



Area Study: East Texas Area

Evaluation of Selected Natural Resources in Angelina, Cherokee, Gregg, Nacogdoches, Rusk, and Smith Counties, Texas



Big Thicket National Preserve, East Texas





**RESOURCE PROTECTION DIVISION:
WATER RESOURCES TEAM**

*Evaluation of Selected Natural
Resources in Angelina,
Cherokee, Gregg, Nacogdoches,
Rusk, and Smith Counties,
Texas*

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November 1998

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EXECUTIVE SUMMARY

This report is an evaluation of selected natural resources of the east Texas area including all of Angelina, Cherokee, Gregg, Nacogdoches, Rusk, and Smith Counties. This report is in response to Senate Bill 1 (75th Texas Legislature, 1997) which directed the completion of pending Priority Groundwater Management Area (PGMA) studies mandated by House Bill 2 (69th Texas Legislature, 1985).

The study area has a warm, sub-humid climate. Most water use in the area is municipal and industrial. Large withdrawals of groundwater have caused water level declines locally (Carrizo-Wilcox aquifer) where large numbers of high-capacity municipal and industrial supply wells occur.

The economy of the area is diversified and consists of manufacturing, petroleum production and refining, service industries, agriculture and agribusiness, and lumber harvest. Tourism, nature tourism, and recreation industries are also important.

The study area contains three major types of bottomland hardwood forests. The most extensive type is the water oak-willow oak-blackgum association. Forested wetlands are the most threatened wetland type in the United States. The proposed Eastex Reservoir site on Mud Creek in Cherokee County would cause the loss of over 3,500 acres of pine-hardwood forest, and several thousand acres of other habitats if constructed. Its construction will also cause the loss of a site for the Neches River rose-mallow (*Hibiscus dasycalyx*), which is a candidate species for federal listing. These losses would require substantial mitigation.

These wetlands, in conjunction with the large reservoirs in the study area, support a diverse fauna and flora consisting of wetland dependent, aquatic, semi-aquatic, and riparian species. The study area rivers and streams have a variety of fish species. Two of those fish species are listed as state threatened species, the paddlefish and the creek chubsucker. Many species of migrating birds, waterfowl, wintering shorebirds, and neotropical stopover in the study area to rest and to feed along the river banks and creek bottoms. Of the 1,100 vertebrate species in Texas, at least 64 species of mammals, amphibians, and reptiles, that are either aquatic, semi-aquatic, or in some way wetland-dependent, are present in the study area.

There are adequate groundwater supplies in the study area, except perhaps very locally. Substantial amounts of surface water are available from the reservoirs of the area. The development of these reservoirs has caused substantial loss of habitat for wildlife and some native river fishes.

Evaluation of Selected Natural Resources in Angelina, Cherokee, Gregg, Nacogdoches, Rusk, and Smith Counties, Texas

INTRODUCTION

Purpose

The Texas Natural Resource Conservation Commission (TNRCC), working with the Texas Water Development Board (TWDB) and the Texas Parks and Wildlife Department (TPWD), is charged with identifying Priority Groundwater Management Areas (PGMAs) - areas in the State that are experiencing, or are expected to experience in the future, critical groundwater problems. The purpose of the PGMA program is to assist local and regional interests in addressing groundwater management issues; including the quantity and quality of surface water and groundwater, contamination, and land subsidence.

Senate Bill 1 (75th legislature, 1997) directed the completion of pending PGMA studies that were called for by House Bill 2 (69th Legislature) in 1985. The TNRCC and TWDB identified all or parts of Angelina, Cherokee, Gregg, Nacogdoches, Rusk, and Smith Counties for continued monitoring. The East Texas study area was not designated as a critical area for a PGMA study in 1990, but the TWDB and TNRCC were to continue monitoring groundwater levels and local groundwater management initiatives. A groundwater study was initiated in 1990 with the TNRCC requesting a groundwater resource and availability study from the TWDB. The TWDB completed the report *Evaluation of Groundwater Resources in the Vicinity of the Cities of Henderson, Jacksonville, Kilgore, Lufkin, Nacogdoches, Rusk, and Tyler in East Texas* (TWDB Report No. 327, Preston and Moore) in February of 1991.

Location and Extent

The area covered by this report includes all of Angelina, Cherokee, Gregg, Nacogdoches, Rusk, and Smith Counties (Fig. 1). The study area is located within the Sabine, Neches, and Cypress Creek basins (Fig. 2). The area is defined by the counties boundary lines and includes the cities of Henderson, Jacksonville, Kilgore, Lufkin, Nacogdoches, Rusk and Tyler. The study area covers approximately 4,926.9 square miles.

Geography and Ecology

The study area is located mostly within the Piney Woods natural region except for the northwestern tip of Smith County, which is located in the Oak Woods and Prairies natural region (LBJ School of Public Affairs 1978; Fig. 3). These regions are located on the western edge of the Mississippi embayment, a northern extension of the Gulf Coastal Plain. The Tyler basin and the Sabine Uplift affect the northern part of the study area (Preston and Moore 1991) .

Most of the study area is in the Mixed Pine-Hardwood Forest subregion, which typifies the Piney Woods region. Mixed pine-hardwood forests containing species such as loblolly pine, shortleaf pine, blackjack oak, sand post oak, southern red oak, flowering dogwood dominate the flora of the region, as well as wax myrtle, broomsedge bluestem, and little bluestem (McMahan et al. 1984).

Figure 1. Location Map of the Study Area



Produced by the TPWD Water Resources Team, July 1998. No claims are made to the accuracy of the data or the suitability of the data for a particular use.

Sources:
TPWD GIS lab archives data 1998.

Projections:
Texas Statewide Projection
(Lambert Conformal Conic)

Figure 2. River Basins of the Study Area

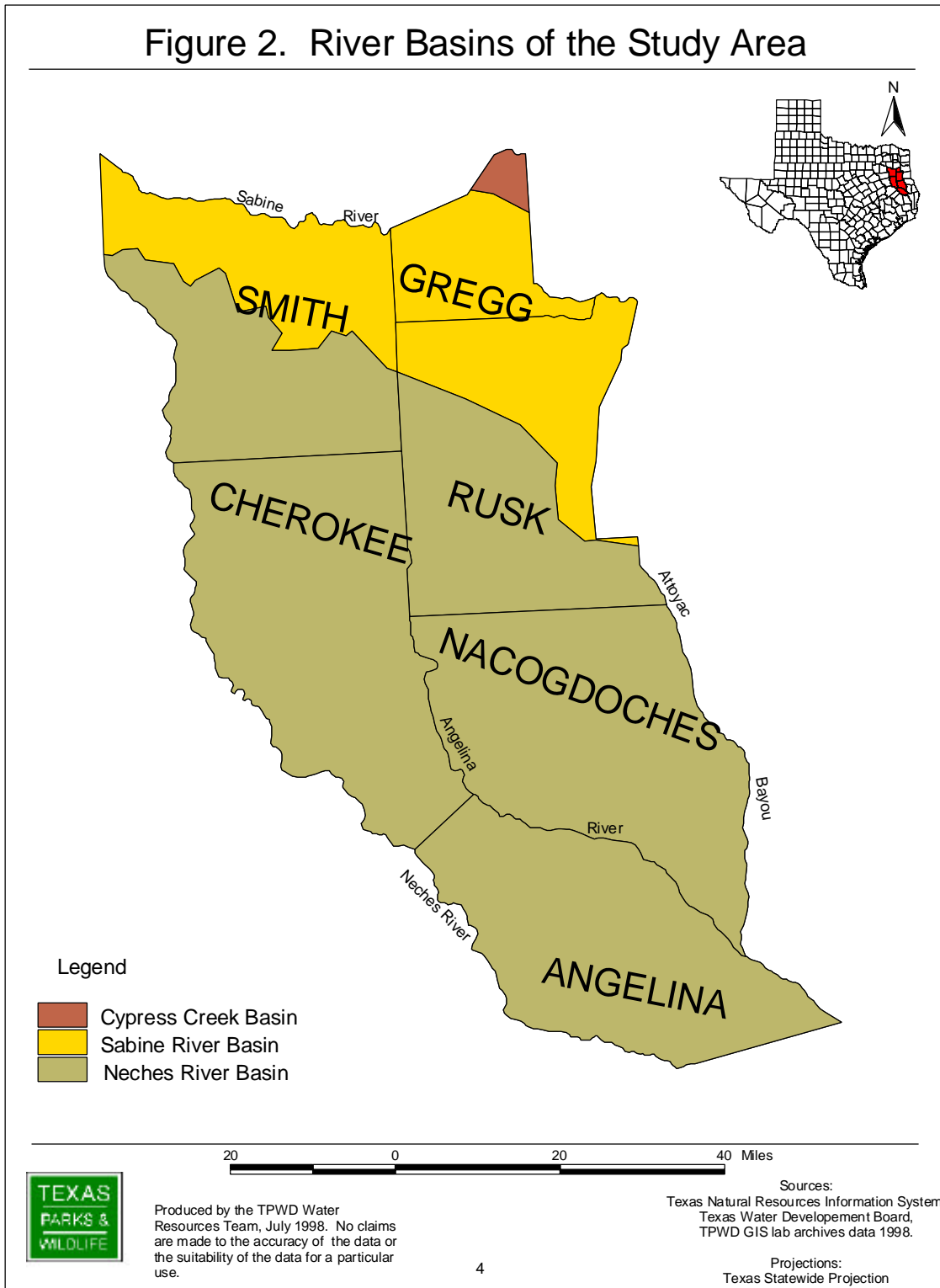
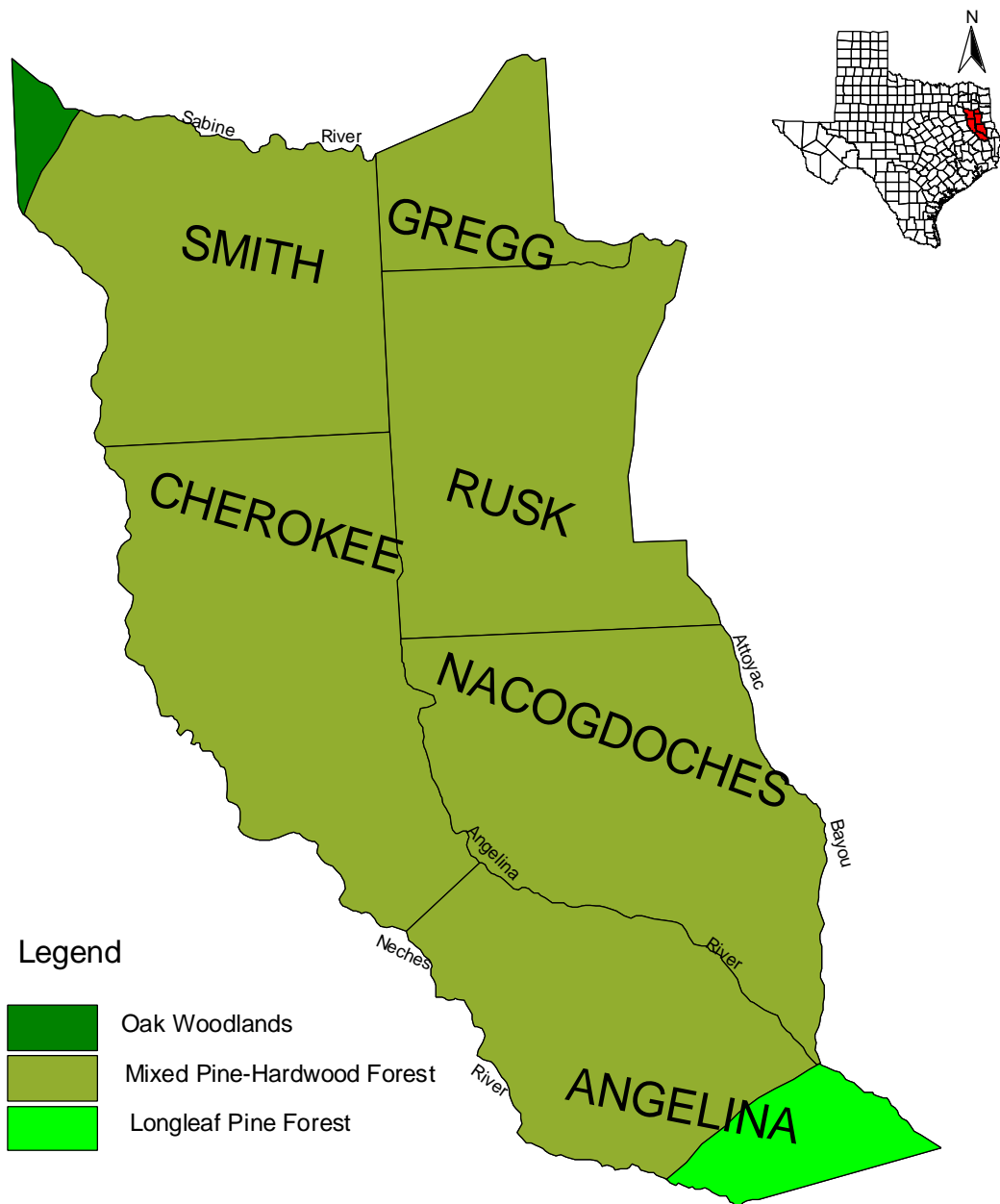





Figure 3. Natural Subregions of the Study Area



Legend

-  Oak Woodlands
-  Mixed Pine-Hardwood Forest
-  Longleaf Pine Forest

20 0 20 40 Miles



Produced by the TPWD Water Resources Team, July 1998. No claims are made to the accuracy of the data or the suitability of the data for a particular use.

Sources:
Preserving Texas' Natural Heritage.
LBJ School of Public Affairs Policy Research Project, Report 31, 1978.

Projections:
Texas Statewide Projection

The topography of the region consists of, north to south, relatively flat valleys formed by the major streams with rolling to hilly terrain between these valleys. There is a general slope from north to south and the elevation ranges from about 600 feet above sea level in the north to about 200 feet in the south (Preston and Moore 1991). Among the major physiographic features of the study area are (1) the flood plains of the Angelina, Neches, and Sabine Rivers and (2) the Carrizo-Wilcox Aquifer.

The study area is characterized by a warm sub-humid climate, with long hot summers and short mild winters. The average annual precipitation ranges from about 43 inches per year at Lufkin to over 47 inches per year east of Kilgore. Much of the rainfall occurs in May-June and September-October. Annual average lake surface evaporation is about 60 inches. The July mean temperature is between 94° F and 96° F and the January mean ranges from 37° F to 39° F. The growing season ranges from 243 to 259 days, with the first frost occurring between November 13 and 21 and the last in early to mid March.

Demographics

The 1990 census estimated the population of the study area to be 465,678 (Table 1; TWDB 1998). People are distributed uniformly throughout the region. The largest city within the study area is Tyler, with a population of just under 80,250, in Smith County. The TWDB (1998) predicted a 2050 population of 703,766. The projections in Table 1 show Nacogdoches County more than doubling, and the other counties with an upward trend (TWDB 1998).

Table 1. Population Projection for the Study Area (TWDB 1998)

<i>Year P</i> <i>Locality B</i>	1990	2000	2010	2020	2030	2040	2050
Angelina	69,884	77,252	82,800	88,464	94,101	99,436	105,173
Cherokee	41,049	44,077	46,113	48,372	50,782	53,183	55,766
Gregg	104,148	113,599	120,886	128,699	135,804	142,277	149,065
Nacogdoches	54,753	63,382	72,560	82,400	95,373	107,184	117,624
Rusk	43,735	47,194	49,939	54,285	58,722	61,532	63,245
Smith	151,309	170,890	185,669	195,005	202,477	208,824	212,895

Economy and Land Use

The economy of the area consists primarily of petroleum production and refining, lumbering, beef cattle, poultry, and agribusiness. The agriculture market value in the study area is \$ 286.8 million, mostly generated from timber production (Dallas Morning News 1997). Manufacturing added about \$ 4.84 billion to the economy of the six counties in 1985 (TWDB Report No. 327, Preston and Moore 1991).

Acknowledgments

The authors wish to thank the numerous individuals who provided information on the selected natural resources in the study area. Additional thanks are given to those individuals whose comments and proofreading allowed us to put this report out. We appreciate and acknowledge the help and expertise of Jackie Poole, Peggy Horner, Gordon Linam, John Maresh, Dorinda Scott, and Jason Singhurst.

SELECTED NATURAL RESOURCES*

TPWD Regional Facilities

Within the study area, TPWD operates six state parks (Fig. 4), Tyler State Park (SP), Martin Creek Lake SP, Rusk SP, Texas State Railroad State Historic Park (SHP), Jim Hogg SHP, and Caddoan Mounds SHP. In addition, TPWD has two wildlife management areas (WMAs) in this region: Old Sabine Bottom WMA and Alazan Bayou WMA. Also, it is important to note that a sizable section of Angelina National Forest is within the study area. The state parks and WMAs, and Angelina National Forest require water to operate and provide recreational opportunities to the public, as well as maintaining a healthy fauna and flora.

The following is a general description of those facilities offering one or more of the following activities: fishing, hunting, boating, wildlife viewing, and swimming.

The Old Sabine Bottom WMA (5,121 acres) is one of 14 bottomland hardwood preservation sites rated “Priority One” in Texas by the U.S. Fish and Wildlife Service. These sites are considered the most threatened wetland type in the United States. The area is located in the Middle Sabine Bottom contiguous to the Little Sandy National Wildlife Refuge, which many consider as the number one bottomland forest in the state. The two areas preserve one of the largest, intact bottomland hardwood forests remaining in Texas (LeBeau 1997).

The Alazan Bayou WMA (1,973 acres) is located within the Piney Woods ecological area in southern Nacogdoches County. The WMA is managed for the conservation and management of bottomland hardwoods, waterfowl habitat enhancement, and public use opportunity. The area lies adjacent to the Angelina River, which serves as the WMAs southern boundary (Poteet 1997).

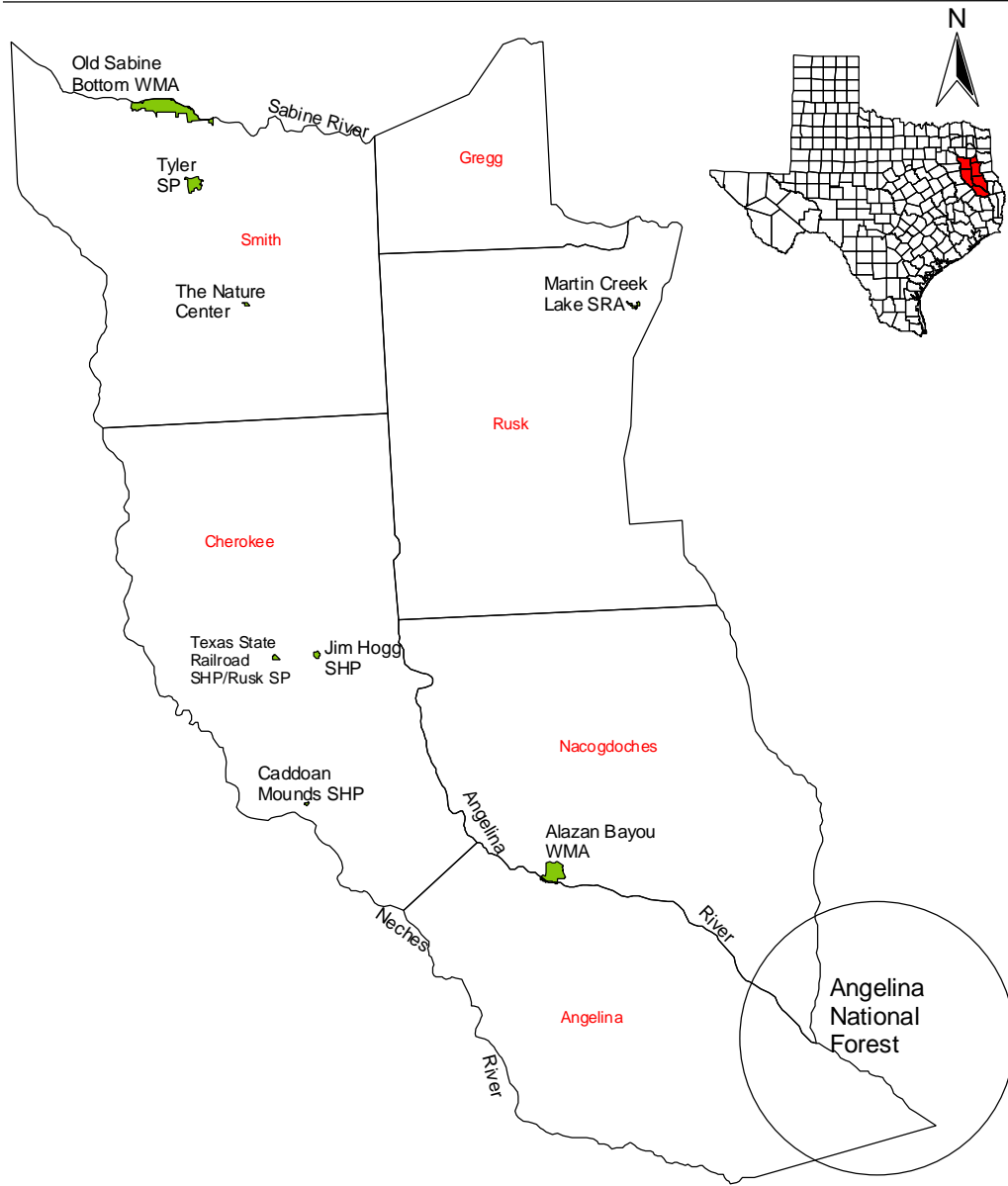
Tyler SP (983 acres) is located in a transition ecotone of the Piney Woods and Post Oak Savanna vegetation areas. The park is situated at the headwaters of a spring fed stream that flows into Hitts Creek, a tributary of the Sabine River. A dam on this creek has formed the 65-acre lake in the center of the park.

Martin Creek Lake SP (286.9 acres) is located on a 5,000-acre lake. It was constructed to provide cooling water for a lignite-fired, electric power generation plant.

Estimates of the economic importance of these parks to the counties of the study area are shown in Table 2 (Crompton et al. 1998). The economic impact parameter estimates the infusion of “new money” into the local economy by out-of-county visitors to the parks. It is a more realistic indicator of economic importance than “economic surge” which also includes expenditures by local visitors. More detailed breakdowns of the data summarized in Table 2 are given in Appendix A. No economic data are available for the WMAs.

* The fauna and flora described in this report represents those species that are riparian, semi-aquatic, and aquatic, unless otherwise noted.

Figure 4. Location Map of TPWD Facilities in the Study Area



20 0 20 40 Miles



Produced by the TPWD Water Resources Team, July 1998. No claims are made to the accuracy of the data or the suitability of the data for a particular use.

Sources:
TPWD GIS lab archives data 1998.

Projections:
Texas Statewide Projection
(Lambert Conformal Conic)

Table 2. Summary of Estimated Economic Importance (Impact and Surge) of State Parks in the Study Area (Crompton et al. 1998)

County	Total Visitors	Total Expenditures (\$)	Total Sales (\$)	Total Personal Income (\$)	Total Employment (persons)
<u>Cherokee</u>					
Impact	9,579	54,047	100,652	29,471	2.4
Surge	9,579	64,268	119,630	35,022	2.8
<u>Rusk</u>					
Impact	181,591	943,325	1,931,717	570,783	43.3
Surge	181,591	1,189,163	2,432,829	719,282	54.5
<u>Smith</u>					
Impact	360,132	697,847	1,563,534	499,942	31.6
Surge	360,132	1,801,146	4,031,675	1,282,894	80.9

Angelina National Forest is one of four National Forests in Texas. The 154,245-acre national forest is located in Angelina, Nacogdoches, San Augustine and Jasper Counties. About 58,440 acres are located in Angelina County, and 9,240 acres in Nacogdoches County. The forest lies in the Neches River Basin and on the north and south side of Sam Rayburn Reservoir, a 114,500-acre lake on the Angelina River formed by the construction of Sam Rayburn Dam in the early 1960s. The Angelina Forest is to protect and obtain the greatest benefit from all forest resources: timber, water, forage, wildlife and recreation (U.S. Forest Service 1998).

Vegetation and Soils

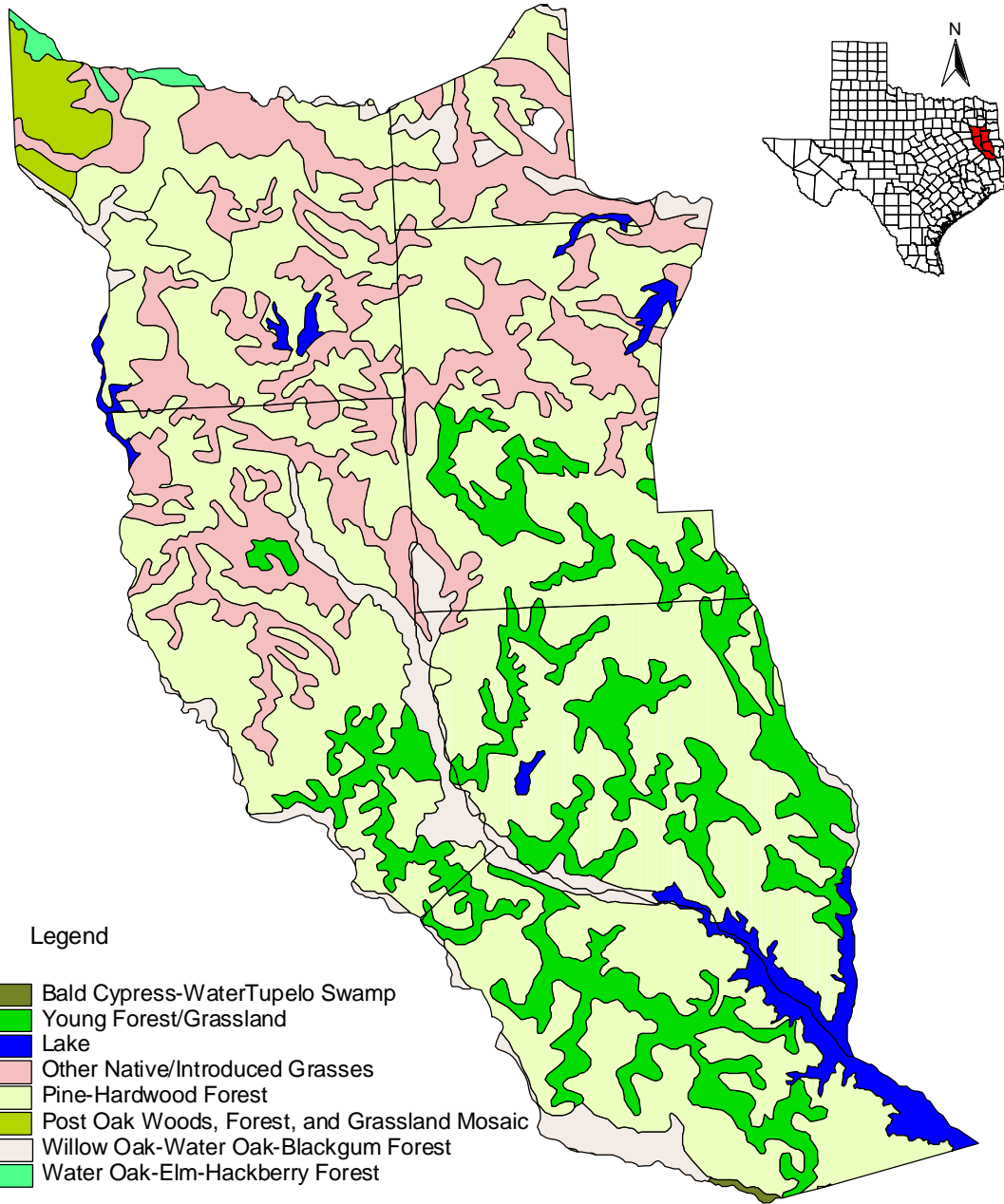
The natural regions of Texas were delineated largely on the basis of soil type (Godfrey et al. 1973) and major vegetation types (McMahan et al. 1984). The study area soils are mostly pale to dark gray sands or sandy loams and are generally acidic.

Figure 5 shows the Pine-Hardwood forest as the dominant vegetation type in the study area. This vegetation type includes two subtypes that occur in the study area. Subtype 1 (Loblolly Pine-Sweetgum) occurs mostly in Angelina County. The associated plants include shortleaf pine (*Pinus echinata*), water oak (*Quercus nigra*), white oak (*Quercus alba*), southern red oak (*Quercus falcata*), winged elm (*Ulmus alata*), beech (*Fagus grandifolia*), blackgum (*Nyssa sylvatica*), magnolia (*Magnolia grandiflora*), American beautyberry (*Callicarpa americana*), American hornbeam (*Carpinus caroliniana*), flowering dogwood (*Cornus florida*), wax myrtle (*Myrica cerifera*), red bay (*Persea borbonia*), southern arrowwood (*Viburnum dentatum*), poison oak (*Rhus toxicodendron*), greenbriar (*Smilas spp.*), and blackberry (*Rubus louisianus*). Subtype 2 (Shortleaf Pine-Post Oak-Southern Red Oak) is found mostly in Gregg and Smith Counties. Associated plants include loblolly pine (*Pinus taeda*), black hickory (*Carya texana*), sandjack oak (*Quercus incana*), flowering dogwood, common persimmon (*Diospyros virginiana*), sweetgum (*Liquidambar styraciflua*), greenbriar, yaupon (*Ilex vomitoria*), wax myrtle, American beautyberry, hawthorn (*Crataegus spp.*), supplejack (*Berchemia scandens*), winged elm, beaked panicum (*Panicum anceps*), spranglegrass (*Chasmanthium sessiliflorum*), Indiangrass (*Sorghastrum avenaceum*), switchgrass (*Panicum virgatum*), three-awn (*Aristida spp.*), bushclover (*Lespedeza spp.*), and tickclover (*Desmodium spp.*) (McMahan et al. 1984).

Another major vegetation types is Young Forest/Grassland, which is composed of various combinations and age classes of pine and regrowth southern red oak, sweetgum, post oak (*Quercus stellata*), white oak, black hickory, elm, hackberry, and water oak. This vegetation type results from recent harvesting of pine or pine-hardwood forest and subsequent establishment of young pine plantation or young pine-hardwood forest (McMahan et al. 1984).

The riparian and aquatic vegetation of TPWD facilities is typical for the study area creeks, rivers, and wetlands (Table 3). Please note that the table provided for the selected plant species should not be considered all-inclusive.

Figure 5. The Vegetation Types of the Study Area



Legend

- Bald Cypress-WaterTupelo Swamp
- Young Forest/Grassland
- Lake
- Other Native/Introduced Grasses
- Pine-Hardwood Forest
- Post Oak Woods, Forest, and Grassland Mosaic
- Willow Oak-Water Oak-Blackgum Forest
- Water Oak-Elm-Hackberry Forest

20 0 20 40 Miles



Produced by the TPWD Water Resources Team, July 1998. No claims are made to the accuracy of the data or the suitability of the data for a particular use.

Source: TPWD GIS lab archives. The vegetation represents a general summary of previously produced larger scale maps. Delineation of the vegetation occurs only where the actual vegetation exhibited a adequate resolution for definition.

Table 3. Selected Plants of the Study Area (Wildlife Diversity Program 1998)

Scientific Name	Common Name
ACANTHACEAE	ACANTHUS FAMILY
<i>Dicliptera brachiata</i>	False mint
<i>Justicia ovata</i>	Lance leaved water willow
<i>Ruellia nudiflora</i>	Violet ruellia
ACERACEAE	MAPLE FAMILY
<i>Acer negundo</i>	Box elder
<i>Acer rubrum</i>	Red maple
ALISMATACEAE	WATER PLANTAIN FAMILY
<i>Echinodorus cordifolius</i>	Heartleaf burweed
<i>Sagittaria latifolia</i>	Common arrowhead
<i>Sagittaria platyphylla</i>	Broadleaf sagittaria
AMARYLLIDACEAE	AMARYLLIS FAMILY
<i>Hypoxis hirsuta</i>	Common goldstar
ANACARDIACEAE	SUMAC FAMILY
<i>Toxicodendron vernix</i>	Poison sumac
APIACEAE	CARROT FAMILY
<i>Cicuta maculata</i>	Water hemlock
<i>Eryngium prostratum</i>	Creeping eryngo
<i>Hydrocotyle ranunculoides</i>	Floating pennywort
<i>Hydrocotyle umbellata</i>	Umbellate pennywort
<i>Hydrocotyle verticillata</i>	Whorled pennywort
APOCYNACEAE	DOGBANE FAMILY
<i>Apocynum cannabinum</i>	Clasping-leaf dogbane
<i>Trachelospermum difforme</i>	American star jasmine
AQUIFOLIACEAE	HOLLY FAMILY
<i>Ilex opaca</i>	American holly
ARECACEAE	PALM FAMILY
<i>Sabal minor</i>	Dwarf palmetto
ARACEAE	PALM FAMILY
<i>Peltandra virginica</i>	Virginia arrow arum
ASTERACEAE	SUNFLOWER FAMILY
<i>Aster scabrigaulis</i>	Rough-stem aster
<i>Baccharis halimifolia</i>	Eastern baccharis
<i>Bidens bipinnata</i>	Spanish needles
<i>Boltonia asteroides</i>	Lilac boltonia
<i>Boltonia diffusa</i>	Small head boltonia
<i>Eclipta prostrata</i>	White eclipta
<i>Erigeron strigosus</i>	Fleabane
<i>Eupatorium coelistinum</i>	Blue mist flower
<i>Eupatorium perfoliatum</i>	Thoroughwort
<i>Eupatorium rugosum</i>	White snakeroot
<i>Eupatorium serotinum</i>	Late eupatorium

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<i>Iva angustifolia</i>	Narrowleaf sumpweed
<i>Iva annua</i>	Annual sumpweed
<i>Mikania scandens</i>	Climbing hempweed
<i>Pluchea camphorata</i>	Camphor pluchea
<i>Rudbeckia maxima</i>	Great coneflower
<i>Verbesina virginica</i>	Frostweed, ice plant
<i>Xanthium strumarium</i>	Common cocklebur
AZOLLACEAE	MOSQUITO FERN FAMILY
<i>Azolla caroliniana</i>	Carolina mosquito fern
BETULACEAE	BIRCH FAMILY
<i>Alnus serrulata</i>	Brook-side alder
<i>Betula nigra</i>	River birch
<i>Carpinus caroliniana</i>	Blue birch
<i>Ostrya virginiana</i>	Eastern hophorn beam
BORAGINACEAE	BORAGE FAMILY
<i>Heliotropium indicum</i>	Turnsole heliotrope
<i>Heliotropium tenellum</i>	Pasture heliotrope
BRASSICACEAE	MUSTARD FAMILY
<i>Cardamine bulbosa</i>	Spring cress
CALLITRICHACEAE	WATER-STARWORT FAMILY
<i>Callitriche heterophylla</i>	Large water-starwort
CAMPANULACEAE	BLUEBELL FAMILY
<i>Lobelia cardinalis</i>	Cardinal flower
<i>Spenoclea zeylanica</i>	Chicken spike
CAPRIFOLIACEAE	HONEYSUCKLE FAMILY
<i>Sambucus canadensis</i>	Common elderberry
CELASTRACEAE	STAFF-TREE FAMILY
<i>Euonymus americanus</i>	Strawberry-bush
CLUSIACEAE	ST. JOHN'S WORT FAMILY
<i>Hypericum mutilum</i>	St. John's wort
<i>Triadenum walteri</i>	Walter's St. John's wort
COMMELINACEAE	SPIDERWORT FAMILY
<i>Commelina virginica</i>	Virginia dayflower
CORNACEAE	DOGWOOD FAMILY
<i>Cornus foemina</i>	English dogwood
<i>Nyssa aquatica</i>	Water tupelo
<i>Nyssa sylvatica</i>	Black gum
CYPERACEAE	SEDGE FAMILY
<i>Carex albolutescens</i>	White sedge
<i>Carex amphibola</i>	Amphibious sedge
<i>Carex atlantica</i>	Atlantic sedge

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<i>Carex blanda</i>	White sedge
<i>Carex caroliniana</i>	Carolina sedge
<i>Carex cherokeensis</i>	Cherokee sedge
<i>Carex crus-corvi</i>	Crowfoot sedge
<i>Carex debilis</i>	Spindlefruit sedge
<i>Carex digitalis</i>	Finger sedge
<i>Carex flaccosperma</i>	Thinfruit sedge
<i>Carex frankii</i>	Frank's sedge
<i>Carex intumescens</i>	Bladder sedge
<i>Carex louisianica</i>	Louisiana sedge
<i>Carex lupulina</i>	Hop sedge
<i>Carex muhlenbergii</i>	Muhlenberg sedge
<i>Carex retroflexa</i>	Reflexed sedge
<i>Eleocharis baldwinii</i>	Tropical flatsedge
<i>Eleocharis minima</i>	Small spikesedge
<i>Fimbristylis autumnalis</i>	Slender fimbry
<i>Fimbristylis vahlii</i>	Vahl's fimbry
<i>Rhynchospora corniculata</i>	Horned beak rush
<i>Scirpus cyperinus</i>	Woolgrass bulrush
<i>Scirpus koilolepis</i>	Small bulrush
<i>Scirpus sp.</i>	Bulrush
<i>Scleria triglomerata</i>	Tall/whip nutrush
EBENACEAE	SEDGE FAMILY
<i>Diospyros virginiana</i>	Common persimmon
EUPHORBIACEAE	SPURGE FAMILY
<i>Acalypha gracilens</i>	Slender copperleaf
FABACEAE	LEGUME FAMILY
<i>Amorpha fruticosa</i>	False indigo bush
<i>Desmanthus illinoensis</i>	Illinois bundleflower
<i>Gleditsia aquatica</i>	Water locust
<i>Gleditsia triacanthos</i>	Honey locust
<i>Sesbania drummondii</i>	Rattlebush
<i>Sesbania vesicaria</i>	Bagpod sesbania
FAGACEAE	BEECH FAMILY
<i>Quercus laurifolia</i>	Laurel oak
<i>Quercus lyrata</i>	Overcup oak
<i>Quercus macrocarpa</i>	Bur oak
<i>Quercus nigra</i>	Water oak
<i>Quercus phellos</i>	Willow oak
HALORAGACEAE	WATER MILFOIL FAMILY
<i>Proserpinaca palustris</i>	Marsh mermaid weed
HAMAMELIDACEAE	WITCH HAZEL FAMILY
<i>Liquidambar styraciflua</i>	Sweetgum

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HYDROCHARITACEAE	FROG BIT FAMILY
<i>Limnobium spongia</i>	Common frog bit
<i>Vallisneria americana</i>	Water celery
HYDROPHYLLACEAE	WATERLEAF FAMILY
<i>Hydrolea ovata</i>	Hairy hydrolea
<i>Hydrolea uniflora</i>	Smooth hydrolea
JUGLANDACEAE	WALNUT FAMILY
<i>Carya aquatica</i>	Water hickory
<i>Carya cordiformis</i>	Bitternut hickory
<i>Carya illinoensis</i>	Pecan
<i>Carya myristiciformis</i>	Nutmeg hickory
<i>Carya texana</i>	Black hickory
<i>Juglans nigra</i>	Black walnut
JUNCACEAE	RUSH FAMILY
<i>Juncus acuminatus</i>	Knotleaf rush
<i>Juncus effusus</i>	Common rush
<i>Juncus scirpoides</i>	Needlepod rush
LAMIACEAE	MINT FAMILY
<i>Lycopus rubellus</i>	Water horehound
<i>Prunella vulgaris</i>	Common selfheal
<i>Salvia lyrata</i>	Lyre-leaf sage
<i>Teucrium canadense</i>	American germander
LEMNACEAE	DUCKWEED FAMILY
<i>Lemna minor</i>	Common duckweed
<i>Spirodela polyrhiza</i>	Greater duckweed
<i>Wolffia braziliensis</i>	Brazilian wolffia
<i>Wolffiella gladiata</i>	Sword bogmat
LENTIBULARIACEAE	BLADDERWORT FAMILY
<i>Utricularia gibba</i>	Conespur bladderwort
LILIACEAE	LILY FAMILY
<i>Allium canadense</i>	Meadow onion
<i>Allium drummondii</i>	Drummond's onion
<i>Smilax bona-nox</i>	Sawtooth greenbriar
<i>Smilax glauca</i>	Cat greenbriar
<i>Smilax hispida</i>	Bristly greenbriar
<i>Smilax laurifolia</i>	Laurel greenbriar
<i>Smilax rotundifolia</i>	Common greenbriar
LYTHRACEAE	LOOSESTRIFE FAMILY
<i>Amannia coccinea</i>	Toothcup
<i>Ammania latifolia</i>	Ammania
<i>Cuphea carthagenesis</i>	Waxweed
<i>Cuphea glutinosa</i>	Blue waxweed
<i>Lythrum alatum</i>	Lanceleaf loosetrife

Continued from the previous page

<i>Rotala ramosior</i>	Tooth-cup
MAGNOLIACEAE	MAGNOLIA FAMILY
<i>Magnolia grandiflora</i>	Southern magnolia
MALVACEAE	MALLOW FAMILY
<i>Hibiscus lasiocarpus</i>	Wooly rosemallow
<i>Hibiscus militaris</i>	Marsh-mallow
<i>Hibiscus moschetos</i>	Mallow
<i>Malvaviscus drummondii</i>	Texas mallow
MARANTHACEAE	ARROWROOT FAMILY
<i>Thalia dealbata</i>	Powdery thalia
MARSILEACEAE	WATER CLOVER FERN FAMILY
<i>Marsilea vestita</i>	Hooked water clover
MELASTOMATACEAE	MELASTOMA FAMILY
<i>Rhexia mariana</i>	Maryland meadow beauty
MORACEAE	MULBERRY FAMILY
<i>Maclura pomifera</i>	Osage orange
MYRICACEAE	WAX-MYRTLE FAMILY
<i>Myrica cerifera</i>	Southern waxmyrtle
<i>Myrica heterophylla</i>	Waxmyrtle
NAJADACEAE	WATER NYMPH FAMILY
<i>Najas guadalupensis</i>	Common water nymph
NYMPHACEAE	WATERLILY FAMILY
<i>Brasenia schreberi</i>	Water shield
<i>Nelumbo lutea</i>	Yellow lotus
<i>Nuphar luteum ssp. macrophyllum</i>	Yellow cowlily
<i>Nymphaea odorata</i>	White waterlily
OLEACEAE	OLIVE FAMILY
<i>Foresteria acuminata</i>	Swamp privet
<i>Fraxinus pennsylvanica</i>	Green ash
ONAGRACEAE	PRIMROSE FAMILY
<i>Ludwigia alternifolia</i>	Bushy seedbox
<i>L. decurrens</i>	Winged seed box
<i>L. palustris</i>	Marsh seed box
<i>L. peploides</i>	Smooth seed box
OPHIOGLOSSACEAE	ADDER'S TONGUE FAMILY
<i>Botrychium biternatum</i>	Sparse lobed grape
OSMUNDACEAE	CINNAMON FERN FAMILY
<i>Osmunda cinnamomea</i>	Cinnamon fern
<i>Osmunda regalis</i>	Royal fern
PINACEAE	PINE FAMILY
<i>Pinus taeda</i>	Loblolly pine
PLANTANACEAE	PLANE-TREE FAMILY
<i>Platanus occidentalis</i>	Sycamore

Continued from the previous page

POACEAE	GRASS FAMILY
<i>Andropogon glomeratus</i>	Bushy bluestem
<i>Arundinaria gigantea</i>	Giant cane
<i>Chasmanthium latifolium</i>	Broadleaf woodoats
<i>Echinochloa walteri</i>	Barnyard grass
<i>Elymus virginicus</i>	Virginia wildrye
<i>Erianthus contortus</i>	Twisted awn plumegrass
<i>Erianthus strictus</i>	Narrow plumegrass
<i>Leersia lenticularis</i>	Catchfly cutgrass
<i>Leersia oryzoides</i>	Rice cutgrass
<i>Leersia virginica</i>	White cutgrass
<i>Luziola fluitans</i>	Floating luziola
<i>Panicum anceps</i>	Beaked panicum
<i>Panicum gymnocarpum</i>	Largeleaf panicum
<i>Sporobolus asper</i>	Dropseed
<i>Sporobolus indicus</i>	Rattail smutgrass
POLYGONACEAE	KNOTWEED FAMILY
<i>Brunnichia ovata</i>	Eardrop vine
<i>Polygonum hydropiper</i>	Smartweed
<i>Polygonum punctatum</i>	Water smartweed
<i>Polygonum sagittatum</i>	Arrow-vine
<i>Polygonum virginianum</i>	Jumpseed
<i>Rumex hastatulus</i>	Heartwing dock
PONTEDERIACEAE	PICKEREL WEED FAMILY
<i>Pontederia cordata</i>	Pickrel weed
PRIMULACEAE	PRIMROSE FAMILY
<i>Samolus valerandi</i>	Brookweed
RANUNCULACEAE	CROWFOOT FAMILY
<i>Myosurus minimus</i>	Tiny mousetail
RHAMNACEAE	BUCKTHORN FAMILY
<i>Berchemia scandens</i>	Rattanvine
ROSACEAE	ROSE FAMILY
<i>Crateagus mollis</i>	Downy hawthorne
<i>Crateagus opaca</i>	Riverflat hawthorne
<i>Prunus umbellata</i>	Flatwood plum
<i>Rubus trivialis</i>	Southern dewberry
<i>Rubus scepes scandens</i>	Leaning blackberry
RUBIACEAE	COFFEE FAMILY
<i>Cephalanthus occidentalis</i>	Buttonbush
<i>Diodia virginiana</i>	Virginia buttonweed
SALICACEAE	WILLOW FAMILY
<i>Populus deltoides</i>	Eastern cottonwood
<i>Salix nigra</i>	Black willow

Continued from previous page

SAPINDACEAE	SOAPBERRY FAMILY
<i>Cardiospermum halicacabum</i>	Common balloonvine
SAURURACEAE	LIZARD'S-TAIL FAMILY
<i>Saururus cernuus</i>	Common lizard-tail
SAXIFRAGACEAE	SAXIFRAGE FAMILY
<i>Penthorum sedoides</i>	Ditch stonecrop
SCROPHULARIACEAE	FIGWORT FAMILY
<i>Bacopa monnieri</i>	Water hyssop
<i>Mecardonia vandelloides</i>	Mecardonia
<i>Mimulus alatus</i>	Sharpwing monkey flower
SPARGANIACEAE	BUR REED FAMILY
<i>Sparganium americanum</i>	American Burreed
THELYPTERIDACEAE	MARSH FERN FAMILY
<i>Thelypteris dentata</i>	Downy maiden fern
TYPHACEAE	CATTAIL FAMILY
<i>Typha latifolia</i>	Broad-leaf cattail
ULMACEAE	ELM FAMILY
<i>Celtis laevigata</i>	Sugarberry
<i>Planera aquatica</i>	Water elm
<i>Ulmus americana</i>	American elm
<i>Ulmus crassifolia</i>	Cedar elm
URTICACEAE	NETTLE FAMILY
<i>Boehmeria cylindrica</i>	Smallspike falsenettle
VALERIANACEAE	VALERIAN FAMILY
<i>Valerianella radiata</i>	Beaked corn salad
VERBENACEAE	VERVAIN FAMILY
<i>Phyla lanceolata</i>	frog fruit
VIOLACEAE	VIOLET FAMILY
<i>Viola missouriensis</i>	Missouri violet
VITACEAE	GRAPE FAMILY
<i>Ampelopsis arborea</i>	Peppervine
WOODSIACEAE	CLIFF FERN FAMILY
<i>Onoclea sensibilis</i>	Sensitive fern

Table 3 is based on reports and observations by Texas Parks and Wildlife Department staff botanists Jackie Poole , Bill Carr, and Jason Singhurst. This table contains those plants that are riparian, semi-aquatic, and aquatic. Table 3 should not be considered all-inclusive.

Rivers and Reservoirs

The Sabine, Neches, and Angelina Rivers flow through the study area (Fig. 6). Major reservoirs (Fig. 6) in the study area store water from these rivers and their tributaries.

Lake Palestine is on the Neches River. It provides water to the city of Palestine and is projected to provide water to Dallas and Tyler (Preston et al. 1991).

Sam Rayburn Reservoir is located on the Angelina River. The City of Lufkin owns water rights from the reservoir, but much of the total permitted capacity is committed to irrigation and industrial supply in the lower part of the Neches River basin (Preston et al. 1991).

Other reservoirs with a storage capacity of greater than 5,000 acre-feet of water in the study area are Lake Taylor, Lake Taylor East, Lake Jacksonville, Lake Nacogdoches, Lake Striker, and Lake Cherokee.

Springs

The distribution and size, as of 1980, of springs and seeps in the area are given by county in Table 4 (Brune 1981). Most springs emanate from the top of the groundwater reservoir, so changes in the water table elevation generally have immediate impact upon spring discharge rates.

Table 4. Distribution and Estimated Size (in 1980) of Springs and Seeps in the Study Area (Brune 1981)

County	Large	Moderately large	Medium	Small	Very small	Seep	Former
Angelina *	NA	NA	NA	NA	NA	NA	NA
Cherokee	0	0	1	12	0	1	0
Gregg	0	0	0	4	5	0	0
Nacogdoches	0	0	2	9	8	2	1
Rusk	0	0	1	12	6	0	0
Smith	0	0	1	11	0	3	1

The numbers above are a reflection of either a spring or a group of springs. * No available records for Angelina County.

Codes:

Large = 280 to 2,800 cfs

Moderately large = 28 to 280 cfs

Medium = 2.8 to 28 cfs

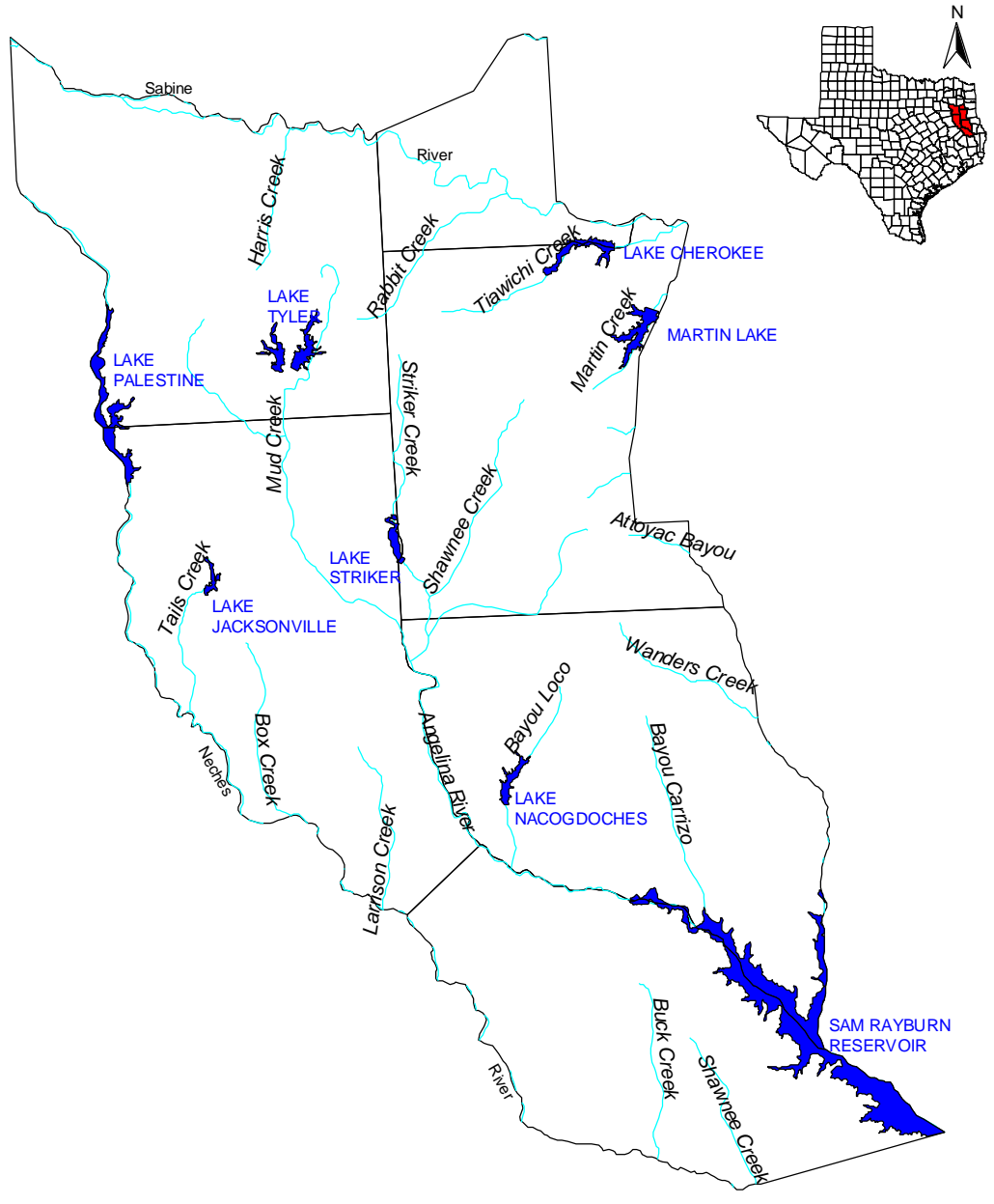
Former = no flow or inundated

Small = 0.28 to 2.8 cfs

Very Small = 0.028 to 0.28 cfs

Seep = less than 0.028 cfs

Figure 6. Streams and Reservoirs of the Area



Produced by the TPWD Water Resources Team, July 1998. No claims are made to the accuracy of the data or the suitability of the data for a particular use.

Sources:
Texas Natural Resources Information System,
Texas Water Development Board,
TPWD GIS lab archives data 1998.

Projections:
Texas Statewide Projection

Most of the springs in the study area issue from Tertiary Eocene sands, primarily Carrizo, Reklaw, and Queen City. These sands dip mostly toward the west into the East Texas embayment at about 3 meters per kilometer. Some springs run from Quaternary terrace sand and gravel, especially along the Sabine River. The combination of many sand aquifers and a hilly topography has produced an abundance of springs in the study area. The vegetation of these springs includes ferns, mosses, and cattails, dogwood, sumac, black gum, redbud, willow, sweetgum, maple, sycamore, birch, and wild plum.

The groundwater table has not been severely affected by man's activities except in areas of heavy pumpage, such as around cities (Brune 1981). The implementation of a PGMA in this region could prevent the lowering of groundwater tables in these areas to the point where more springs go dry. In general, a flowing spring emphasizes the fact that ground and surface water supplies are not depleted.

Wetlands

Some important wetlands of the study area are the forested wetlands on the floodplains of the region's rivers. These wetlands are generally called bottomland hardwood forests. The study area contains three major types of bottomland hardwood forests. The most extensive type is the water oak-willow oak-blackgum association found along the Neches, Angelina, and Sabine Rivers, and along Attoyac Bayou. The water oak-elm-hackberry association is found primarily along the Sabine River in the northwest corner of the area. There is also a significant bald cypress-water tupelo swamp along the Neches River on the southern edge of the area. These wetlands, in conjunction with the large reservoirs in the study area, support a diverse flora and fauna consisting of wetland dependent, aquatic, semi-aquatic, and riparian species as summarized in Tables 3,5,6,7,8, and 9.

Fishes

The study area rivers and streams have a variety of fish species. The Wildlife Diversity Program at Texas Parks and Wildlife Department maintains a database (Texas Biological and Conservation Database "TXBCD") which includes some of those species. It is not a complete list and is not included in this report.

Two of the fish species listed in the TXBCD and on their special species list are threatened species, the paddlefish and the creek chubsucker. The paddlefish, in Texas, once occurred in every major river from the Trinity River Basin eastward. By the 1950s, its numbers and range had been substantially reduced (Hubbs et al. 1991). The creek chubsucker occurs in eastern Texas streams. It prefers headwaters but seldom occurs in springs. Young creek chubsuckers are typically found in headwater rivulets or marshes. Adults spawn in river mouths or pools and riffles, large outlets, and upstream creeks (Hubbs et al. 1991).

Other fish species that have been collected from Mud Creek (Fig. 6) in the study area TPWD scientist Gordon Linam include shiners, minnows, suckers, catfishes, sunfishes, and darters. Table 5 contains the complete list of the species collected from Mud Creek.

Table 5. List of the Fish Species Collected From Mud Creek

Scientific Name	Common Name
CYPRINIDAE	
<i>Cyprinella venusta</i>	Blacktail shiner
<i>Lythrurus fumeus</i>	Ribbon shiner
<i>Notemigonus crysoleucas</i>	Golden shiner
<i>Notropis amnis</i>	Pallid shiner
<i>Notropis atrocaudalis</i>	Blackspot shiner
<i>Notropis texanus</i>	Weed shiner
<i>Notropis volucellus</i>	Mimic shiner
<i>Phenacobius mirabilis</i>	Suckermouth minnow
<i>Pimephales vigilax</i>	Bullhead minnow
CATOSTOMIDAE	
<i>Erimyzon sucetta</i>	Lake chubsucker
<i>Minytrema melanops</i>	Spotted sucker
ICTALURIDAE	
<i>Ameiurus natalis</i>	Yellow bullhead
<i>Noturus nocturnus</i>	Freckled madtom
APHREDODERIDAE	
<i>Aphredoderus sayanus</i>	Pirate perch
ESOCIDAE	
<i>Esox americanus vermiculatus</i>	Grass pickerel
CYPRINODONTIDAE	
<i>Fundulus notatus</i>	Blackstripe topminnow
POECILIDAE	
<i>Gambusia affinis</i>	Western mosquitofish
CENTRARCHIDAE	
<i>Centrarchus macropterus</i>	Flier
<i>Lepomis cyanellus</i>	Green sunfish
<i>Lepomis gulosus</i>	Warmouth
<i>Lepomis macrochirus</i>	Bluegill
<i>Lepomis megalotis</i>	Longear sunfish
<i>Lepomis microlophus</i>	Redear sunfish
<i>Lepomis punctatus</i>	Spotted sunfish
<i>Micropterus salmoides</i>	Largemouth bass

Continued

Scientific Name	Common Name
PERCIDAE	
<i>Etheostoma asprigene</i>	Mud darter
<i>Etheostoma chlorosomum</i>	Bluntnose darter
<i>Etheostoma gracile</i>	Slough darter
<i>Etheostoma histrio</i>	Harlequin darter
<i>Percina sciera</i>	Dusky darter

During 1978 and 1979, a series of fish kills in three East Texas reservoirs were investigated by TPWD biologists and personnel from other agencies. The findings for one of the reservoirs within the study area, Martin Creek Lake, attributed the fish kills to elevated selenium body burdens in fish, which apparently accumulated after discharges from power plant ash settling ponds to the reservoir. Selenium concentrations in these ponds were determined to be in excess of 2000 parts per billion (ppb) (Cantu and Moss 1990).

Selenium is acutely toxic to fish, and can affect reproduction at lower than toxic concentrations. The potential for selenium toxicity in the aquatic environment depends upon the characteristics of each individual ecosystem: clear, shallow bodies of water, with low to moderate productivity, low sedimentation rates, and long retention times favor the likelihood of selenium accumulating to toxic levels (Lemly and Smith 1987 in Cantu and Moss 1990).

Mean selenium concentrations in largemouth bass and bluegill muscle (edible tissue) from Martin Creek Lake have approached or exceeded 2.0 ppm wet weight since a 1985 collection. It was reported by Baumann and May (1984) and Saiki (1985) that selenium concentrations greater than or equal to 2.0 ppm wet weight may cause toxic effects in sensitive fish (Cantu and Moss 1990).

In summary, selenium concentrations in fish from Martin Creek Lake remain elevated a decade after the selenium discharges. Studies indicate that mean selenium body burdens decreased between 1985 and 1988, but that selenium concentrations ceased to decrease, or increased in 1989 (Cantu and Moss 1990). During the study period, mean selenium residues in fish liver tissue exceeded 3.5 ppm wet weight, and approached or exceeded 2.0 ppm wet weight in muscle or whole fish (Cantu and Moss 1990). High selenium concentrations may pose a hazard to sensitive fish species or predators, and human health implications need to be considered.

The study area has a number of large reservoirs and impoundments (Fig. 6) that support game fish and other fish not as typical of rivers and streams. These lakes provide recreational fishing opportunities, as do the rivers and streams. They also provide habitat for birds and other wildlife.

Birds and Waterfowl

Table 6 is extracted from the *Checklist of the Birds of Nacogdoches County and Lake Sam Rayburn* (Fisher and Wolf 1979). The data on the checklist were gathered during a 10-year period, from 1969 through 1978. Table 6 represents those bird species that use riparian, wetlands, or aquatic habitats within the study area. Species appearing on this table do not share the same probability of occurrence.

Many species of waterfowl, migrating birds, wintering shorebirds, and neotropical songbirds (Table 6) stopover in the study area to feed and rest along the river banks and creek bottoms. The trees and shrubs that grow along the rivers, streams, and lakes (the riparian habitat) are of special importance to migrating and nesting songbirds and raptors, such as the yellow-throated vireo and the swallow-tailed kite.

Bald eagles (*Haliaeetus leucocephalus*), although rare in the study area, are a state and federally threatened species that is found primarily near rivers and large lakes in the study area. Bald eagles nest in tall trees or on cliffs near water.

Swallow-tailed kites (*Elanoides forficatus*), a rare species in the study area, is listed as threatened by the state of Texas. In the study area, this species is found in lowland forested regions, especially swampy areas, ranging into open woodland, and marshes, along rivers, lakes, and ponds. It nests high in tall trees in clearings, or on forest woodland edge, usually in pine, cypress, or various deciduous trees.

Table 6. Selected Birds and Waterfowl of the Study Area (from Fisher and Wolf 1979)

	Sp	S	F	W
Podicipedidae				
Horned Grebe	5		5	5
Eared Grebe	4	8	4	5
Western Grebe	8		7	7
Pied-billed Grebe	3	6	3	4
Pelecanidae				
White Pelican	5	8	5	8
Brown Pelican	8			
Phalacrocoracidae				
Double-crested cormorant	2	7	2	3
Olivaceous cormorant		7		
Ardeidae				
Great blue heron	4	4	4	5

1- abundant 2- very common 3- common 4- fairly common 5- uncommon 6- scarce/irregular
 7- rare or very local 8- very rare **Sp-** March-May; **S-** June-July; **F-** Aug.-Nov.; **W-** Dec-Feb

Continued from previous page

	Sp	S	F	W
Green heron	4	4	3	7
Little blue heron	3	3	2	
Cattle egret	3	3	2	6
Great egret	5	4	3	6
Snowy egret	6	5	5	
Tricolored heron		6	5	
Black-crowned night heron	6		5	
Yellow-crowned night heron	5	5	4	
Least bittern	7	7	7	
American bittern	6		6	7
Threskiomithidae				
White-faced ibis	7	7	6	
White ibis	6	6	5	
Roseate spoonbill		7	5	
Ciconiidae				
Wood Stork		5	4	
Anatidae				
Canada goose	6		5	7
White-fronted goose	6		5	7
Snow goose	4		3	5
Mallard	3	7	3	3
Black duck				7
Gadwall	3	7	2	4
Pintail	3		3	5
Green-winged teal	2		2	4
Blue-winged teal	2	6	2	
Cinnamon teal	7			
American wigeon	3		3	4
Northern shoveler	3	7	3	4
Wood duck	5	5	4	4
Redhead	7		5	6
Ring-necked duck	3	7	3	4
Canvasback	5		4	5
Greater scaup			7	6
Lesser scaup	2	7	2	2
Common goldeneye	5		5	6
Bufflehead	4		4	4
Oldsquaw	8		8	7
White-winged scoter	7			7

1- abundant 2- very common 3- common 4- fairly common 5- uncommon 6- scarce/irregular
7- rare or very local 8- very rare **Sp-** March-May; **S-** June-July; **F-** Aug.-Nov.; **W-** Dec-Feb

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	Sp	S	F	W
Black scoter	8			
Ruddy duck	2	7	2	2
Hooded merganser	6		5	5
Common merganser				8
Red-breasted merganser	5		6	6
Accipitridae				
Swallow-tailed kite	8			
Mississippi kite	5		5	
Red-shouldered hawk	4	4	4	4
Bald eagle	6	7	6	5
Marsh hawk	5		5	6
Osprey	5	8	5	7
Rallidae				
King rail	6	6	6	8
Virginia rail	6		5	
Sora	5		4	
Purple gallinule	6	6	6	
Common gallinule	6	6	6	
American coot	1	6	1	2
Gruidae				
Sandhill crane			7	
Charadriidae				
American golden plover	4		6	
Black-bellied plover			5	
Semipalmated plover	6		4	
Killdeer	3	4	3	3
Piping plover			6	8
Snowy plover			8	
Recurvirostridae				
American avocet			5	
Scolopacidae				
Hudsonian godwit	8			
Whimbrel	8			
Long-billed curlew				
Upland sandpiper	4	8	5	
Greater yellowlegs	5		4	6
Lesser yellowlegs	4		3	
Solitary sandpiper	4		4	8
Willet	6		5	
Spotted sandpiper	4		4	6

1- abundant 2- very common 3- common 4- fairly common 5- uncommon 6- scarce/irregular
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	Sp	S	F	W
Ruddy turnstone	7		6	
Wilson's phalarope	5		5	
Red phalarope			8	
American woodcock	6		6	5
Common snipe	3		3	4
Short-billed dowitcher			5	
Red knot			7	
Sanderling	7		5	
Semipalmated sandpiper	3		12	
Western sandpiper	3		2	
Least sandpiper	2		1	4
White-rumped sandpiper	4			
Baird's sandpiper	5		5	
Pectoral sandpiper	2		1	
Buff-breasted sandpiper	6		4	
Ruff			8	
Laridae				
Ring-billed gull	3		3	3
Herring gull	5		6	5
Laughing gull		7		
Franklin's gull	5		6	
Bonaparte's gull	4		4	4
Black tern	3		3	
Caspian tern	6	7	5	7
Common tern			6	
Forster's tern	3	6	2	4
Alcedinidae				
Belted kingfisher	4	5	4	5
Picidae				
Red-headed woodpecker	4	4	4	4
Tyrannidae				
Eastern phoebe	5	6	4	4
Yellow-bellied flycatcher	5		4	
Acadian flycatcher	3	3	4	
Willow flycatcher	5	8		
Alder flycatcher	5			
Vermillion flycatcher			6	7
Hirundinidae				
Bank swallow	4		4	
Rough-winged swallow	3	5	3	

1- abundant 2- very common 3- common 4- fairly common 5- uncommon 6- scarce/irregular
7- rare or very local 8- very rare **Sp-** March-May; **S-** June-July; **F-** Aug.-Nov.; **W-** Dec-Feb

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	Sp	S	F	W
Troglodytidae				
Carolina wren	2	2	2	2
Marsh wren	6		6	7
Sedge wren	5		5	6
Motacillidae				
Water pipit	4		3	4
Sprague's pipit	5		5	6
Vireonidae				
Yellow-throated vireo	4	4	5	
Solitary vireo	5		5	5
Red-eyed vireo	3	3	4	
Emberizidae				
Henslow's sparrow			7	6
Lincoln's sparrow	3		3	5
Swamp sparrow	3		3	3
Parulidae				
Prothonotary warbler	4	4	5	
Swainson's warbler	5	5	6	
Blue-winged warbler	6		6	
Northern parula	3	3	4	
Yellow warbler	4		4	
Blackburnian warbler	5		6	
Palm warbler			7	8
Northern waterthrush	4		5	
Louisiana waterthrush	5	5	6	
Kentucky warbler	4	4	5	
Common yellowthroat	2	4	3	7
Hooded warbler	4	4	5	
Icteridae				
Yellow-headed blackbird	7			
Red-winged blackbird	1	2	1	1

1- abundant 2- very common 3- common 4- fairly common 5- uncommon 6- scarce/irregular
7- rare or very local 8- very rare **Sp-** March-May; **S-** June-July; **F-** Aug.-Nov.; **W-** Dec-Feb

Mammals, Reptiles, and Amphibians

There are 1,100 vertebrate species in Texas, 60 of which are endemic to the state (Texas Audubon 1997). There are at least 64 species of mammals (Table 7), reptiles (Table 8), and amphibians (Table 9) that are either aquatic, semi-aquatic, or in some way wetland-dependent, present in the study area.

The bats listed in Table 7 typically drink from rivers and other riparian habitats as well as use the rivers and streams as travel corridors. For example the southeastern myotis leave their roosts in the evening and fly to ponds and streams over which they forage and from which they drink (Davis and Schmidly 1994). River otter, swamp rabbit, and marsh rice rat are but a sample of the diverse riparian fauna that exists in the study area.

The listed frogs, salamanders, turtles, and muskrats are aquatic animals. Most toads require aquatic habitats in order to reproduce. The East Texas toad and the green treefrog are good examples. The former prefers sandy areas near marshes, irrigation ditches, or temporary rain pools and the latter is at home wherever there is water with sandy banks and dense vegetation. It can be seen in swamps, along streams and in rivers, or around the edges of lakes.

In the study area, most of the snakes and lizards listed in Table 8 are restricted to riparian habitats adjacent to the rivers, springs, ponds, lakes, and wetlands. The alligator snapping turtle, a state threatened species, is found in deep water of rivers, lakes, oxbows, and ponds near deep running water within the study area (Table 8). It is usually in water with mud bottom and abundant aquatic vegetation (Garrett and Barker 1987). The Southern water snake is very uncommon in parts of its East Texas range. It occurs in and around permanent bodies of slow-moving or still water, as well as in wet prairie and coastal wetlands (Garrett and Barker 1987).

The following selected tables are based on the Texas Biological Conservation Database (TXBCD) inventory, and input from Texas Parks and Wildlife staff scientists.

Table 7. Selected Mammals of the Study Area (Wildlife Diversity Program, 1998; Davis and Schmidly 1994)

Scientific name	Common name	County
<i>Blarina carolinensis</i>	Southern short-tailed shrew	Gregg, Rusk
<i>Castor canadensis</i>	American beaver	All study area
<i>Corynorhinus rafinesquii</i>	Rafinesque's big-eared bat	Angelina, Nacogdoches, Smith
<i>Cryptotis parva</i>	Least shrew	Gregg, Rusk, Smith
<i>Lutra canadensis</i>	River otter	Angelina, Cherokee, Nacogdoches, Rusk

Continued from previous page

<i>Mustela vison</i>	Mink	Angelina, Cherokee, Gregg, Rusk, Smith
<i>Myocastor coypus</i>	Nutria	Gregg, Rusk, Smith
<i>Myotis austroriparius</i>	Southeastern myotis bat	Angelina, Gregg, Smith
<i>Nycticeius humeralis</i>	Evening bat	Gregg, Smith
<i>Oryzomys palustris</i>	Marsh rice rat	Gregg
<i>Pipistrellus subflavus</i>	Eastern pipistrelle	Gregg
<i>Scalopus aquaticus</i>	Eastern mole	Angelina, Cherokee, Gregg, Rusk, Smith
<i>Sylvilagus aquaticus</i>	Swamp rabbit	Angelina, Cherokee, Gregg, Smith

Table 8. Selected Reptiles of the Study Area (Wildlife Diversity Program, 1998)

Scientific Name	Common Name	County
<i>Alligator mississippiensis</i>	American alligator	All study area
<i>Chelydra serpentina</i>	Snapping turtle	Angelina, Nacogdoches, Gregg, Rusk, Smith
<i>Elaphe guttata</i>	Corn snake	Angelina, Nacogdoches, Smith
<i>Farancia abacura</i>	Mud snake	Angelina, Cherokee, Nacogdoches, Smith
<i>Graptemys pseudogeographica</i>	False map turtle	Angelina, Cherokee, Nacogdoches, Gregg, Smith
<i>Graptemys kohni</i>	Mississippi map turtle	Angelina, Cherokee, Nacogdoches, Gregg
<i>Kinosternon flavescens</i>	Yellow mud turtle	Rusk
<i>Kinosternon subrubrum</i>	Eastern mud turtle	Angelina, Cherokee, Nacogdoches, Rusk, Smith
<i>Macrolemys temminckii</i>	Alligator snapping turtle	Rusk, Smith
<i>Micrurus fulvius</i>	Eastern coral snake	Angelina Gregg, Rusk, Smith
<i>Nerodia erythrogaster</i>	Plainbelly water snake	Angelina, Nacogdoches, Rusk, Smith
<i>Nerodia fasciata</i>	Southern water snake	All study area
<i>Nerodia rhombifer</i>	Diamondback water snake	All study area
<i>Pseudemys concinna</i>	River cooter	All study area
<i>Regina rigida</i>	Glossy crayfish snake	Angelina, Nacogdoches, Gregg, Rusk, Smith
<i>Thamnophis sirtalis</i>	Common garter snake	Angelina
<i>Trionyx muticus</i>	Smooth softshell turtle	Gregg
<i>Trionyx spinifera</i>	Spiny softshell turtle	Angelina, Cherokee, Nacogdoches, Rusk, Smith

Table 9. Selected Amphibians of the Study Area (Wildlife Diversity Program, 1998)

Scientific Name	Common Name	County
<i>Acris crepitans</i>	Northern cricket frog	All study area
<i>Ambystoma maculatum</i>	Spotted salamander	Cherokee, Gregg, Rusk, Smith
<i>Ambystoma opacum</i>	Marbled salamander	Angelina, Cherokee, Gregg, Nacagdoches, Rusk
<i>Ambystoma texanum</i>	Smallmouth salamander	Angelina, Cherokee, Nacagdoches, Rusk, Smith
<i>Ambystoma tigrinum</i>	Tiger salamander	Gregg, Nacagdoches, Smith
<i>Amphiuma tridactylum</i>	Three-toed amphiuma	Angelina, Cherokee, Nacagdoches, Smith
<i>Bufo americanus</i>	American toad	Gregg
<i>Bufo valliceps</i>	Gulf coast toad	Angelina, Gregg, Nacagdoches
<i>Bufo velatus</i>	East Texas toad	All study area
<i>Desmognathus auriculatus</i>	Southern dusky salamander	Cherokee, Nacagdoches
<i>Eurycea quadridigitata</i>	Dwarf salamander	All study area
<i>Gastrophryne carolinensis</i>	Eastern narrowmouth toad	Angelina, Cherokee, Nacagdoches, Rusk, Smith
<i>Gastrophryne olivacea</i>	Great plains narrowmouth toad	Nacagdoches, Smith
<i>Hyla chrysoscelis</i>	Cope's gray treefrog	All study area
<i>Hyla cinerea</i>	Green treefrog	All study area
<i>Hyla squirella</i>	Squirrel treefrog	Angelina, Nacagdoches
<i>Hyla versicolor</i>	Northern gray treefrog	All study area
<i>Necturus beyeri</i>	Gulf coast waterdog	All study area
<i>Notophthalmus viridescens</i>	Eastern newt	All study area
<i>Pseudacris crucifer</i>	Spring peeper	Angelina, Cherokee, Nacagdoches, Smith
<i>Pseudacris streckeri</i>	Strecker's chorus frog	Gregg, Nacagdoches, Rusk, Smith
<i>Pseudacris triseriata</i>	Striped chorus frog	All study area
<i>Rana areolata</i>	Crawfish frog	Nacagdoches
<i>Rana catesbeiana</i>	Bullfrog	Angelina, Cherokee, Nacagdoches, Rusk, Smith
<i>Rana clamitans</i>	Green frog	Angelina, Cherokee, Nacagdoches, Rusk, Smith
<i>Rana palustris</i>	Pickerel frog	Cherokee, Nacagdoches, Smith
<i>Rana sphenoccephala</i>	Southern leopard frog	Angelina, Cherokee, Nacagdoches, Rusk, Smith
<i>Scaphiopus holbrookii</i>	Eastern spadefoot	Angelina, Cherokee, Gregg, Nacagdoches, Rusk
<i>Siren intermedia</i>	Lesser siren	Gregg, Nacagdoches, Rusk
<i>Syrhophus cystignathoides</i> (introduced)	Rio Grande chirping frog	Smith

Conclusions

Stresses on the area's different ecosystems come from the number of people and their location; and the nature and scale of their activities. The 1990 human population of the study area was approximately 465,700 and is expected to increase to slightly more than 703,770 by the year 2050.

Selected natural resources covered in the report face an uncertain future; a future that depends on the quality and quantity of the water resources, both surface and ground, within the study area.

The construction of Sam Rayburn Reservoir and several other reservoirs within the study area has resulted in the loss of significant amounts of valuable forested wetlands. The Angelina and Neches River Authority has a state permit to construct the proposed Eastex Reservoir on Mud Creek in Cherokee County but has not obtained the necessary federal permits. This project is permitted to supply 85,100 ac-ft of water per year for municipal and industrial use. The estimated cost for the Eastex project (1996 dollars) is \$122 million. Studies by TWDB on ground-water resources of the region indicate that there should be adequate supplies in the region to meet long-range needs at less cost than the Eastex project. Considerable mitigation requirements would add to the overall cost to build the Eastex project (TWDB 1997).

Mitigating the negative impacts of past and current activities, such as grazing, forestry, agriculture, industrialization, urbanization, and reservoir construction will improve the chances of natural resources recovery. In addition, fundamental changes in natural resources management strategies and valuation are needed to protect the biological systems and natural resources in the study area.

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Appendix A

(From Crompton et al. 1998)

RUSK/PALESTINE STATE PARK

ECONOMIC IMPACT

AVERAGE PARTY SIZE:
 Day Visitors = 2.44
 Overnight Visitors = 2.98

AVERAGE DISTANCE TRAVELED TO SITE:
 Day Visitors = 40.0 miles
 Overnight Visitors = 178.0 miles

ACTUAL 1997 VISITATION (Fiscal Year):
 Day Visitors = 221,789
 Overnight Visitors = 944

PERCENT OF OUT-OF-COUNTY VISITORS:
 Day Visitors = 72.73
 Overnight Visitors = 97.00

PER PERSON PER DAY EXPENDITURES

Sector	Day Visitors*			Overnight Visitors			Visitor Average
	Adjacent	Enroute	Total	Adjacent	Enroute	Total	
Transportation	\$1.16	\$1.88	\$3.04	\$2.54	\$3.45	\$5.99	\$4.52
Food	2.41	1.61	4.02	2.45	4.57	7.02	5.52
Lodging	0.54	0.43	0.97	0.03	0.04	0.07	0.52
Other	0.68	0.23	0.91	1.20	0.15	1.35	1.13
Total	4.79	4.15	8.94	6.22	8.21	14.43	11.69

ESTIMATED ANNUAL ECONOMIC IMPACT ON SALES

Sector	Day Visitors*			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$187,666	\$187,666	\$297,601	\$2,329	\$2,329	\$3,693	\$301,294
Food	388,425	388,425	754,671	2,242	2,242	4,356	759,027
Lodging	87,287	87,287	165,687	25	25	47	165,734
Other	109,108	109,108	231,484	1,102	1,102	2,339	233,823
Total	772,486	772,486	1,449,443	5,698	5,698	10,435	1,459,878

ESTIMATED ANNUAL ECONOMIC IMPACT ON PERSONAL INCOME

Sector	Day Visitors*			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$187,666	\$73,209	\$101,996	\$2,329	\$908	\$1,266	\$103,262
Food	388,425	127,442	220,703	2,242	736	1,274	221,977
Lodging	87,287	22,502	42,989	25	6	12	43,001
Other	109,108	38,515	70,877	1,102	389	716	71,593
Total	772,486	261,668	436,565	5,698	2,040	3,268	439,833

ESTIMATED ANNUAL ECONOMIC IMPACT ON EMPLOYMENT

Sector	Day Visitors*			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$187,666	3.40	5.21	\$2,329	0.04	0.06	5.28
Food	388,425	11.57	17.62	2,242	0.07	0.10	17.72
Lodging	87,287	2.14	3.43	25	0.00	0.00	3.43
Other	109,108	4.41	6.48	1,102	0.04	0.07	6.55
Total	772,486	21.51	32.75	5,698	0.15	0.23	32.98

* Average PPPD Expenditure data for Texas State Parks were used.

RUSK/PALESTINE STATE PARK

ECONOMIC SURGE

AVERAGE PARTY SIZE:
 Day Visitors = 2.44
 Overnight Visitors = 2.98

AVERAGE DISTANCE TRAVELED TO SITE:
 Day Visitors = 40.0 miles
 Overnight Visitors = 178.0 miles

ACTUAL 1997 VISITATION (Fiscal Year):
 Day Visitors = 221,789
 Overnight Visitors = 944

PERCENT OF OUT-OF-COUNTY VISITORS:
 Day Visitors = 72.73
 Overnight Visitors = 97.00

PER PERSON PER DAY EXPENDITURES

Sector	Day Visitors*			Overnight Visitors			Visitor Average
	Adjacent	Enroute	Total	Adjacent	Enroute	Total	
Transportation	\$1.16	\$1.88	\$3.04	\$2.54	\$3.45	\$5.99	\$4.52
Food	2.41	1.61	4.02	2.45	4.57	7.02	5.52
Lodging	0.54	0.43	0.97	0.03	0.04	0.07	0.52
Other	0.68	0.23	0.91	1.20	0.15	1.35	1.13
Total	4.79	4.15	8.94	6.22	8.21	14.43	11.69

ESTIMATED ANNUAL ECONOMIC SURGE ON SALES (Including Local Visitors)

Sector	Day Visitors*			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$258,031	\$258,031	\$409,186	\$2,401	\$2,401	\$3,807	\$412,993
Food	534,064	534,064	1,037,634	2,311	2,311	4,491	1,042,125
Lodging	120,014	120,014	227,811	26	26	48	227,860
Other	150,018	150,018	318,278	1,137	1,137	2,411	320,690
Total	1,062,128	1,062,128	1,992,909	5,874	5,874	10,758	2,003,667

ESTIMATED ANNUAL ECONOMIC SURGE ON PERSONAL INCOME (Including Local Visitors)

Sector	Day Visitors*			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$258,031	\$100,658	\$140,240	\$2,401	\$937	\$1,305	\$141,545
Food	534,064	175,227	303,455	2,311	758	1,313	304,769
Lodging	120,014	30,940	59,107	26	7	13	59,120
Other	150,018	52,956	97,452	1,137	401	738	98,190
Total	1,062,128	359,781	600,254	5,874	2,103	3,369	603,623

ESTIMATED ANNUAL ECONOMIC SURGE ON EMPLOYMENT (Including Local Visitors)

Sector	Day Visitors*			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$258,031	4.68	7.17	\$2,401	0.04	0.07	7.24
Food	534,064	15.90	24.23	2,311	0.07	0.10	24.33
Lodging	120,014	2.94	4.72	26	0.00	0.00	4.72
Other	150,018	6.06	8.92	1,137	0.05	0.07	8.98
Total	1,062,128	29.58	45.03	5,874	0.16	0.24	45.27

* Average PPPD Expenditure data for Texas State Parks were used.

TYLER STATE PARK

ECONOMIC IMPACT

AVERAGE PARTY SIZE:
 Day Visitors = 2.72
 Overnight Visitors = 3.07

AVERAGE DISTANCE TRAVELED TO SITE:
 Day Visitors = 98.6 miles
 Overnight Visitors = 134.1 miles

ACTUAL 1997 VISITATION (Fiscal Year):
 Day Visitors = 293,599
 Overnight Visitors = 66,533

PERCENT OF OUT-OF-COUNTY VISITORS:
 Day Visitors = 26.26
 Overnight Visitors = 83.17

PER PERSON PER DAY EXPENDITURES

Sector	Day Visitors*			Overnight Visitors			Visitor Average
	Adjacent	Enroute	Total	Adjacent	Enroute	Total	
Transportation	\$1.16	\$1.88	\$3.04	\$1.79	\$0.05	\$1.84	\$2.44
Food	2.41	1.61	4.02	2.60	0.11	2.71	3.36
Lodging	0.54	0.43	0.97	0.00	0.00	0.00	0.49
Other	0.68	0.23	0.91	1.56	0.00	1.56	1.23
Total	4.79	4.15	8.94	5.94	0.16	6.10	7.52

ESTIMATED ANNUAL ECONOMIC IMPACT ON SALES

Sector	Day Visitors*			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$89,698	\$89,698	\$157,967	\$98,812	\$98,812	\$174,018	\$331,985
Food	185,653	185,653	435,450	143,727	143,727	337,112	772,562
Lodging	41,720	41,720	95,080	0	0	0	95,080
Other	52,150	52,150	137,284	86,087	86,087	226,623	363,907
Total	369,221	369,221	825,781	328,626	328,626	737,753	1,563,534

ESTIMATED ANNUAL ECONOMIC IMPACT ON PERSONAL INCOME

Sector	Day Visitors*			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$89,698	\$38,570	\$57,864	\$98,812	\$42,489	\$63,744	\$121,608
Food	185,653	62,082	133,448	143,727	48,062	103,311	236,759
Lodging	41,720	11,848	27,185	0	0	0	27,185
Other	52,150	18,487	43,154	86,087	30,518	71,237	114,391
Total	369,221	130,988	261,650	328,626	121,069	238,292	499,942

ESTIMATED ANNUAL ECONOMIC IMPACT ON EMPLOYMENT

Sector	Day Visitors*			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$89,698	1.32	2.31	\$98,812	1.45	2.55	4.86
Food	185,653	5.43	9.06	143,727	4.21	7.02	16.08
Lodging	41,720	0.93	1.73	0	0.00	0.00	1.73
Other	52,150	2.09	3.35	86,087	3.45	5.54	8.89
Total	369,221	9.77	16.46	328,626	9.11	15.10	31.56

* Average PPPD Expenditure data for Texas State Parks were used.

TYLER STATE PARK

ECONOMIC SURGE

AVERAGE PARTY SIZE:
 Day Visitors = 2.72
 Overnight Visitors = 3.07

AVERAGE DISTANCE TRAVELED TO SITE:
 Day Visitors = 98.6 miles
 Overnight Visitors = 134.1 miles

ACTUAL 1997 VISITATION (Fiscal Year):
 Day Visitors = 293,599
 Overnight Visitors = 66,533

PERCENT OF OUT-OF-COUNTY VISITORS:
 Day Visitors = 26.26
 Overnight Visitors = 83.17

PER PERSON PER DAY EXPENDITURES

Sector	Day Visitors*			Overnight Visitors			Visitor Average
	Adjacent	Enroute	Total	Adjacent	Enroute	Total	
Transportation	\$1.16	\$1.88	\$3.04	\$1.79	\$0.05	\$1.84	\$2.44
Food	2.41	1.61	4.02	2.60	0.11	2.71	3.36
Lodging	0.54	0.43	0.97	0.00	0.00	0.00	0.49
Other	0.68	0.23	0.91	1.56	0.00	1.56	1.23
Total	4.79	4.15	8.94	5.94	0.16	6.10	7.52

ESTIMATED ANNUAL ECONOMIC SURGE ON SALES (Including Local Visitors)

Sector	Day Visitors*			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$341,575	\$341,575	\$601,548	\$118,808	\$118,808	\$209,232	\$810,781
Food	706,982	706,982	1,658,226	172,811	172,811	405,329	2,063,554
Lodging	158,872	158,872	362,070	0	0	0	362,070
Other	198,590	198,590	522,789	103,507	103,507	272,481	795,271
Total	1,406,020	1,406,020	3,144,633	395,126	395,126	887,042	4,031,676

ESTIMATED ANNUAL ECONOMIC SURGE ON PERSONAL INCOME (Including Local Visitors)

Sector	Day Visitors*			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$341,575	\$146,877	\$220,350	\$118,808	\$51,087	\$76,643	\$296,993
Food	706,982	236,415	508,178	172,811	57,788	124,217	632,395
Lodging	158,872	45,120	103,521	0	0	0	103,521
Other	198,590	70,400	164,334	103,507	36,693	85,652	249,985
Total	1,406,020	498,812	996,383	395,126	145,569	286,511	1,282,895

ESTIMATED ANNUAL ECONOMIC SURGE ON EMPLOYMENT (Including Local Visitors)

Sector	Day Visitors*			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$341,575	5.02	8.80	\$118,808	1.75	3.06	11.86
Food	706,982	20.69	34.52	172,811	5.06	8.44	42.95
Lodging	158,872	3.53	6.60	0	0.00	0.00	6.60
Other	198,590	7.97	12.77	103,507	4.15	6.66	19.43
Total	1,406,020	37.21	62.69	395,126	10.96	18.16	80.85

* Average PPPD Expenditure data for Texas State Parks were used.

MARTIN CREEK LAKE STATE RECREATION AREA

ECONOMIC IMPACT

AVERAGE PARTY SIZE:
 Day Visitors = 2.01
 Overnight Visitors = N/A

AVERAGE DISTANCE TRAVELED TO SITE:
 Day Visitors = 29.8 Miles
 Overnight Visitors = N/A Miles

ACTUAL 1997 VISITATION (Fiscal Year):
 Day Visitors = 162,331
 Overnight Visitors = 19,260

PERCENT OF OUT-OF-COUNTY VISITORS:
 Day Visitors = 77.06
 Overnight Visitors = 100.0

PER PERSON PER DAY EXPENDITURES

Sector	Day Visitors			Overnight Visitors*			Visitor Average
	Adjacent	Enroute	Total	Adjacent	Enroute	Total	
Transportation	\$2.77	\$1.41	\$4.18	\$1.69	\$2.07	\$3.76	\$3.97
Food	2.77	0.43	3.21	3.15	2.45	5.60	4.40
Lodging	0.15	0.00	0.15	0.27	0.07	0.34	0.24
Other	0.91	0.05	0.96	0.99	0.15	1.14	1.05
Total	6.60	1.89	8.50	6.10	4.73	10.84	9.67

ESTIMATED ANNUAL ECONOMIC IMPACT ON SALES

Sector	Day Visitors			Overnight Visitors*			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$346,911	\$346,911	\$598,317	\$32,569	\$32,569	\$56,171	\$654,488
Food	346,911	346,911	762,892	60,708	60,708	133,503	896,395
Lodging	18,615	18,615	41,643	5,211	5,211	11,657	53,301
Other	113,381	113,381	280,481	19,020	19,020	47,052	327,533
Total	825,817	825,817	1,683,333	117,508	117,508	248,384	1,931,716

ESTIMATED ANNUAL ECONOMIC IMPACT ON PERSONAL INCOME

Sector	Day Visitors			Overnight Visitors*			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$346,911	\$131,167	\$194,999	\$32,569	\$12,314	\$18,307	\$213,305
Food	346,911	106,987	213,316	60,708	18,722	37,329	250,645
Lodging	18,615	4,064	9,970	5,211	1,138	2,791	12,761
Other	113,381	37,994	80,557	19,020	6,374	13,514	94,071
Total	825,817	280,212	498,841	117,508	38,548	71,941	570,782

ESTIMATED ANNUAL ECONOMIC IMPACT ON EMPLOYMENT

Sector	Day Visitors			Overnight Visitors*			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$346,911	6.67	10.92	\$32,569	0.63	1.02	11.94
Food	346,911	10.88	17.92	60,708	1.90	3.14	21.06
Lodging	18,615	0.52	0.90	5,211	0.15	0.25	1.16
Other	113,381	4.94	7.83	19,020	0.83	1.31	9.14
Total	825,817	23.01	37.57	117,508	3.50	5.73	43.30

* Average PPPD expenditure data for Texas State Recreation Areas were used.

MARTIN CREEK LAKE STATE RECREATION AREA

ECONOMIC SURGE

AVERAGE PARTY SIZE:
 Day Visitors = 2.01
 Overnight Visitors = N/A

AVERAGE DISTANCE TRAVELED TO SITE:
 Day Visitors = 29.8 Miles
 Overnight Visitors = N/A Miles

ACTUAL 1997 VISITATION (Fiscal Year):
 Day Visitors = 162,331
 Overnight Visitors = 19,260

PERCENT OF OUT-OF-COUNTY VISITORS:
 Day Visitors = 77.06
 Overnight Visitors = 100.0

PER PERSON PER DAY EXPENDITURES

Sector	Day Visitors			Overnight Visitors*			Visitor Average
	Adjacent	Enroute	Total	Adjacent	Enroute	Total	
Transportation	\$2.77	\$1.41	\$4.18	\$1.69	\$2.07	\$3.76	\$3.97
Food	2.77	0.43	3.21	3.15	2.45	5.60	4.40
Lodging	0.15	0.00	0.15	0.27	0.07	0.34	0.24
Other	0.91	0.05	0.96	0.99	0.15	1.14	1.05
Total	6.60	1.89	8.50	6.10	4.73	10.84	9.67

ESTIMATED ANNUAL ECONOMIC SURGE ON SALES (Including Local Visitors)

Sector	Day Visitors			Overnight Visitors*			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$450,183	\$450,183	\$776,430	\$32,569	\$32,569	\$56,171	\$832,601
Food	450,183	450,183	989,997	60,708	60,708	133,503	1,123,500
Lodging	24,156	24,156	54,040	5,211	5,211	11,657	65,697
Other	147,133	147,133	363,977	19,020	19,020	47,052	411,029
Total	1,071,655	1,071,655	2,184,445	117,508	117,508	248,384	2,432,828

ESTIMATED ANNUAL ECONOMIC SURGE ON PERSONAL INCOME (Including Local Visitors)

Sector	Day Visitors			Overnight Visitors*			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$450,183	\$170,214	\$253,048	\$32,569	\$12,314	\$18,307	\$271,355
Food	450,183	138,836	276,817	60,708	18,722	37,329	314,147
Lodging	24,156	5,273	12,938	5,211	1,138	2,791	15,729
Other	147,133	49,304	104,538	19,020	6,374	13,514	118,052
Total	1,071,655	363,628	647,341	117,508	38,548	71,941	719,282

ESTIMATED ANNUAL ECONOMIC SURGE ON EMPLOYMENT (Including Local Visitors)

Sector	Day Visitors			Overnight Visitors*			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$450,183	8.65	14.17	\$32,569	0.63	1.02	15.19
Food	450,183	14.12	23.25	60,708	1.90	3.14	26.39
Lodging	24,156	0.67	1.17	5,211	0.15	0.25	1.43
Other	147,133	6.41	10.16	19,020	0.83	1.31	11.47
Total	1,071,655	29.86	48.76	117,508	3.50	5.73	54.48

* Average PPPD expenditure data for Texas State Recreation Areas were used.

JIM HOGG STATE HISTORICAL PARK

ECONOMIC IMPACT

AVERAGE PARTY SIZE:
 Day Visitors = 3.36
 Overnight Visitors = N/A

AVERAGE DISTANCE TRAVELED TO SITE:
 Day Visitors = 135.8 miles
 Overnight Visitors = N/A miles

ACTUAL 1997 VISITATION (Fiscal Year):
 Day Visitors = 5,596
 Overnight Visitors = N/A

PERCENT OF OUT-OF-COUNTY VISITORS:
 Day Visitors = 80.82
 Overnight Visitors = N/A

PER PERSON PER DAY EXPENDITURES

Sector	Day Visitors			Overnight Visitors			Visitor Average
	Adjacent	Enroute	Total	Adjacent	Enroute	Total	
Transportation	\$2.39	\$3.08	\$5.48	-	-	-	\$5.48
Food	4.03	2.67	6.70	-	-	-	6.70
Lodging	1.22	0.57	1.79	-	-	-	1.79
Other	0.93	0.12	1.06	-	-	-	1.06
Total	8.58	6.44	15.02	-	-	-	15.02

ESTIMATED ANNUAL ECONOMIC IMPACT ON SALES

Sector	Day Visitors			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$10,829	\$10,829	\$17,359	-	-	-	\$17,359
Food	18,233	18,233	34,727	-	-	-	34,727
Lodging	5,506	5,506	10,881	-	-	-	10,881
Other	4,222	4,222	8,935	-	-	-	8,935
Total	38,790	38,790	71,903	-	-	-	71,903

ESTIMATED ANNUAL ECONOMIC IMPACT ON PERSONAL INCOME

Sector	Day Visitors			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$10,829	\$4,148	\$5,789	-	-	-	\$5,789
Food	18,233	5,802	9,924	-	-	-	9,924
Lodging	5,506	1,260	2,618	-	-	-	2,618
Other	4,222	1,495	2,687	-	-	-	2,687
Total	38,790	12,704	21,018	-	-	-	21,018

ESTIMATED ANNUAL ECONOMIC IMPACT ON EMPLOYMENT

Sector	Day Visitors			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$10,829	0.20	0.32	-	-	-	0.32
Food	18,233	0.56	0.86	-	-	-	0.86
Lodging	5,506	0.15	0.24	-	-	-	0.24
Other	4,222	0.17	0.26	-	-	-	0.26
Total	38,790	1.08	1.68	-	-	-	1.68

JIM HOGG STATE HISTORICAL PARK

ECONOMIC SURGE

AVERAGE PARTY SIZE:
 Day Visitors = 3.36
 Overnight Visitors = N/A

AVERAGE DISTANCE TRAVELED TO SITE:
 Day Visitors = 135.8 miles
 Overnight Visitors = N/A miles

ACTUAL 1997 VISITATION (Fiscal Year):
 Day Visitors = 5,596
 Overnight Visitors = N/A

PERCENT OF OUT-OF-COUNTY VISITORS:
 Day Visitors = 80.82
 Overnight Visitors = N/A

PER PERSON PER DAY EXPENDITURES

Sector	Day Visitors			Overnight Visitors			Visitor Average
	Adjacent	Enroute	Total	Adjacent	Enroute	Total	
Transportation	\$2.39	\$3.08	\$5.48	-	-	-	\$5.48
Food	4.03	2.67	6.70	-	-	-	6.70
Lodging	1.22	0.57	1.79	-	-	-	1.79
Other	0.93	0.12	1.06	-	-	-	1.06
Total	8.58	6.44	15.02	-	-	-	15.02

ESTIMATED ANNUAL ECONOMIC SURGE ON SALES (Including Local Visitors)

Sector	Day Visitors			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$13,399	\$13,399	\$21,479	-	-	-	\$21,479
Food	22,559	22,559	42,969	-	-	-	42,969
Lodging	6,813	6,813	13,463	-	-	-	13,463
Other	5,223	5,223	11,056	-	-	-	11,056
Total	47,996	47,996	88,967	-	-	-	88,967

ESTIMATED ANNUAL ECONOMIC SURGE ON PERSONAL INCOME (Including Local Visitors)

Sector	Day Visitors			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$13,399	\$5,132	\$7,163	-	-	-	\$7,163
Food	22,559	7,178	12,279	-	-	-	12,279
Lodging	6,813	1,559	3,240	-	-	-	3,240
Other	5,223	1,850	3,324	-	-	-	3,324
Total	47,996	15,719	26,006	-	-	-	26,006

ESTIMATED ANNUAL ECONOMIC SURGE ON EMPLOYMENT (Including Local Visitors)

Sector	Day Visitors			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$13,399	0.25	0.39	-	-	-	0.39
Food	22,559	0.69	1.06	-	-	-	1.06
Lodging	6,813	0.18	0.30	-	-	-	0.30
Other	5,223	0.21	0.32	-	-	-	0.32
Total	47,996	1.33	2.08	-	-	-	2.08

TEXAS STATE RAILROAD STATE HISTORICAL PARK

ECONOMIC IMPACT

AVERAGE PARTY SIZE:
 Day Visitors = 4.35
 Overnight Visitors = N/A

AVERAGE DISTANCE TRAVELED TO SITE:
 Day Visitors = 163.5 miles
 Overnight Visitors = N/A miles

ACTUAL 1997 VISITATION (Fiscal Year):
 Day Visitors = 209,059
 Overnight Visitors = N/A

PERCENT OF OUT-OF-COUNTY VISITORS:
 Day Visitors = 96.50
 Overnight Visitors = N/A

PER PERSON PER DAY EXPENDITURES

Sector	Day Visitors			Overnight Visitors			Visitor Average
	Adjacent	Enroute	Total	Adjacent	Enroute	Total	
Transportation	\$1.80	\$5.32	\$7.12	-	-	-	\$7.12
Food	2.62	3.52	6.14	-	-	-	6.14
Lodging	1.01	2.21	3.22	-	-	-	3.22
Other	2.00	0.43	2.44	-	-	-	2.44
Total	7.44	11.47	18.91	-	-	-	18.91

ESTIMATED ANNUAL ECONOMIC IMPACT ON SALES

Sector	Day Visitors			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$362,979	\$362,979	\$575,612	-	-	-	\$575,612
Food	529,458	529,458	1,028,684	-	-	-	1,028,684
Lodging	204,687	204,687	388,538	-	-	-	388,538
Other	403,916	403,916	856,949	-	-	-	856,949
Total	1,501,041	1,501,041	2,849,783	-	-	-	2,849,783

ESTIMATED ANNUAL ECONOMIC IMPACT ON PERSONAL INCOME

Sector	Day Visitors			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$362,979	\$141,598	\$197,279	-	-	-	\$197,279
Food	529,458	173,715	300,838	-	-	-	300,838
Lodging	204,687	52,768	100,809	-	-	-	100,809
Other	403,916	142,582	262,384	-	-	-	262,384
Total	1,501,041	510,664	861,310	-	-	-	861,310

ESTIMATED ANNUAL ECONOMIC IMPACT ON EMPLOYMENT

Sector	Day Visitors			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$362,979	6.59	10.08	-	-	-	10.08
Food	529,458	15.77	24.02	-	-	-	24.02
Lodging	204,687	5.01	8.05	-	-	-	8.05
Other	403,916	16.31	24.00	-	-	-	24.00
Total	1,501,041	43.67	66.15	-	-	-	66.15

TEXAS STATE RAILROAD STATE HISTORICAL PARK

ECONOMIC SURGE

AVERAGE PARTY SIZE:
 Day Visitors = 4.35
 Overnight Visitors = N/A

AVERAGE DISTANCE TRAVELED TO SITE:
 Day Visitors = 163.5 miles
 Overnight Visitors = N/A miles

ACTUAL 1997 VISITATION (Fiscal Year):
 Day Visitors = 209,059
 Overnight Visitors = N/A

PERCENT OF OUT-OF-COUNTY VISITORS:
 Day Visitors = 96.50
 Overnight Visitors = N/A

PER PERSON PER DAY EXPENDITURES

Sector	Day Visitors			Overnight Visitors			Visitor Average
	Adjacent	Enroute	Total	Adjacent	Enroute	Total	
Transportation	\$1.80	\$5.32	\$7.12	-	-	-	\$7.12
Food	2.62	3.52	6.14	-	-	-	6.14
Lodging	1.01	2.21	3.22	-	-	-	3.22
Other	2.00	0.43	2.44	-	-	-	2.44
Total	7.44	11.47	18.91	-	-	-	18.91

ESTIMATED ANNUAL ECONOMIC SURGE ON SALES (Including Local Visitors)

Sector	Day Visitors			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$376,144	\$376,144	\$596,489	-	-	-	\$596,489
Food	548,661	548,661	1,065,994	-	-	-	1,065,994
Lodging	212,111	212,111	402,630	-	-	-	402,630
Other	418,566	418,566	888,030	-	-	-	888,030
Total	1,555,483	1,555,483	2,953,143	-	-	-	2,953,143

ESTIMATED ANNUAL ECONOMIC SURGE ON PERSONAL INCOME (Including Local Visitors)

Sector	Day Visitors			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$376,144	\$146,734	\$204,434	-	-	-	\$204,434
Food	548,661	180,016	311,749	-	-	-	311,749
Lodging	212,111	54,682	104,465	-	-	-	104,465
Other	418,566	147,754	271,901	-	-	-	271,901
Total	1,555,483	529,186	892,549	-	-	-	892,549

ESTIMATED ANNUAL ECONOMIC SURGE ON EMPLOYMENT (Including Local Visitors)

Sector	Day Visitors			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$376,144	6.82	10.45	-	-	-	10.45
Food	548,661	16.34	24.89	-	-	-	24.89
Lodging	212,111	5.19	8.34	-	-	-	8.34
Other	418,566	16.90	24.87	-	-	-	24.87
Total	1,555,483	45.25	68.55	-	-	-	68.55

CADDUAN MOUNDS STATE HISTORIC SITE

ECONOMIC IMPACT

AVERAGE PARTY SIZE:
 Day Visitors = 3.01
 Overnight Visitors = N/A

AVERAGE DISTANCE TRAVELED TO SITE:
 Day Visitors = 230.7 miles
 Overnight Visitors = N/A miles

ACTUAL 1997 VISITATION (Fiscal Year):
 Day Visitors = 3,983
 Overnight Visitors = N/A

PERCENT OF OUT-OF-COUNTY VISITORS:
 Day Visitors = 93.76
 Overnight Visitors = N/A

PER PERSON PER DAY EXPENDITURES

Sector	Day Visitors			Overnight Visitors			Visitor Average
	Adjacent	Enroute	Total	Adjacent	Enroute	Total	
Transportation	\$1.01	\$3.72	\$4.73	-	-	-	\$4.73
Food	1.70	2.64	4.34	-	-	-	4.34
Lodging	0.47	1.46	1.93	-	-	-	1.93
Other	0.89	0.60	1.49	-	-	-	1.49
Total	4.09	8.41	12.50	-	-	-	12.50

ESTIMATED ANNUAL ECONOMIC IMPACT ON SALES

Sector	Day Visitors			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$3,789	\$3,789	\$6,074	-	-	-	\$6,074
Food	6,365	6,365	12,124	-	-	-	12,124
Lodging	1,768	1,768	3,494	-	-	-	3,494
Other	3,334	3,334	7,057	-	-	-	7,057
Total	15,257	15,257	28,749	-	-	-	28,749

ESTIMATED ANNUAL ECONOMIC IMPACT ON PERSONAL INCOME

Sector	Day Visitors			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$3,789	\$1,451	\$2,026	-	-	-	\$2,026
Food	6,365	2,025	3,465	-	-	-	3,465
Lodging	1,768	405	841	-	-	-	841
Other	3,334	1,181	2,122	-	-	-	2,122
Total	15,257	5,062	8,453	-	-	-	8,453

ESTIMATED ANNUAL ECONOMIC IMPACT ON EMPLOYMENT

Sector	Day Visitors			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$3,789	0.07	0.11	-	-	-	0.11
Food	6,365	0.19	0.30	-	-	-	0.30
Lodging	1,768	0.05	0.08	-	-	-	0.08
Other	3,334	0.13	0.20	-	-	-	0.20
Total	15,257	0.45	0.69	-	-	-	0.69

CADDUAN MOUNDS STATE HISTORIC SITE

ECONOMIC SURGE

AVERAGE PARTY SIZE:
 Day Visitors = 3.01
 Overnight Visitors = N/A

AVERAGE DISTANCE TRAVELED TO SITE:
 Day Visitors = 230.7 miles
 Overnight Visitors = N/A miles

ACTUAL 1997 VISITATION (Fiscal Year):
 Day Visitors = 3,983
 Overnight Visitors = N/A

PERCENT OF OUT-OF-COUNTY VISITORS:
 Day Visitors = 93.76
 Overnight Visitors = N/A

PER PERSON PER DAY EXPENDITURES

Sector	Day Visitors			Overnight Visitors			Visitor Average
	Adjacent	Enroute	Total	Adjacent	Enroute	Total	
Transportation	\$1.01	\$3.72	\$4.73	-	-	-	\$4.73
Food	1.70	2.64	4.34	-	-	-	4.34
Lodging	0.47	1.46	1.93	-	-	-	1.93
Other	0.89	0.60	1.49	-	-	-	1.49
Total	4.09	8.41	12.50	-	-	-	12.50

ESTIMATED ANNUAL ECONOMIC SURGE ON SALES (Including Local Visitors)

Sector	Day Visitors			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$4,041	\$4,041	\$6,478	-	-	-	\$6,478
Food	6,789	6,789	12,931	-	-	-	12,931
Lodging	1,886	1,886	3,726	-	-	-	3,726
Other	3,556	3,556	7,527	-	-	-	7,527
Total	16,272	16,272	30,663	-	-	-	30,663

ESTIMATED ANNUAL ECONOMIC SURGE ON PERSONAL INCOME (Including Local Visitors)

Sector	Day Visitors			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$4,041	\$1,548	\$2,160	-	-	-	\$2,160
Food	6,789	2,160	3,695	-	-	-	3,695
Lodging	1,886	431	897	-	-	-	897
Other	3,556	1,259	2,263	-	-	-	2,263
Total	16,272	5,399	9,016	-	-	-	9,016

ESTIMATED ANNUAL ECONOMIC SURGE ON EMPLOYMENT (Including Local Visitors)

Sector	Day Visitors			Overnight Visitors			Visitor Total
	Expenditures	Direct Impact	Total Impact	Expenditures	Direct Impact	Total Impact	
Transportation	\$4,041	0.08	0.12	-	-	-	0.12
Food	6,789	0.21	0.32	-	-	-	0.32
Lodging	1,886	0.05	0.08	-	-	-	0.08
Other	3,556	0.14	0.22	-	-	-	0.22
Total	16,272	0.48	0.74	-	-	-	0.74