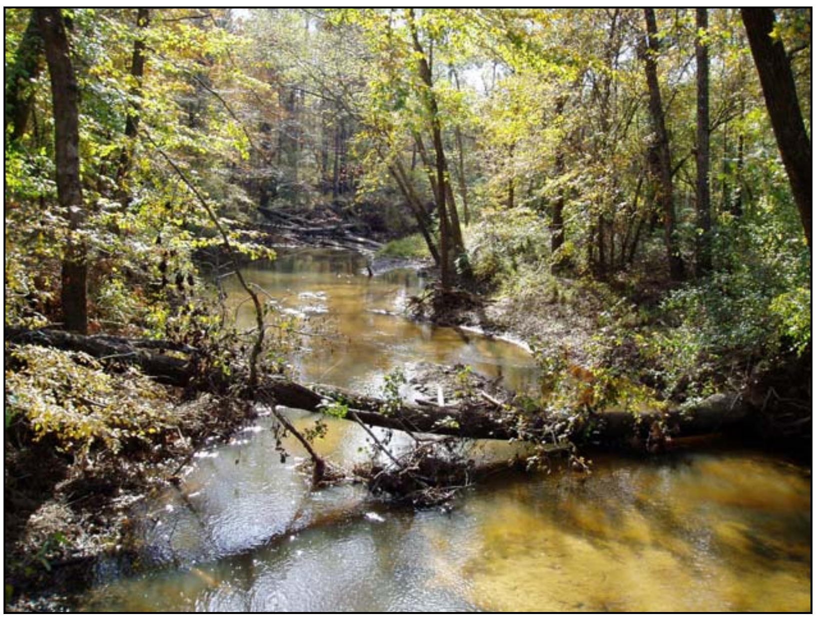
THICKET OF DIVERSITY

All Taxa Biodiversity Inventory
Big Thicket National Preserve, Texas

SCIENCE PLAN

Prepared by the Thicket of Diversity Science Committee

Jerry L. Cook, President - Thicket of Diversity
Dale A. Kruse, Chair – Thicket of Diversity Science Committee
Curtis R. Hoagland, Member - Thicket of Diversity Science Committee



This Science Plan represents a condensed view of the overall project goals and guidelines that structure the work of the Thicket of Diversity. This plan was prepared by the BITH-ATBI Science Committee and approved by the BITH-ATBI Executive Council. This document is available on the Thicket of Diversity website www.thicketofdiversity.org or through the Big Thicket Association website www.btatx.org. In addition, all supporting documents, forms, current requests for proposals, relevant online links, and other important information are regularly updated through these web pages.

Anyone interested in further information about the Science Plan, or the Thicket of Diversity in general, is encouraged to contact the Thicket of Diversity through the Executive Director director@bigthicket.org or 936-274-1181. Additional contact information for key Thicket of Diversity council and committee members and other relevant personnel is also provided through these web pages. This plan was adapted, in part, from the Science Plan for the Great Smoky Mountains National Park ATBI (White & Morse with Science Committee, 2000).

1.0 INTRODUCTION

The Big Thicket National Preserve (BITH) - All Taxa Biodiversity Inventory (ATBI), represents a collaborative effort between various public agencies, local and regional universities, and private individuals to conduct an inventory of all extant species of organisms in the Big Thicket National Preserve of southeast Texas. The subsequent development of checklists, reports, maps, databases, and natural history profiles will significantly enhance our knowledge of this rich and diverse landscape. The ATBI will document past scientific observations, expand and enhance ongoing interest in the BITH, and initiate a systematic approach to observations of diversity throughout the BITH's landscape. Although the species level of biological diversity is central to the ATBI concept, the broader perspective of the project will incorporate a much wider, ecological context, which subsequently enhances overall resource conservation and management.

The *"Big Thicket"* of East Texas has been referred to as the "Biological Crossroads of North America." Its biota includes representatives from tropical and subtropical biomes, as well as species characteristic of the arid west (Gunter 1993). The region also represents the western most extension of the Southeastern Evergreen Forest Region (McCleod 1971), and is the western boundary for distributions of many aquatic insects of largely eastern fauna (Abbott et al. 1997). Despite its status as both a National Park and Preserve, the Big Thicket is a permanently threatened region. Nearly 97% of the primitive Big Thicket, which was estimated to originally encompass around 3.5 million acres, was destroyed in the 20th Century (NPCA 2005). A recent study by the nonpartisan, National Parks Conservation Association (NPCA), reiterates the vulnerability of the preserve by placing it on its list of America's Ten Most Endangered National Parks (NPCA 2005). Currently the BITH lands are in small parcels connected by river corridors analogous to a "string of pearls" each designed to save examples of habitat and preserve diversity in the 10 distinct biomes of the region. The design was prescient of contemporary attempts to save threatened habitats in small parcels, but also serves as a laboratory for examining the efficacy of such strategies. The BITH encompasses four major watersheds which feed the Sabine, Neches, San Jacinto, and Trinity Rivers in southeast Texas, the “string”. The "pearls" of the string straddle these drainages and are thus continuously subject to changes in water quality and quantity from numerous point and non-point sources outside preservation lands. In addition; rapid urbanization, agricultural development, oil exploitation and accompanying salt lagoon releases, watershed recharge changes due to timber exploitation and development, collectively magnify the threat to these watersheds and in the end; the unique nature of the Big Thicket and its biota. The preserve truly represents an extraordinary laboratory for the evaluation of preservation establishment and management.

Not only will the ATBI add to the understanding of the preserve and its conservation of biological diversity, it will promote training in such disciplines as systematics, ecology, environmental education, etc., by stimulating funding for research in these fields. Training future generations of scientists and citizens in the importance of conservation and sustainable management of our nation’s vital resources, is another important outcome of the ATBI.

1.1 Primary Questions to be Addressed

Clearly, a significant amount of knowledge will be gained from this effort. Through the individual and collective work of a diverse group of researchers, substantial data will be generated which is not directly related to the specified goals of the ATBI. Park conservation managers need information on threats to resources, information to underlie decisions related to habitat restoration, and an ability to monitor and predict change. Although the principal data to be collected by the ATBI are the occurrence and distribution of species within the park, much additional ecological information will be directly associated with this primary data. Numerous inferences can therefore be made regarding interactions and interrelationships of the regions biota. This combination of distribution data and ecological inferences will foster better understanding and management of the preserve’s resources. Use of GIS data in particular will facilitate mapping of species occurrences and modeling of species distributions. Species distributions and richness can be related to past human disturbance, environmental variables, size and isolation of habitats, and organism characteristics. Inventories linked to long-term projects and monitoring sites will be useful in making comparisons among taxonomic groups. The following goals, or questions, are to be considered the primary tasks to be achieved.

1. *What species occur in the park: where do they occur (for example, by community, habitat, and geography) and when do they occur (for example, by season and time of day)?*

2. *As the project progresses, how many of the species are new park records, new county records, new state records, new national records, and new to science?*

3. *What species are endemic or nearly endemic to the park?*

4. *What rare or listed species occur in the park?*

5. *What invasive or exotic species occur in the park? Are particular habitats vulnerable to exotic invasions? Are these invasive/exotics expanding their range?*

6. *What are the areas of greatest species diversity within the park?*

2.0 OVERALL PROJECT ORGANIZATION

The implementation and management of this project is guided and coordinated by the Big Thicket Association (BTA). Acting under the auspices of the BTA, the Executive Council (EC) of the Thicket of Diversity directly oversees the program through four separate sub-committees; Science, Funding, Education and Outreach, and Data Management. Each of these committees has individual, as well as collective, goals and tasks as part of the ATBI. The EC and its sub-committees are each charged with providing support and logistics directed toward achieving the overall goals of the ATBI. These include, but are not limited to, the following broad tasks.

- Identify areas in which concurrent overlap of field work is desirable or to be avoided

- Receive and archive Annual Investigator Reports

- Maintain a registry of current and past ATBI participants

- Maintain a summary account of the ATBI, including working checklists and newsworthy statistics

- Track and archive the history of the project

- Provide information for ATBI participants (especially regarding access to research areas)

- Coordinate the availability of support functions (housing, temporary work space, storage facilities, and transportation, bulk sampling and sorting)

2.1 Science Committee

The Science Committee oversees and directs the work of the Taxonomic Working Groups (TWIGs) and monitors the general progress of the ATBI project. The general tasks of the Committee are to;

- Regularly review the organizational status and composition of TWIGs and seek specialists for understudied taxonomic groups and groups without current leadership;
- Provide assistance to TWIGs in organizing and in devising methods for inventory;
- Maintain an overview of checklists and estimates of inventory completeness for all organisms;
- Produce summaries and newsworthy statistics useful to publicize the ATBI activities;
- Participate in seeking funding and other forms of support (travel, housing), that will provide opportunities for work in the preserve.

2.1.1 Taxonomic Working Groups (TWIGs)

The fundamental work of ATBI will be done by Taxonomic Working Groups, or TWIGs, each organized around specific taxonomic or biological groups. The structure and organization of TWIG's are subject to change, and likely will be changed, as new researchers are identified and more input is gathered from specialists. Therefore, any list of TWIGs should be viewed as a flexible starting point and not a rigid framework. Some TWIGs have been organized on method of collecting specimens. For example: It makes more sense to have a TWIG include several groups that collect by the same method so that collecting efforts can be coordinated and then sorting can direct specimens to the appropriate specialists. Therefore, groups that primarily use Malaise traps should be grouped together so that each entity is not setting its own Malaise traps at the same locations (likewise for other collecting techniques). The specialists will likely need additional collecting by specialized methods, which they can then be responsible for, or they might make arrangements with the TWIG leader to deploy these additional methods.

Ideally, TWIG leaders should be located as close to the Big Thicket as possible. This will allow for more frequent and efficient collecting efforts. Therefore, TWIG leaders would likely be from central or east Texas or Louisiana if interested experts are available for those TWIGS. The taxonomic experts to handle subgroups collected by the TWIG could be located anywhere, since most of the collecting and sorting effort would be coordinated by the TWIG leader(s).

A TWIG can be led by an individual or several collaborating researchers. The TWIG would need enough resources and support to conduct trapping, sorting, and dispersal of specimens, as well as collecting data from specialists. The TWIG leader(s) should be an expert(s) in the group, or at least one subgroup, that is being collected by the TWIG and should have contacts with specialists served by the TWIG.

Voucher depositories are specified for the taxa collected by each TWIG. However, some TWIGs may produce large numbers of samples and might have auxillary depositories for extra specimens. For example: Malaise traps will likely produce large numbers of some species and due to the nature of the trapping method, these specimens will be dead and preserved before they are identified. It makes sense to deposit a series in the primary depository, with additional specimens deposited in auxillary sites. The primary depository will likely not want hundreds of a fly species, but other museums might welcome these excess specimens.

Not all TWIGs will be equal in size. For example, a bat TWIG may consist of one or a couple of specialists while some of the invertebrate TWIGs may have one or more TWIG leaders and a large number of specialists working on specimens collected by the TWIG. Allocation of available funds will take into account the size of the TWIG and resources needed to properly work on that group. The insects are obviously not divided in taxonomic groupings, but instead, loosely by trapping method. There will be overlap of TWIGs to collect some groups. For example, different beetle families will be collected by several groups and within the beetles there will be many specialists needed to correctly identify and name species. Insect TWIGs will need to be further divided, but the exact number of TWIGs depends largely on interested parties. There are some minor groups that may simply not have a TWIG, but could be found by the existing TWIG collection activities. An example is freshwater nemertines. This phylum of worms has only a few freshwater species, and have not been yet even been collected in this region of Texas, but there is no reason at least one species should not be found here. This group has no real researchers in North America.

Ultimately, TWIGs and TWIG leaders will be designated by the Science Committee. Proposals for the formation of a TWIG can be made to the Committee as a separate proposal, or in conjunction with a proposal for funding submitted to the Committee in response to a Request for Proposal from the ATBI. (See also Appendix A below)

Key Tasks of TWIG's

- Assess the current state of knowledge about each taxonomic group (including preliminary checklists and bibliographies, synonymy, and important holdings of voucher specimens)
- Conduct field inventories (with voucher specimens, locality and ecological data)
- Maintain working checklists and estimates of inventory completeness
- Produce checklists, including common names, synonymy, and status (for example, field-sighting record, specimen-based record, extant taxon, believed-extirpated taxon, most-recent record, abundance)
- Describe species new to science, when necessary
- Ensure accountability of the quality of the data collected
- Plan field work and determine collection methods
- Participate in the design of convention for specimen label and observational data
- Enlist the participation of a network of taxonomists
- Write an annual report, research plan, and budget request

- Produce field guides, identification aids, drawings, and photographs
- Summarize current data and interesting aspects of the inventories for web communication

2.2 General Information for ATBI Scientists

Certain kinds of information are essential to every scientist or group inventorying in BITH or planning to inventory. This information is made accessible through various sources including the Thicket of Diversity website at *www.thicketofdiversity.org*. Additional information and contacts are also available through the Big Thicket Association's website *www.btatx.org.*

- Registry of current and past ATBI field projects, including (for each) a brief summary of the project, with names of scientists, dates, and general localities.
- Bibliographies of past research and main locations of voucher specimens.
- Maps of the BITH units and the distribution of vegetation types are available.
- General information on access to BITH units and research sites for scientists.
- Field Research Station. The BITH Field Research Station includes a small laboratory, audio-visual equipment, library, classroom, kitchen, dining area, men and women's dormitories, showers, and laundry equipment. The Station is operated by the Big Thicket Association under an agreement with the Preserve and Rice University. This facility is located on a 6-acre campus in the town of Saratoga, within minutes of the Lance Rosier Unit.
- Summaries of environmental and historical factors that control distribution of organisms in the Park, including those of terrestrial, aquatic, and soil ecosystems. Such factors include topographic features, drainage patterns, soil types, human and disturbance history, geographic position, and vegetation type. Particularly critical are vegetation maps and information on availability of other kinds of maps and how to acquire them. Much of the information noted above can be found in Cooper et al. 2004. This report provides summaries of taxonomic and ecological studies of BITH, Federal and State Listed Species that have been documented in and immediately around the park, geological and hydrologic features, management issues, and a complete bibliography. Indices are included for various types of maps covering the park area. Cooper 2004, notes that a list of available spatial and non-spatial data is provided for the park. Data have been organized into the following groups: GIS data, non-GIS digital maps, hardcopy maps, digital databases, digital publications, and NatureBib maps. GIS data have been further separated into three categories: park specific or local, statewide, and nation-wide.

3.0 INVENTORY METHODOLOGY AND GUIDELINES

3.1 BITH Units and Corridors

The Big Thicket National Preserve comprises nine separate land units and six water corridors. These vary widely in overall size and shape. Because of the relatively discrete geographic nature of the preserve components, it is likely that a significant portion of the taxonomic sampling will correspond to the boundaries of unit or corridor. Most of the units, however, include several highly distinct vegetation types (Section 3.2).

Units	Corridors
Beaumont	Menard Creek
Beech Creek	Pine Island Bayou-Little Pine Island Bayou
Big Sandy Creek	Big Sandy Creek
Canyonlands	Village Creek
Hickory Creek Savannah	Upper Neches River
Jack Gore Baygall and Neches Bottom	Lower Neches River
Lance Rosier	
Loblolly	
Turkey Creek	

3.2 BITH Vegetation Types

The BITH landscapes are generally described as four *Major Vegetation* Types (Marks 1981). Each of these is further subdivided into more specific vegetation types (for each of the units and corridors). Because relatively small differences in slope are a major factor in determining vegetation and significant inter-gradation occurs between the major types and their subdivisions. See Appendix B below for a detailed description of these vegetation types.

Major Vegetation Types	Subdivisions
Uplands	Sandhill Pine Forest - Upland Pine Forest - Wetland Pine Savannah
Slopes	Upper Slope Pine Oak Forest - Mid Slope Oak Pine Forest Lower Slope Hardwood Pine Forest
Floodplains	Floodplain Hardwood Pine Forest - Floodplain Hardwood Forest Wetland Baygall Shrub Thicket - Swamp Cypress Tupelo Forest
Flatlands	Flatland Hardwood Forest

3.3 General Collection and Inventory Guidelines

The National Park Service (NPS), the Big Thicket Association, and the Executive Council and Science Committee of the Thicket of Diversity have established the following protocols and policies with the intent of effectively managing the Preserve's resources while maximizing scientific benefits to the All Taxa Biodiversity Inventory (ATBI) and its participating researchers.

● Biodiversity Reference Points - Sites have been situated by ATBI planners at specific localities characteristic of these vegetation subtypes and together represent the diversity of environments and histories of the Park's landscape. These structured sampling points will be documented by the ATBI, including data covering latitude, longitude, soil, geology, topography, habitat and vegetation, and history of human use.

● Specimen Collecting – Collection of specimens within the Big Thicket National Preserve (BITH) boundaries should be limited to only those taxa which are necessary for the researcher to fulfill the designated goals of the grant under which they are operating. Except in certain situations that follow; the actual number of specimens collected should be limited to no more than three (3) specimens per BTNP Unit. However, in those BTNP Units that cross one or more county line(s), additional specimens may be collected to represent a collection for each county.

● Traditional Collecting and Observing - Collections and observations are made by individual investigators based on their experience, knowledge, time constraints, and methods not formally oriented around Biodiversity Reference Points. Traditional activities are usually the most efficient means to building a checklist and discovering rarities. These activities also may include observations from Bioquests.

● Structured Collecting and Observing - Collections and observations take place at predetermined sampling points (Biodiversity Reference Points). Structured sampling points will be available to all field workers and will be especially valuable for bulk sampling, particularly sampling done by the public and volunteers. Structured collecting and observing will allow comparisons among seasons and years, among habitats and places with different disturbance histories, and along environmental gradients. Structured sampling will allow documentation of species-effort curves and will allow estimates of species turnover and complementarity among sites, thus contributing to assessment of how many biodiversity reference areas are needed.

● Completeness Estimates - Estimates of completeness for taxonomic groups are critical because it is nearly impossible that all species for any single group will be completely known. Objective measures of completeness can be obtained by methods such as species-area, species-individual, species-time, and species-effort curves, as well as by comparison of known BITH diversity with that of surrounding areas or other areas where the taxonomic group may be well known.

● Bulk Sampling and Sorting Centers - TWIGs will establish procedures for bulk sampling for certain groups and set up centers for sorting and distributing specimens to taxonomic experts.

● Bioquests - Bioquests will bring groups of scientists and amateur naturalists (see Citizen Scientist Volunteers below) to the Park for short but intense periods of field work organized around particular biological groups. The TWIGs and Science Committee have developed guidelines for Bioquests (including organization, support functions, and data capture) and for quality control of data (including identifications and specimen labels).

● Citizen Scientist Volunteers - A key component of the ATBI, and an essential goal of the BITH, is to educate the public about the value of our natural resources and promote good stewardship of these resources. As part of that dual mission, the Education Committee has organized a group of "Citizen Scientists" to assist researchers in the field and lab. These volunteers contribute to the collection of data, help NPS staff educate students, and foster public interest in the Big Thicket National Preserve and scientific discovery. While the inclusion of citizen scientists is not required for participation in the Thicket of Diversity ATBI, it is strongly encouraged, especially for Principal Investigators (PIs) who apply for funding from the Thicket of Diversity. PIs are also strongly encouraged to host formal, or informal, seminars or other outreach type activities for the volunteers and members of the public. In addition, PIs are encouraged to present their findings at the Big Thicket Science Conference.

There are two types of volunteers available. These volunteer groups differ primarily in their level of training and time commitments, or both.

Short term: Short term volunteers are available for one time collecting trips such as a Bio-Blitz. The Thicket of Diversity maintains a list of individuals and organizations, such as Master Naturalists, interested in volunteering for the ATBI.

Volunteer TWiG members: Volunteer TWiG members are citizen scientists who have been trained in general data collection, the use of GPS hand-held units, field catalog maintenance, introductory level specimen preparation, etc. Additionally, many are knowledgeable about park logistics (i.e. how to get to and from different units, lodging, placement of supplies).

Steps to obtaining volunteers:

1. Identify your needs.

    What skill sets are you looking for?
    Do you need volunteers for just one or two days or over a period of time?
    How many volunteers do you need?
    When do you need them?

2. Complete the volunteer request form provided in this packet, or through the websites listed above, if requesting long term volunteers. Submit the form to the Big Thicket Association or submit online.

3. If volunteers are needed for just one day, contact the Big Thicket Association at least three weeks in advance.

4. All volunteers are required to fill out a National Park Service volunteer release form if working in the Big Thicket National Preserve. These forms are also available on the BTA website.

5. Log volunteer hours using forms provided in this packet or through the websites listed above.

● Repositories – Specific institutions have been designated as repositories for voucher specimens in their respective groups. A "primary" repository has been established for each specific group of taxa based on the current location of that groups TWIG Leader and the institutions reputation as a source for specimens in a given geographic or taxonomic group. Duplicates of collections should be deposited in secondary institutions as designated. Any remaining duplicates are to be utilized at the discretion of the individual researcher. Researchers making collections on non-NPS properties as part of the ATBI (*i.e.*, The Nature Conservancy, National Forests, Texas Parks and Wildlife, etc.) are advised to adhere to the specific policies set forth by those agencies.

3.4 Data Collection

A vital objective of the ATBI is to determine what is in BITH, and where it is located. A list of priority/required data types is given below. Each data type represents an individual field in the database tables. Depending on the specific taxonomic group involved, some fields may not be relevant to any particular data group. Researchers are asked to adhere as close as possible to these data standards. The list below is separated into three groups or categories of data.

3.4.1 Site or Location Information (the where)

Site Code (a unique code)
Coordinate #1 - UTM north or latitude in NAD 1983 Datum
Coordinate #2 - UTM east or longitude
State of Site (TX)
County of Site
Site Location (as specific as possible, so that it can be used to check your coordinates)
Site Ecological Description (including major and specific vegetation types, slope degree and aspect, soil)
Site Elevation (in meters)
Site Notes (misc. notes about the site, NOT the collection)

3.4.2 Collection Data (the how, who and when)

Organism habitat (at date of collection)
Organism substrate (at date of collection)
Collection Method (by hand, by butterfly net, etc.)
Collection Notes (misc. notes about the collection, NOT the site)
Collection Date (date collection was made = specific day net was lifted, etc.)
Collector(s) Name(s)
Primary Investigator (project leader or person responsible for all collectors)

3.4.3 Individual Organism or Specimen Information (the what)

Class
Order (if unknown, then use the class name such as Hyphomycetes_order)
Family (if unknown, then use the order name such as Pezizales_family)
Genus (if unknown, then use the family name such as Halosphaeriacae_genus)
Species (if unknown, then use the genus name such as Massarina_species)

Authoritiy(ies)
Infraspecific categories (subspecies, variety, etc.)
Common Name (use official name if possible)
Life Stage
Sex
Specimen ID
Count of Specific Organism
Preservation Method
Repository
Specimen Notes
Determiner Name
Year of Determination
Site Code (this must be a valid site that is also in the site data fields list)

3.4.4 Suggestions for Error Checking:

Be consistent with formatting - To a computer, Smith, R. is different than R. Smith. Dates must be specific dates and not a range of dates, nor just a month and year.

Check for misspellings - Spell checkers don't get them all. Minnow and winnow both check out ok.

Be careful in determining mapping coordinates - One second of latitude may throw your stream sample site 150 feet up the side of a cliff!

Use the latest accepted taxonomy

Notes fields can contain a text of any length - However, all other text fields should stay under 50 characters, or whatever is reasonable, such as about 25 characters for a name.

The details on data collection procedures, data delivery methods and formats, data flow, taxonomic standards, GPS standards, and database structure (e.g. NPSpecies or ATBI database) will be provided. The standards and formating items listed above have been addressed through a series of protocols and SOPs developed to insure they meet the ATBI's collection objectives and promote good data management. Researchers are asked to comply with these data standards as part of their research in the BITH. The ATBI Science Committee will provide an electronic copy of the ATBI database to any researcher free of charge. In addition, support for the use and dissemination of the data will be provided by the ATBI Data Management Committee.

4.0 REFERENCES

Abbott, J. C., K. W. Stewart, and S. R. Moulton, II. 1997. Aquatic Insects of the Big Thicket Region of East Texas. Texas Journal of Science 49: 35-50.

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Appendix A: Vegetation Types of the Big Thicket

The following vegetation descriptions for plant communities in the Big Thicket are excerpts from: *Forest Vegetation of the Big Thicket Southeast Texas* by P. L. Marks and P. A. Harcombe 1981.

APPENDIX 1

Description of vegetation types.

Upland Forests

Sandhill Pine Forest

Sandhill Pine Forest is short, open woodland with low tree density and basal area, low shrub density, a relatively sparse herb layer, and much exposed sand. *Quercus incana* and *Q. stellata* (*Q. margaretta*?) are dominant, and there is an emergent overstory of widely scattered pines (*Pinus taeda, P. echinata,* and *P. palustris*). The distinctiveness of the type is emphasized by the fact that both dominant species (*Q. incana* and *Q. stellata*) reach their maximum importance in this type and are relatively unimportant in any of the other types. The low abundance of *P. palustris* today may reflect past cutting. In spite of the openness of the tree canopy, there are no distinctive small tree or shrub species. The most abundant ones are *Ilex vomitoria* and *Cornus florida*, both of which reach maximum importance in other types.

The Sandhill Pine type is as distinctive in its soil characteristics as it is in its vegetation. The surface soil is >90% sand, and as a consequence levels of extractable soil nutrients are low.

Upland Pine Forest

Upland Pine Forest consists of open stands of *P. palustris*, which vary considerably in height and density, presumably depending on stand history and soil depth (Oliver 1978). *Pinus taeda* and *P. echinata* are common overstory associates, and *Quercus incana, Q. marilandica, Q. falcata, Q. stellata,* and *Liquidambar styraciflua* may be present. The understory is highly variable, depending on fire history, and is dominated by saplings of the above species, roughly in the order indicated. *Cornus florida, Callicarpa americana, Myrica cerifera,* and *Rhus copallina* are additional common understory species. Where woody species are absent from the understory due to fire, the herb layer is dense and consists of many species of grasses and forbs. Usually *Andropogon* species are dominant. Upland Pine Forest has long been known to burn regularly due to natural causes (Garren 1943, Vogl 1972, Delcourt 1976), and is highly flammable (Streng 1979).

Wetland Pine Savanna

Wetland Pine Savanna occurs in areas with poor internal drainage, ranging from small depressions or swales in Upland Pine Forest to broad, swampy, interdistributary flats. It normally contains widely scattered *P. palustris* or *P. taeda* with little else in the overstory, though stunted individuals of *Nyssa sylvatica, Liquidambar styraciflua,* and *Quercus falcata* often occur. *Magnolia virginiana, Myrica cerifera,* and *Cyrilla racemiflora* are common shrubs or small trees and may occur in dense patches interspersed with grassy meadows that include sedges, insectivorous plants, and orchids.

Both fire and soil saturation are important in determining whether shrubs or herbs predominate (Streng 1979). Komarek (1974) stresses the importance of fire, but these areas undergo cycles of extreme wetting and drying, wetting due to poor internal drainage, drying due to restricted rooting depth (clay pan), which may favor perennial herbs over woody plants as has been suggested for tropical savannas (Beard 1953). Wells (1942) cites poor internal drainage as a factor preventing encroachment of trees in upland bogs and savannas in North Carolina; Streng (1979) came to similar conclusions in our study area. In contrast, Sandhill Pine and Upland Pine seldom experience standing water.

Slope Forests

Regional vegetation maps (Küchler 1964, USFS 1969) show the Big Thicket area to contain two major types, longleaf pine and loblolly-shortleaf pine (or oak-pine of Küchler), and our analysis and observations are consistent with the boundary as drawn. However, the loblolly-shortleaf type can be segregated into three slope types depending on the hardwood associates, and our Upper Slope Pine Oak occupies only a portion of the area mapped as loblolly-shortleaf, the rest being Mid Slope Oak Pine or Lower Slope Hardwood Pine.

Upper Slope Pine Oak Forest

Upper Slope Pine Oak Forest is closed-canopy forest with a moderately well-developed shrub layer. *Pinus echinata* is usually dominant, and *Quercus falcata*, *P. palustris*, *P. taeda*, *Q. marilandica* in some combination often are codominant. Associated species include *Q. stellata*, *Liquidambar styraciflua*, and *Q. alba*. Usually the pines are more important than the hardwoods. The most important understory species are *Ilex vomitoria*, *Cornus florida*, and *Callicarpa americana*. Several species, including *Pinus echinata*, *Carya tomentosa*, *Ilex vomitoria*, *Quercus marilandica*, *Callicarpa americana*, and *Sassafras albidum*, reach their maxima in this type.

Mid Slope Oak Pine Forest

Mid Slope Oak Pine Forest is generally taller, has a more closed canopy, and a greater proportion of hardwoods in the overstory than Upper Slope Pine Oak. Overstory dominants are *Pinus taeda*, *Q. falcata*, *P. echinata*, and *Q. alba*. *Liquidambar styraciflua*, *Nyssa sylvatica*, and *Acer rubrum* are next in tree basal area, though they seldom reach canopy status. In these forests, the understory is dominated by understory species rather than canopy tree saplings, and the most important understory species are *Cornus florida*, *Ilex vomitoria*, *I. opaca*, and *Acer rubrum*. *Quercus falcata*, *Q. alba*, *C. florida*, and *I. vomitoria* reach their maximum importance in this type.

Lower Slope Hardwood Pine Forest

Lower Slope Hardwood Pine Forest generally occupies gentle to steep slopes near creeks. It has greater canopy density and hardwood abundance than does Mid Slope Oak Pine, although stand history will greatly influence the proportion of pine. In the northern part of the study area *Fagus grandifolia* is a conspicuous dominant, whereas in the southern part it is absent. *Magnolia grandiflora*, *P. taeda*, *Q. alba*, and *Q. nigra* are codominants. Other important species include *Q. laurifolia*, *Q. phellos*, and *Ilex opaca*. In the understory stratum, *Ilex opaca* and *I. vomitoria* are most important.

Floodplains, Flats, and Swamps

The common feature of this group of types (Floodplain Hardwood Pine, Floodplain Hardwood, Flatland Hardwood, Swamp Cypress Tupelo, Wetland Baygall Shrub Thicket) is that they occur in situations where moisture is superabundant for part or all of the year. They are predominantly hardwood forests, and are sometimes considered collectively as bottomland hardwoods (SAF 1954) in the broadest sense.

Floodplain Hardwood Pine Forest

Floodplain Hardwood Pine Forest occurs in active floodplains of smaller streams. *Pinus taeda* and *Fagus grandifolia* are leading dominants, and *Liquidambar styraciflua*, *Nyssa sylvatica*, *Magnolia grandiflora*, and *Quercus nigra* are the other important canopy species. The paucity of shrubs which is characteristic of floodplains (Curtis 1959, Robertson et al. 1978) is perhaps the most distinctive feature of these forests. The most important species in the understory stratum is *Carpinus caroliniana*. No species reach peak importance in this type.

Floodplain Hardwood Forest

Floodplain Hardwood Forest occurs on active floodplains of larger streams and the Neches River. *Quercus nigra* and *Liquidambar styraciflua* are the dominant overstory species, and *Carpinus caroliniana* also contributes significantly to tree basal area. *Fagus grandifolia* and *P. taeda* were abundant in two stands on higher terraces that seldom flood. Other common species on more typical floodplain terraces include *Quercus michauxii*, *Nyssa sylvatica*, *Carya aquatica*, *Acer rubrum*, *Ilex opaca*, and *Q. falcata* var. *pagodaefolia*. Many of the overstory individuals reach great girth, an appearance accentuated by the open understory. The overstory canopy is frequently discontinuous, but is filled in at midstory level by a dense canopy of *Carpinus caroliniana* and, on higher terraces, *Ilex opaca*. Either may have enough large individuals to have as much basal area as the overstory dominants in particular stands. Together with the overstory, they form a dense canopy, and consequently the low shrub layer is sparse. *Sebastiana fruticosa* and *I. decidua* are the principal understory species. Arboreal vines are a conspicuous feature of the Floodplain Hardwood Forest. *Vitis rotundifolia* and *Berchemia scandens* in particular form large lianas, sometimes >10 cm dbh.

Backswamps, meander scars, abandoned channels, and other depressions lend an aspect of diversity to these otherwise uniform forests. In shallow backswamps and sloughs *A. rubrum*, *Fraxinus caroliniana*, *Cephalanthus occidentalis*, *Planera aquatica*, and *Carya aquatica* commonly occur at least along the margins (Mohler 1979).

Swamp Cypress Tupelo Forest

In the deeper backswamps, sloughs, oxbows, and other depressions, and along inlets of the Neches River, *Taxodium distichum* and *Nyssa aquatica* predominate. Stands range from many hectares down to a single or double row of trees in braided channels. Both species form large buttresses and in the larger stands the trees may reach immense proportions (100–150 cm dbh). These are unquestionably the most structurally impressive forest stands in the Big Thicket. The only other woody species in the large stands are *Cephalanthus occidentalis*, *F. caroliniana*, and *Planera aquatica*. They are often more common around the edges; the most common swamp-edge tree is *Carya aquatica* (Mohler 1979).

Flatland Hardwood Forest

The Flatland Hardwood type is found on low, wide, interdistributary flats in the southern and western part of the study area. *Quercus michauxii* is most frequently dominant, but *Q. phellos*, *Q. laurifolia*, and *Q. lyrata* are frequently important, and may be locally dominant. *Liquidambar styraciflua*, *Nyssa sylvatica*, and *Acer rubrum* are commonly present and may also be important. Frequently the understory stratum contains a dense cover of *Sabal minor* or *Viburnum dentatum*. *Acer rubrum*, *L. styraciflua*, *N. sylvatica*, and *Fraxinus* *pensylvanica* are also important in the understory. Although Flatland Hardwood Forest has many species in common with Floodplain Hardwood Forest, the three important Floodplain species, *Q. nigra*, *L. styraciflua*, and *Carpinus caroliniana*, are only of minor importance in this type. In addition, the Flatland Hardwood Forest is lower in stature and contains a much more dense and diverse shrub stratum.

Wetland Baygall Shrub Thicket

Stands of this type frequently occur in depressions where water stands for much of the year. The overstory dominants are *Q. laurifolia* and/or *Nyssa sylvatica*. *Magnolia virginiana* and *Acer rubrum* are characteristic associated species, and *Fraxinus pensylvanica*, *Liquidambar styraciflua*, and *Taxodium distichum* are commonly present. *Cyrilla racemiflora* and *Ilex coriacea* are the important understory species, though many other shrubs may be locally abundant. Depending on overstory density, the shrub layer may vary from relatively open to nearly impenetrable.

Sometimes the Baygall shrubs will be associated with a very sparse overstory of longleaf pine on poorly drained interdistributary flats, in a mosaic with open grassy meadows. In this case, the vegetation would fall into our Wetland Pine Savanna type. The two types are easily distinguished on the basis of the overstory (pine vs. hardwood).