PART III
OPERATING STIPULATIONS AND MITIGATION MEASURES FOR NONFEDERAL OIL AND GAS OPERATIONS

CHAPTER 2

PART III - OPERATING STIPULATIONS AND MITIGATION MEASURES FOR NONFEDERAL OIL AND GAS OPERATIONS

The following section lists required operating stipulations and suggested mitigation measures for each type of oil and gas operation that could occur in Big Thicket National Preserve. This section is organized by geophysical exploration (Table 2.20), drilling and production, including roads, drilling, production, and flowlines and pipelines (Table 2.21), and plugging, abandonment, and reclamation operations (Table 2.22). Operating stipulations that are required by law or regulation are listed at the beginning of each table with the appropriate citation shown in parentheses after the stipulation. Recommended mitigation measures follow the operating stipulations. The tables also specify which resource(s) would be protected by the particular operating stipulation or mitigation measure.

The following tables focus on the National Park Service's Nonfederal Oil and Gas regulations at 36 CFR Part 9 Subpart B. Many, but not all of the operating stipulations required under other federal and state laws and regulations are also listed in this table. To ensure compliance with all applicable legal and policy mandates, it is the operator's responsibility to consult with the appropriate federal, state, and local agencies prior to conducting operations in the Preserve.

Many of the mitigation measures are derived from environmental guidelines and publications developed by the oil and gas industry and environmental professionals. These measures may not address every environmental topic or risk that may be encountered during oil and gas operations.

Table 2.20. Operating Stipulations and Mitigation Measures for Nonfederal Oil and Gas Geophysical Exploration Operations

GEOPHYSICAL EXPLORATION OPERATIONS
REQUIRED OPERATING STIPULATIONS
AND
RECOMMENDED MITIGATION MEASURES

The primary resource(s) that would be protected by the operating stipulation or mitigation measure are denoted by a √ symbol. Other resources that would benefit from the protective measures are marked with a + symbol.

RESOURCES	Air Quality	Geologic Resources	Water (Surface and G.W.)	Floodplains	Vegetation	Wetlands	Fish and Wildlife	Species of Special Concern	Cultural Resources	Visitor Use and Experience	Human Health and Safety
REQUIRED OPERATING STIPULATIONS - The applicable legal citation is noted in [parenthesis] after the stipulation.											
In order to use surface or subsurface water from inside the park, the operator must demonstrate in the plan of operations that his water rights are superior to any claim of the U.S. to use the water, and where the use is subordinate to that of the U.S., that use of the water will not damage park resources. Since any use of park water has the potential to negatively affect water quality, quantity, and flow patterns, the operator should note what resources would benefit from the in-park water use and how they would benefit the resources. [36 CFR § 9.35]		+	√	+	+	+	+	+		+	
Prepare an Emergency Response Plan to ensure safe operating procedures in the event of a reportable quantity spill; damage to wells, pipelines, or other structures; fire; explosion; medical evacuation; or other emergencies such as strong winds, heavy rainfall, swift currents, and flooding. [36 CFR 9.36(a)(10)(vi), 40 CFR § 112]	+	+	+	+	+	+	+	+	+	+	√
Prior to beginning operations, in consultation with the U.S. Fish and Wildlife Service, Texas Parks and Wildlife Department and NPS, identify all species of special concern (threatened, endangered, and sensitive species) that may be present in the project area. Based on the species and the proposed operation, operators may be required to conduct biological surveys in the project area. [36 CFR § 9.36(a)(16)(i); Endangered Species Act of 1973 -16 USC 1531 *et. seq.*]					+	+	+	√			
Conduct cultural resource surveys to document the location and significance of any cultural resource (includes various components of archeological, ethnographic, historic architectural, and historic landscape resources) that might be affected by operations. [36 CFR §9.36 (a)(16)(I), 36 CFR § 63, 36 CFR § 800.4]									√	+	
Conduct a pre-operational analysis to adequately describe the natural, social and economic environments that would be affected by the operations (including air quality, geology, topography, soils, surface and subsurface hydrology, vegetation, wetlands, fish and wildlife, threatened and endangered species, cultural resources, and all water and oil and gas wells within a 2-mile radius of proposed operation). [36 CFR 9.36(a)(16)(i)]	√	√	√	√	√	√	√	√	√		
For geophysical operations using underground explosives, conduct a risk assessment of proposed operating methods (depth, size, pattern, and array of explosives) with respect to site conditions (landscape features and physical properties of soils, including depth and thickness of aquitards or water-retardant layers). [36 CFR § 9.37(a)(1)]		√	√				+	+	+		
Discharge explosives at safe distances from pipelines, telephone lines, railroad tracks, roads, power lines, water wells, oil and gas wells, oil and gas production facilities, buildings, etc. Use accepted industry minimum safe offset distances, unless otherwise specified. [36 CFR § 9.37(a)(1)]											√
Surface operations shall at no time be conducted within 500 feet of the banks of perennial, intermittent or ephemeral watercourses; or within 500 feet of the high pool shoreline of any natural or man-made impoundments…unless specifically authorized by an approved plan of operations. If necessary, the operator must specifically request exemptions from this standard in the plan of operations and demonstrate that the exemptions are necessary for acceptable data quality, can be conducted with insignificant effects on park waters or manmade infrastructure, and result in overall resource impact reduction. [36 CFR §9.41(a)]		+	√	√	+	+	+	+		+	

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RESOURCES	Air Quality	Geologic Resources	Water (Surface and G.W.)	Floodplains	Vegetation	Wetlands	Fish and Wildlife	Species of Special Concern	Cultural Resources	Visitor Use and Experience	Human Health and Safety
Protect all survey monuments, witness corners, reference monuments and bearing trees against destruction, obliteration, or damage from operations. Operator shall be responsible for the reestablishment, restoration, or referencing of any monuments, corners, or bearing trees which are destroyed, obliterated, or damaged by such operations. [36 CFR § 9.41(b)]					√					+	
The operator shall take technologically feasible precautions to prevent accidents and fires. [36 CFR § 9.46]	+	+	+	+	+	+	+	+	+	+	√
Operations shall not injure, alter, destroy, or collect any object, structure, or site of historical, archeological, or cultural value, without the written authorization of the NPS. [36 CFR § 9.47(a); 43 CFR § 3]									√	+	
Ensure that a qualified monitor is present during appropriate operational phase(s). Once operations have commenced, the operator shall immediately bring to the attention of the Superintendent any cultural or scientific resource, or species of special concern encountered that might be altered, harmed or destroyed by the operation and shall leave such discovery intact until told to proceed by the Superintendent. The Superintendent will evaluate the discoveries brought to his/her attention, and will determine within ten (10) days what action will be taken with respect to such discoveries. [36 CFR § 9.47(b)]						+		√	√	+	
Include stop work provisions in the event of a cultural or scientific discovery in operator's contracts. [36 CFR § 9.47(b); 36 CFR § 800.11]									√	+	
Use of park roads must be in accordance with procedures outlined in an approved plan of operations. [36 CFR 9.50]		√	+				+	+		√	+
Firearms are prohibited in the Preserve, except as permitted under Big Thicket National Preserve Hunting Regulations. [36 CFR § 7.85]							√	√		√	√
Do not locate staging areas within the 100-year floodplain unless there is no practicable alternative. Avoid the use of fill in the 100-year floodplain. [EO 11988 Sec 3 (b)]		+	+	√	+	+	+	+			√
Develop an adequate flood warning system which monitors one or more physical parameters (e.g., rainfall, runoff, streamflow) and provides warning of an impending flood to the operator, operator's contractors and subcontractors, visitors and Preserve personnel with adequate time to permit evacuation; and use signs, high-water indicators, and other information indicating that a site is floodprone and suggesting appropriate actions in the event of flooding. [NPS Procedures Manual 77-2]											√
Wetlands (both Cowardin classification system and jurisdictional wetlands) must be delineated where proposed operations would directly or indirectly adversely impact wetlands. Wetland delineations shall be approved by the U.S. Army Corps of Engineers and the Water Resources Division of the National Park Service and incorporated in the Statement of Findings and Plan of Operations. [Executive Order 11990, NPS Procedural Manual 77-1 § 5.1]		+	+		+	√					
Plan work to avoid known cultural resources. If work cannot avoid known cultural resources, assess and mitigate effects on National Register eligible or listed properties in consultation with State Historic Preservation Office and Advisory Council on Historic Preservation. [36 CFR § 800.3-800.9]									√	+	
An incidental take of a federally listed species must be immediately reported to the NPS and USFWS, all other protected species would be reported to the NPS. [Endangered Species Act, 16 USC §§ 1531 – 1544, 50 CFR Parts 402, 450]								√			

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RESOURCES	Air Quality	Geologic Resources	Water (Surface and G.W.)	Floodplains	Vegetation	Wetlands	Fish and Wildlife	Species of Special Concern	Cultural Resources	Visitor Use and Experience	Human Health and Safety
RECOMMENDED MITIGATION MEASURES											
Hold daily safety and environmental meetings with crews to reinforce crew and public safety, environmental concerns, and operating procedures.	+	+	+	+	+	+	+	+	+	+	√
Minimize conflicts with visitors by avoiding designated visitor use areas. If operations are needed in or around designated visitor use areas for successful completion of the project, then schedule work during low visitor use times and/or implement strategies to minimize the sights, sounds, and duration of operations in and around these areas.										√	√
Use minimum number of vehicles, boats, or aircraft necessary to provide efficient and safe access for personnel and equipment.	√	√	√	√	√	√	√	√	√	√	√
Perform conformity demonstration during project planning to quantify level of expected air emissions.	√										
Reduce vehicle speeds on roads to minimize dust. Consider spraying roads and access routes with freshwater to reduce dust.	√		√		√		+				+
Use properly designed, maintained and operated equipment to reduce emissions such as proper engine fuel mixtures, regularly serviced exhaust systems, and proper engine tuning.	√										
Use designated access routes, designated roads, and natural routes (e.g., bayous and other waterways) whenever possible during operations and during travel to and from the project area. Minimize multiple passes along roads to reduce resource impacts.		√	√	+	+	+	+	+	+	√	√
Locate primary staging areas outside the Preserve. Confine refueling, lubrication, and maintenance of vehicles and equipment to areas outside the Preserve where feasible.		√	√	+	+	+	+	+	+	+	+
Where feasible, use global positioning systems (GPS) technology to minimize the amount of vegetation cut to survey source and receiver lines.		+	+	+	√	+	+	+	+	+	
Selectively cut vegetation along source and receiver lines, offsets, and designated access routes as necessary to accommodate safe passage of personnel and equipment.		+	+		√	+	+	+		+	√
Leave small vegetation in place, (low shrubs, and herbaceous vegetation) consistent with safe passage of personnel and equipment.		+	+	+	√	+	+	+		+	
Leave topsoil, rootstock, and seeds on lines and designated access routes to encourage natural regeneration.		√	+	+	√	+	+	+		+	
Cut vegetation by hand, supplementing as necessary with chain saws or other motorized cutting equipment.										√	√
When vegetation cutting is done, ensure that branches and brush lie in contact with the ground to enhance vegetative decay.		+			√					√	√
Cut vegetation in accordance with the Preserve's current management practices for geophysical exploration operations which are as follows: Other than Chinese tallow (*Sapium sebiferum*), the cutting of live or dead vegetation larger than three (3) inches in diameter, measured one (1) foot above ground level, is strictly prohibited. All cuts must be made flush with the ground and the remaining stump shall be no higher than one (1) inch above the ground. No limb larger than three (3) inches in diameter, measured at the branch collar or branch bark ridges, shall be cut. The remaining limb shall not extend more than one (1) inch beyond the main trunk. No cypress knees will be cut. Use of motorized cutting equipment is permitted.		+	+	+	√	+	+	+		x	
Secure flagging, other markers, cables, or other equipment without cutting or slicing vegetation.					√	+					

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Do not permanently mark any tree in the Preserve.										√	
Select means of access other than land vehicles when soils are saturated to minimize compaction, displacement, and rutting of clayey soils.		√	+	+	+	√					
Conduct operations during dry seasons when certain soils are less susceptible to compaction, displacement and rutting.		√	+	+	+	√					
Conduct operations during plant dormancy seasons.					x	+					
Use vehicles with low ground pressure to minimize surface impacts. In lieu of using large mechanized drilling equipment, use lightweight, walk behind tracked drills or hand augers as appropriate in the Preserve.		√	+	+	+	+				+	
Plan efficient refueling of vehicles and equipment to minimize travel and chances for spills.		√	√	+	+	+	+				+
Refuel or lubricate equipment over secondary containment such as drip pans, drip basins, or impenetrable polyvinyl covered by absorbent materials.		√	√	+	+	+	+				+
Periodically check for leaks under all operating vehicles and equipment; contain and remove contaminated soil for proper disposal.		√	√	+	+	+	+	+			+
Replace all cuttings in shotholes or boreholes, including proper tamping of cuttings during shothole plugging. Avoid backfilling shotholes too quickly to avoid bridging. Spread any remaining cuttings on the surface into a thin layer at each hole. Note: Plugging materials may be required for shotholes less than 20 feet below the land surface.		√								√	
Use existing stream crossings whenever practicable.			√	+	+	√	+	+		+	
Cross streams at right angles to the stream, and minimize stream crossings by good project planning.		+	√	+	+	√	+	+			
Ensure that approaches to stream crossings do not alter natural drainage into the stream. Temporary runoff diversion and/or erosion control may be appropriate to minimize erosion and vegetation loss.		+	√	+	√	√	+	+			
Wherever possible, cross streams or watercourses where the water is shallow and the streambed or bottom is firm.		+	√			√	√	√			
Minimize width of survey lines and designated access routes, particularly at water crossings to minimize sediment input and brush in watercourses.		+	√	+	+	+	+	+			
Avoid blocking or filling any natural drainage path.			√	+	+	√	+	+			
When traveling in water, slow vehicle and boat speeds to minimize wake.			√			√	√	√		+	
When using boats, ensure adequate water depth to minimize bank erosion and adverse effects on aquatic life.		√	√	+	+	√	√	√			
Secure portable fuel tanks to the boat for safety and to prevent loss.			√		+	+	+	+			√
Use biodegradable lubricants.			√	+	+	+	+	+			
Use biodegradable charges during seismic operations.		√	+			+					
Avoid disturbing rare vegetation such as magnolia, beech and old growth cypress trees. If this is not possible, drill shotholes outside the crown of the tree.					√	+		√			
Do not load charges into flowing holes.			√			+					

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Use loading poles or tamping poles to ensure charges are placed and seated at the proper depth, and shotholes are properly plugged with cuttings and/or other authorized materials. Use plugging materials that meet International Association of Geophysical Contractors (IAGC) standards.		√	√								√
Use plugging materials in tubes or casing which will expand appropriately. Recommended tube diameter is 75 percent of shothole diameter.		√	√								
Plugs should be set at least 24 hours before detonation of charges.		√	√								√
If fluid flows in a shothole (groundwater that is under artesian conditions), attempt to plug it immediately. If the flow is too great, use expansive plugging material to backfill the hole above the aquifer to the surface.		√	√								
Clean vehicles and equipment prior to entering the project area to avoid introducing foreign plant materials.					√						
For vehicles, clear the undercarriage of brush to prevent fires when driving over dry areas. Use spark arresters and spark suppression accessories on equipment.				+	√	+	+	+			√
Avoid species of special concern (threatened, endangered and sensitive species) and their habitats during project design.						+		√			
Use USFWS “Conservation Guidance for Plant and Animal Candidate Species” or other pertinent information provided by the USFWS, TWPD, or NPS to minimize disturbances to species of special concern and their habitat.						+		√			
Use qualified monitors with expertise in identifying threatened, endangered and sensitive plant and wildlife species and their habitats to accompany field crews, especially land survey crews.					√	+	√	√			
Provide field personnel and monitors with training in identification and habits of wildlife (including species of special concern) in the project area.						+	√	√			
If using helicopters, locate helipads as far apart as practical in existing clearings.							√	√		√	
Consistent with safety, minimize the number of helicopter flyways.							√	√		√	
Use long sling lines, consistent with safety, to minimize the effects of down draft from the rotor.							√	√		√	
Avoid or bypass wildlife areas marked on the project map and/or in the field to minimize disruption to wildlife, especially in areas of active denning, nesting, spawning, migration, and feeding. Where interaction with wildlife is unavoidable, minimize the sights, sounds, and duration of operations to the maximum extent feasible.							√	√		+	
Report any sighting of threatened, endangered, or sensitive species to the NPS.								√			
Inform visitors, area residents, and others during project planning and while conducting an operation. During geophysical exploration operations, post warning and informational signs in visible locations (such as intersections), notices in visitor centers, notices in local newspapers and publications, etc., to inform them of the timing and types of operations that will occur.										√	√
Conduct operations during low visitor use periods.										√	√
Provide trash bags and trash receptacles for cans, bottles, paper, and other trash generated daily by crews.										√	
Do not burn vegetation, survey stakes, flagging, refuse, or other debris or waste incidental to maintenance or operation.	√				+					√	√

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Remove survey stakes, flagging, trash or other debris or waste from the project area.						+	+	+		√	
Bury and/or secure capwire from undetonated or live charges to reduce risk to human health and safety.											√
Take appropriate measures to ensure all charges are fired. Disable misfired charges by breaking or cutting the capwire as deep below ground as practical.											√
When working in dry vegetation, prohibit smoking, or only allow smoking at designated times and locations.					√						√
Ensure fire-fighting equipment and personnel are available while operating in dry vegetation. Consider both fire danger and fire danger rating during planning and conduct of operations.					√						√
Use seed, mulch, or other authorized materials or structures to mitigate the potential for erosion.		√	√	+	+	+	+	+		+	

Table 2.21. Operating Stipulations and Mitigation Measures for Nonfederal Oil and Gas Drilling and Production Operations. This table lists required operating stipulations and recommended mitigation measures for constructing roads and wellpads, drilling operations, production operations, and flowlines and pipelines. The 36 CFR 9B operating stipulations shown in the following table are required for all nonfederal oil and gas operations under a Plan of Operations and are recommended for directional drilling operations originating outside of the Preserve. Mitigation measures are recommended for all oil and gas operations regardless of whether the surface operation is sited within or outside of the Preserve.

ROADS	DRILLING	PRODUCTION	FLOWLINES/PIPELINES	DRILLING AND PRODUCTION OPERATIONS REQUIRED OPERATING STIPULATIONS AND RECOMMENDED MITIGATION MEASURES The primary resource(s) that would be protected by the operating stipulation or mitigation measure are denoted by a √ symbol. Other resources that would benefit from the protective measures are marked with a + symbol.	RESOURCES: Air Quality	Geologic Resources	Water (Surface and G.W.)	Floodplains	Vegetation	Wetlands	Fish and Wildlife	Species of Special Concern	Cultural Resources	Visitor Use and Experience	Human Health and Safety
REQUIRED OPERATING STIPULATIONS - The applicable legal citation is noted in [parenthesis] after the stipulation.															
√	√			In order to use surface or subsurface water from inside the park, the operator must demonstrate in the plan of operations that his water rights are superior to any claim of the U.S. to use the water, and where the use is subordinate to that of the U.S., that use of the water will not damage park resources. Since any use of park water has the potential to negatively affect water quality, quantity, and flow patterns, the operator should note what resources would benefit from the in-park water use and how they would benefit. [36 CFR § 9.35]		+	√	+	+	+	+	+		+	
	√	√	√	Prepare an Emergency Response Plan to ensure safe operating procedures in the event of a reportable quantity spill; damage to wells, pipelines, or other structures; fire; explosion; medical evacuation; or other emergencies such as strong winds, heavy rainfall, swift currents, and flooding and secure storage tanks and other production equipment to reduce structural and environmental risks. [36 CFR 9.36(a)(10)(vi), 40 CFR § 112]	+	+	+	+	+	+	+	+	+	+	√
√	√		√	Prior to beginning operations, in consultation with the U.S. Fish and Wildlife Service, Texas Parks and Wildlife Department and NPS, threatened, endangered, and sensitive species that may be present in the project area must be identified. Based on the species and the proposed operation, operators may be required to conduct biological surveys in the project area. [36 CFR § 9.36(a)(16)(i); Endangered Species Act of 1973 -16 USC 1531 *et. seq*.]					+	+	+	√			
√	√		√	Conduct cultural resource surveys to document the location and significance of any cultural resource (includes various components of archeological, ethnographic, historic architectural, and historic landscape resources) that might be affected by operations. [36 CFR §9.36 (a)(16)(i), 36 CFR § 63, 36 CFR § 800.4]									√	+	
√	√		√	Conduct a pre-operational analysis to adequately describe the natural, social and economic environments that would be affected by the operations (including air quality, geology, topography, soils, surface and subsurface hydrology, vegetation, wetlands, fish and wildlife, threatened and endangered species, cultural resources, and all water and oil and gas wells within a 2-mile radius of proposed operation. [36 CFR § 9.36(a)(16)(i)]	√	√	√	√	√	√	√	√	√		
√	√	√	√	Surface operations shall at no time be conducted within 500 feet of the banks of perennial, intermittent or ephemeral watercourses; or within 500 feet of the high pool shoreline of any natural or man-made impoundments…unless specifically authorized by an approved plan of operations. If necessary, the operator must specifically request exemptions from this standard in the plan of operations and demonstrate that the exemptions are necessary for acceptable data quality, can be conducted with insignificant affects on park waters or manmade infrastructure, and result		+	√	√	+	+	+	+		+	

ROADS	DRILLING	PRODUCTION	FLOWLINES/PIPELINES	**DRILLING AND PRODUCTION OPERATIONS** **REQUIRED OPERATING STIPULATIONS** **AND** **RECOMMENDED MITIGATION MEASURES** The primary resource(s) that would be protected by the operating stipulation or mitigation measure are denoted by a √ symbol. Other resources that would benefit from the protective measures are marked with a + symbol. **RESOURCES**	Air Quality	Geologic Resources	Water (Surface and G.W.)	Floodplains	Vegetation	Wetlands	Fish and Wildlife	Species of Special Concern	Cultural Resources	Visitor Use and Experience	Human Health and Safety
				in overall resource impact reduction. [36 CFR § 9.41(a)]											
√	√	√	√	Protect all survey monuments, witness corners, reference monuments and bearing trees against destruction, obliteration, or damage from operations. Operator shall be responsible for the reestablishment, restoration, or referencing of any monuments, corners, or bearing trees which are destroyed, obliterated, or damaged by such operations. [36 CFR § 9.41(b)]					√					√	
	√	√		Whenever drilling or production operations are suspended for 24 hours, but less than 30 days, the wells shall be shut-in by closing wellhead valves or blowout prevention equipment. When production operations are suspended for 30 days or more, a suitable plug or other fittings acceptable to the Preserve Superintendent shall be used to close the well. [36 CFR § 9.41(c)]		+	+	+	+	+	+	+		√	√
	√	√		Clearly sign every operation or well in a conspicuous place with the name of the operator or owner, well number, lease number, location (i.e., surface owner), phone number, and take all necessary precautions to preserve these markings. [36 CFR § 9.41(d)]										√	√
		√		Secure production operation sites with acceptable fencing around wells, storage tanks, all high pressure equipment, and storage tanks, unless otherwise authorized by the park superintendent. [36 CFR § 9.41(e)]							+	+		√	√
	√	√	√	Operators shall remove from the Preserve or store in an orderly manner, all scrap materials or other materials that are not in use or other materials deemed to be fire hazards from the vicinity of well locations and lease tanks. [36 CFR § 9.41(f)]		+	+	+	+	+	+	+	+	√	√
	√	√		Operators must use procedures and equipment of sufficient pressure rating to keep the well under control at all times. Surface casing must be cemented to surface unless otherwise permitted. All other casing strings must be adequately cemented in place to ensure control of the well. [36 CFR § 9.43]	+	+	+	+	+	+	+	+	+	+	√
	√	√		Operators must use procedures and equipment of sufficient pressure rating to prevent uncontrolled discharges of oil, gas, or brine. Operators must act quickly to control blowouts or burning wells. [36 CFR § 9.44]	+	+	+	+	+	+	+	+	+	+	√
	√	√		Oilfield brine, and all other waste and contaminating substances must be kept in the smallest practicable area, must be confined so as to prevent escape as a result of percolation, rain, high water or other causes, and such wastes must be stored and disposed of or removed from the area as quickly as practicable in such a manner as to prevent contamination, pollution, damage or injury to the lands, water (surface and subsurface), facilities, cultural resources, wildlife, and vegetation of or visitors to the unit. [36 CFR § 9.45]		√	√	+	√	+	√	√	√	+	√
	√	√		The operator shall take technologically feasible precautions to prevent accidents and fires. [36 CFR § 9.46]	+	+	+	+	+	+	+	+	+	+	√
√	√	√	√	Operators shall not injure, alter, destroy, or collect any object, structure, or site of historical, archeological, or cultural value, without the written authorization from the NPS. [36 CFR § 9.47(a); 43 CFR Part 3]									√	+	
√	√		√	Include stop work provisions in the event of a cultural or scientific resource discovery in operator's contracts. [36 CFR § 9.47(b); 36 CFR § 800.11]									√	+	

DRILLING AND PRODUCTION OPERATIONS
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ROADS	DRILLING	PRODUCTION	FLOWLINES/PIPELINES	Measure	Air Quality	Geologic Resources	Water (Surface and G.W.)	Floodplains	Vegetation	Wetlands	Fish and Wildlife	Species of Special Concern	Cultural Resources	Visitor Use and Experience	Human Health and Safety
				Use of park roads must be in accordance with procedures outlined in an approved plan of operations. [36 CFR § 9.50]		√	+				+	+		√	+
√	√	√	√	Firearms are prohibited in the Preserve, except as permitted under Big Thicket National Preserve Hunting Regulations. [36 CFR §7.85]							√	√		√	√
√	√	√	√	Dispose of stormwater in accordance with federal and state laws. [33 USC 1251 et. seq. § 402]		+	√	+	+	+	+	+		+	√
	√	√		If required by the park superintendent, provide analyses of soils, surface water, groundwater, and sediments before and after well drilling or production operations (or change of ownership or leasing rights). [See NPS "Guideline for the Detection and Quantification of Contamination at Oil and Gas Operations" found in Appendix H of this document.]		√	+	+	+	+				+	
	√	√		Cover or place netting on storage tanks to minimize the likelihood of accidental deaths of migratory birds. [Migratory Bird Treaty Act -16 U.S.C. § 703-712, Executive Order 13186]							√	√			
√	√	√		Do not locate oil and gas well access roads and flowlines in the 100-year floodplain unless no practical alternative exists. Where such operations must be located in the 100-year floodplain, appropriate mitigation measures must be taken to floodproof or elevate the road or flowline to minimize structural and environmental risks associated with flooding, including debris flows. [EO 11988 § 3 (b), NPS Procedural Manual 77-2 § (VI) (G)] These activities would be permitted in the 500-year floodplain if appropriate mitigation measures are taken to floodproof or elevate the site to minimize environmental risks associated with flooding.		+	+	√	+	+	+	+			√
√	√	√	√	Do not locate oil and gas well access roads, drill and production pads, flowlines, gathering lines or oil and gas processing and storage facilities and equipment, including heater treaters, separators, oil storage tanks, produced water storage tanks, etc., in the 500-year floodplain unless there is no practicable alternative. Where such operations must be located in the 500-year floodplain, appropriate mitigation measures must be taken to floodproof or elevate the structures to minimize the environmental risks associated with flooding. [EO 11988 § 3(b), NPS Procedural Manual 77-2 § (VI) (G)]		+	+	√	+	+	+	+			√
	√	√	√	Develop an adequate flood warning system which monitors one or more physical parameters (e.g., rainfall, runoff, streamflow) and provides warning of an impending flood to the operator, operator's contractors and subcontractors, visitors and Preserve personnel with adequate warning of an impending flood with time to permit evacuation; and signs, highwater indicators, and other information indicating that a site is floodprone and suggesting appropriate actions in the event of flooding. [NPS Procedural Manual 77-2]		+	+	√	+	+	+	+			√
√	√		√	Wetlands (both Cowardin classification system and jurisdictional wetlands) must be delineated where proposed operations would directly or indirectly adversely impact wetlands. The wetland delineations shall be approved by the U.S. Army Corps of Engineers and the National Park Service, Water Resources Division, and be incorporated in the Statement of Findings and operator's proposed plan of operations. [Executive Order 11990, NPS Procedural Manual 77-1 § 5.1]		+	+		+	√					
√	√		√	When proposed operations cannot avoid direct and/or indirect impacts on wetlands, the operator shall compensate for direct and indirect impacts on to wetlands by restoring degraded or former wetland habitats. Wetland restoration must, at a minimum, provide for one-for-one (1:1) wetland function replacement (i.e., focus on no net loss of wetland functions,		+	+		+	√	+	+			

DRILLING AND PRODUCTION OPERATIONS
REQUIRED OPERATING STIPULATIONS AND RECOMMENDED MITIGATION MEASURES

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ROADS	DRILLING	PRODUCTION	FLOWLINES/PIPELINES	RESOURCES	Air Quality	Geologic Resources	Water (Surface and G.W.)	Floodplains	Vegetation	Wetlands	Fish and Wildlife	Species of Special Concern	Cultural Resources	Visitor Use and Experience	Human Health and Safety
				not just wetland acreage). Compensation <u>shall</u> be performed prior to or at the same time impacts associated with approved oil and gas operations occur. [Executive Order 11990, NPS Procedural Manual 77-1 § 5.2 (C)]											
√	√		√	Plan work to avoid known cultural resources. If work cannot avoid known cultural resources, assess and mitigate effects on National Register eligible or listed properties in consultation with State Historic Preservation Office and Advisory Council on Historic Preservation. [36 CFR § 800.3-800.9]									√	+	
		√		Firewalls constructed around storage tanks or tank batteries must be of sufficient size to contain at least 1.5 times the storage capacity of the largest enclosed tank. Firewalls must be properly constructed and maintained. [40 CFR § 112.7(e)(5)(B)]		+	+	+	+	+	+	+		+	√
√	√	√	√	An incidental take of a federally listed species will be immediately reported to the NPS and the USFWS and all other protected species would be reported immediately to the NPS. [Endangered Species Act, 16 USC §§ 1531 – 1544, 50 CFR Parts 402, 450].								√			
				RECOMMENDED MITIGATION MEASURES											
√	√	√	√	Avoid direct impacts to unit resources and values by siting surface operations outside the boundaries of the Preserve (applies to directionally drilled wells, and siting of production facilities).	√	√	√	√	√	√	√	√	√	√	√
√	√	√	√	Confine all activities, including personal and company vehicles, to right-of-way, existing roads, disturbed areas, or other designated areas.		+	+	+	+	+	+	+	+	√	√
√	√	√	√	Avoid or bypass wildlife areas, especially in areas of active denning, nesting, spawning, migration, or feeding. Where interaction with wildlife is unavoidable, minimize the sights, sounds and duration of operations to the maximum extent feasible.						+	√	√			
√	√	√	√	Schedule work for seasonal times least likely to affect threatened and endangered species.					√		√	√			
√	√	√	√	Before moving equipment on or off location, make sure machinery is plugged, drained, or otherwise secured to keep fluids from leaking during transport.		√	√	+	+	+	+	+			
√	√	√	√	Reduce vehicle speeds to reduce chances of injuring wildlife.							√	√			
√	√	√	√	Use seed, mulch, or other authorized materials or structures to mitigate the potential for erosion. Use certified weed-free mulch, native seed, or sterile cover crops that are not sources of undesirable nonnative plant species.		√	√	+	+	+	+	+		+	
√	√	√	√	Use mechanical or physical methods to control vegetation along roadways, adjacent to wellpads, at wellheads, valves, meter stations, production facilities, etc.										+	√
√	√	√	√	Use NPS-approved herbicides to control vegetation where mechanical or physical methods are ineffective.		+	+	+	+	+	+	+		+	√
√	√	√	√	Apply pesticides when visitors/public are not in area and post signs in areas that have been treated until they are dry.										√	√
√	√	√	√	Apply pesticides according to label directions, when applying outdoors (especially herbicides) and do not apply during windy conditions.	+			+	+	+	+	+		√	√

Drilling and Production Operations
Required Operating Stipulations and Recommended Mitigation Measures

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√	√	√	√	Ensure that individuals applying herbicides are certified by the state for herbicide applications.	+			+	+	+	+	+		+	√
√	√	√	√	As authorized under an approved plan of operations, annually report the types and amounts of pesticide use to the park Superintendent (by January 30) of each year.											√
√	√	√	√	Perform a conformity determination during project planning to quantify level of expected air emissions.	√										
√	√	√	√	Do not burn vegetation, refuse, or other debris or wastes incidental to maintenance activities or oil/gas operation.	√				+					+	√
√				Minimize new surface disturbance by utilizing existing roads, and properly maintain all oil and gas access roads.		√	+	+	+	+	+	+	+	+	+
√				Use alternative construction methods, such as board roads, for temporary access to exploratory well locations.		√	+	+	+	+	+	+		+	
√				Use the minimum road design standard sufficient to carry anticipated traffic and loads with reasonable safety and with minimum environmental impact.		√	+	+	+	+	+	+			√
√				When possible, construct roads in drainage divides.		√	+			+					
√				Avoid constructing roads on clayey soils. If not possible, roads should trend perpendicular to contours when crossing clayey soils. In permeable soils, plan roads to run parallel to contours and design to enhance recharge.		√	+		+						
√				Crown or outslope the road surface to dissipate surface runoff and minimize erosion of the roadbed.		√	+	+	+	+	+	+			
√				Install drainage structures (ditches, culverts, cross drains, wing ditches, etc.) and bridges on roads to maintain hydrology of the site and adjoining wetlands, to protect aquatic life, and to allow for safe passage of wildlife.		+	√	+	+	√	√	+			√
√				Minimize the number of stream crossings along oil and gas access roads. Crossings should be perpendicular to the stream, resulting in less vegetation clearing than oblique crossings.		+	√	+	+	√	√	+			
√				Post appropriate signs on access roads to indicate speed limits, animal crossings, turnouts, blind curves, etc.							√	√		√	√
√	√			When possible, adding fill is preferable to grading and excavation to construct roadways, wellpads, berms, secondary containment, etc. All reasonable attempts should be made not to disrupt the hydrology of the site and adjoining wetlands.		√	+	+	+	+					
√	√			Conduct drilling operations during the dry season to avoid soil disturbance and compaction and disruption of water drainages caused by temporary access roads.		√	√	+	+	+					
√	√			Whenever possible, place access roads and wellpads on soil classes in hydrologic soil groups “A” and “B” and avoid or minimize placement of access roads and wellpads on soil classes in hydrologic soil groups “C” and “D.”		√	+	+	+	+					
	√			Consistent with safe operations, plan and conduct operations to minimize site disturbance. Site operation on elevated areas outside of floodplain and wetland areas and use the minimum size wellpad necessary to drill and produce well.	√	√	√	√	√	√	√	√	√	√	√
	√			Design wellpads to conform to the natural topography and other surface features of the area.		√	√							√	
	√			If properly sited for operations, use a single wellpad to directionally drill multiple wells.		√	√	+	√	+	+	+	+	√	
	√			Use portable wellpads (e.g., board locations) and skid-mounted equipment to minimize surface disturbance.		√	+	+	√	+	+	+			
	√			Avoid locating drilling/production pads on slopes greater than 3 percent to minimize soil disturbances and disruption of		√	+	+	+	+					

DRILLING AND PRODUCTION OPERATIONS
REQUIRED OPERATING STIPULATIONS AND RECOMMENDED MITIGATION MEASURES

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ROADS	DRILLING	PRODUCTION	FLOWLINES/PIPELINES		Air Quality	Geologic Resources	Water (Surface and G.W.)	Floodplains	Vegetation	Wetlands	Fish and Wildlife	Species of Special Concern	Cultural Resources	Visitor Use and Experience	Human Health and Safety
				natural drainage patterns. Locating operations within the Preserve on slopes greater than 3 percent would not be permitted unless operator uses methods least damaging to resources while assuring protection of human health and safety.											
	√			Wellpads should not be located within a minimum buffer zone from all first order streams that are defined by an observable channel or swale. Note: Minimum buffer zone is determined by site specific analysis.		+	√	+	+	+	+	+			
	√			Establish minimum buffer strip between wellpad and access road for protection of recharge, water quality, and aesthetics. Note: Minimum buffer strip is determined by site specific analyses.			√	+	+	+				√	
	√			Construct a berm or ring levee around the drilling location. Install impermeable liners underneath the drilling rig and associated equipment including fuel storage and transfer areas. Install the liner to direct fluids to a collection point(s) for recycling or disposal.		+	√	+	+	+	+	+	+		√
	√			Secure drilling site to restrict public access with appropriate fencing, gate, security guard, or signs.							+	+		+	√
	√			Use containerized drilling mud system to minimize drilling mud volumes, drilling fluid wastes, and site disturbance. Earthen pits will not be permitted for nonfederal oil and gas operations inside the Preserve.		√	√	+	+	+	+	+		+	+
	√			Manage traffic to and from operation using two-way communications or other procedure. For drilling operations that run continuously, hire qualified security personnel to monitor egress and ingress to the drill site.										√	√
	√			Use an inside-diameter wiping tool for drillpipe to reduce loss of drilling fluids.		√	√								
	√			Maintain ample materials to increase drilling fluid density in an emergency situation. Install and maintain equipment capable of efficient, even delivery and mixing of drilling fluid weighting material.	+	+	+	+	+	+	+	+	+	+	√
	√			For wells that may encounter hydrogen sulfide gas, prepare a contingency plan that provides an organized approach for alerting and protecting the public within an area of exposure prior to release, intentional or otherwise, of a potentially harmful volume of hydrogen sulfide.							+	+		+	√
	√			Install, test, and maintain toxic gas detection equipment prior to reaching any formations suspected of containing toxic gases.							+	+		+	√
	√	√		Design, operate, and monitor drilling and production equipment and vehicles to minimize air emissions.	√			+	+	+	+	+		+	+
	√	√		Use fuels and control technologies that minimize release of air emissions from compressors, turbines, and other equipment.	√			+	+	+	+	+		+	+
	√	√		Prevent leaks and spills by practicing regular inspection and maintenance, good housekeeping, and in design of the operations.		√	√	+	+	+	+	+			√
	√	√		Use dust control techniques (such as watering roads) which do not adversely impact human health and safety, soils, ground and surface water quality, or other park resources.	√	√	+	+	+	+					√
	√	√		Reduce vehicle speed to minimize dust.	√		√	+	√	+	+	+			
	√	√		Flaring of gas from wells should be minimized. Such gases should be utilized for energy production with appropriate	√				+					√	√

Drilling and Production Operations
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				process and pollution controls applied to minimize air pollutant emissions.											
	√	√		Install and maintain catalytic converters on engines.	√									+	
	√	√		Use natural gas engines or electric engines instead of engines fueled by diesel or other fuels.	√									+	
	√	√		Maintain thief hatch seals on storage tanks to minimize the release of volatile organic compounds.	√									+	+
	√	√		When possible, use bulk drilling fluids, additives, and chemicals provided in reuseable containers to reduce solid waste generation from empty sacks or buckets.		√	√	+	+	+	+	+			+
	√	√		Use less volatile solvents and chemicals during operations. Properly store and label containers to prevent degradation, overflow, or contamination. Keep containers covered when not in use to decrease loss due to vaporization.	√	+	+	+	+	+	+	+			√
	√	√		Use nonhazardous products or less toxic substitutes whenever possible.		+	+	+	+	+	+	+			√
	√	√		Properly calibrate and operate monitoring equipment for hydrogen sulfide gas detection and warning.	√										√
	√	√		Stabilize wellpads to avoid or minimize erosion.		√	+	+	+	+	+	+	+	+	
	√	√		Use secondary containment (impermeable liner) around fuel, crude, and brine tanks, vessels, and under tank battery load-line connections to collect leaks, drips, and spills. Recommended impermeable liner thickness is 30 mil. Design secondary containment to eliminate or minimize collection of precipitation.		√	√	+	√	+	+	+		+	
	√	√		For drilling or workover operations, use a multi-layered or specialized impermeable liner system beneath the rig and associated equipment (including fuel and transfer areas). Use cellar as collection point for drilling fluid waste, rigwash, other fluids, etc.		√	√	+	√	+	+	+		+	
	√	√		Contain garbage in animal-proof containers before disposal at approved facilities.							√	x		+	
	√	√		Store sanitary wastes in approved, above ground septic tank or system before disposal at approved facilities.		+	√	+	+	+	+	+			√
	√	√		Use biodegradable, lead-free pipe dope whenever possible; avoid excessive use.		√	√								
	√	√		Carefully plan well completions to minimize production of sand and produced water.		√	√	+	√	+	+	+		+	
	√	√		Collect and reuse rigwash for subsequent rig maintenance, for initial washing of equipment, or as make-up water in drilling and completion operations.		√	√	+	√	+	+	+			
	√	√		Segregate or avoid mixing hazardous and nonhazardous chemicals to reduce the amount of hazardous waste for subsequent management.		√	√		+						√
	√	√		Contour and/or ditch around chemical, fuel, lubricant, and waste storage areas to a collection point that is separate from other rig equipment and not into the cellar.		√	√		+						
	√	√		Improve work process and properly maintain facilities and equipment to minimize stormwater contamination. Note: “Contaminated stormwater runoff” includes, but is not limited to runoff which: (1) contains a hazardous substance in excess of reporting quantities established at 40 CFR § 117.3 or 40 CFR § 302.4, (2) contains oil in excess of the reporting quantity established at 40 CFR § 110.3 (e.g., causes a visible sheen), or (3) contributes to a violation of a water		√	√	+	√	+	+	+		+	√

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				quality standard.											
	√	√		Keep lighting to the minimum needed for safe operations. Design/use wellpad lighting only where necessary e.g., use low pressure sodium lights, downward directed lighting, and shield lights to prevent offsite glare.							√	√		√	
	√	√		Use appropriate sound-absorbing or sound-muffling equipment or materials such as electric motors, quiet design exhaust mufflers and acoustic covers on vehicles and equipment, and acoustically insulated buildings. Direct noise away from visitor use areas, adjacent landowners, and developed areas.							√	√		√	
	√	√		Install, test, and maintain pressure control equipment in proper working condition. Perform weekly pressure tests of the blowout prevention system.							√	√			√
	√	√		Construct and maintain firelane or firebreak along the perimeter of wellpads or production facilities. Use erosion control measures during firelane or firebreak construction and maintenance to mitigate the potential for site erosion.		√	√		√	+	√	√			x
	√	√		Do not drill a water supply well deeper than the surface casing in areas where abnormal pressures might be encountered.			√			+					+
	√	√		Divert stormwater from the wellsite by contouring, grading, berming, or trenching.		√	√	+	√	+	+	+			
	√	√		Protect usable quality aquifers by designing/implementing a surface casing and cementing program to place a properly designed cement slurry around a centered casing in a borehole of adequate size from which mud and mud cake has been removed. Specific measures include: -Cure any lost circulation problems prior to cementing. -Design hole size and casing size to provide a minimum of 1 inch clearance around pipe, but no more than 2 inches of clearance. -Implement a centralizer design (type and quantity) appropriate for hole conditions to achieve good casing centralization. When available, use borehole caliper information to place centralizers in locations where hole is in gauge. -Base mud circulation and conditioning on achieving hole stability rather than a specified volume. Condition mud to lower gel strength and viscosity. Proper hole conditioning is shown by a clean shaker, stable pump pressure and strokes at a constant throttle, and stable drag trends. -Reciprocate casing during hole conditioning and cementing. -Pump a preflush (water or engineered system depending on well conditions) in turbulent flow with enough volume to achieve 10 minutes contact time. Use fluid-loss additives as necessary to prevent preflush loss to high permeability zones. -Use lightweight or ultra-lightweight lead cement slurries if necessary to avoid lost circulation. -Design a large excess cement volume to account for uncertain annular volume and to improve mud removal efficiency. -Displace cement at maximum rate compatible with equipment and bottom-hole allowable pressure. -Prior to drilling out the surface casing shoe, verify surface casing integrity by pressure testing the surface casing as		+	√	+	+	+	+	+			+

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AND
RECOMMENDED MITIGATION MEASURES

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				required by most state regulations and NPS standards as taken from Department of Interior Order No. 2, Section III. B.h. -After drilling between 10 and 20 feet of new formation, verify casing shoe integrity by testing the casing shoe to a minimum of the mud weight equivalent anticipated to control formation pressures at total depth.											
		√		Set storage tanks and other equipment on elevated and aerated base to prevent corrosion.		√	√	+	√	+	+	+			+
		√		Whenever possible, place workover wastes into production stream.		√	√	+	√	+	+	+			
		√		Use excess well completion, treatment, and stimulation fluids in other wells.		√	√	+	√	+	+	+			
		√		To reduce leakage from common points of friction and wear (e.g., stuffing box packing rubbers, valve stems), consider using magnetic ion coating technology.		√	√	+	√	+	+	+			
		√		Treat production streams with biocide or inhibitor to reduce sulfide formation.		√	√	+	√	+	+	+			+
		√		Paint production equipment to blend in with the surrounding environment. For facilities within the Preserve, the NPS must approve the selection of colors prior to the operator painting equipment and facilities.										√	
		√		Reduce and control paint overspray; use a brush for small painting jobs.		+	√		+						
		√		Replace mercury manometers or other instruments with mercury-free instruments.		√	√	+	√	+	+	+			√
		√		Use alternative methods to reduce sandblasting such as paint that does not require sandblast preparation, cathodic protection, or materials that do not need to be painted.		√	√		√						
		√		Design and maintain operation to reduce locations in the production system prone to NORM (Naturally Occurring Radioactive Materials) scale formation.		√	√		√						√
		√		Periodically monitor for accumulations of NORM or NORM-containing materials to minimize volume of NORM-contaminated waste requiring disposal.		√	√		√						√
		√		Store NORM-contaminated waste in aboveground tanks for proper disposal.		√	√		√						√
		√		Provide NORM management training for appropriate personnel of NORM-affected production facilities.											√
		√		Replace electrical equipment containing PCBs (polychlorinated biphenyls) with non-PCB containing equipment.		√	√		√						√
		√		Cover the top of all open vent stacks with a screen or cage to prevent injury to birds and wildlife.							√	√			
		√		Empty storage tanks and fill with water in preparation for a flood or hurricane.		√	√	+	√	+	+	+			√
		√	√	Install surface controlled subsurface safety valves on wells capable of natural flow.		√	√	+	√	+	+	+			√
		√	√	Provide for automatic shut-in of wells in response to pressure changes on the flowline to reduce spill volumes.		√	√	+	√	+	+	+			√
			√	Use only metal pipe for above-ground flowlines, gathering lines, and pipelines.		+	√	√	√	√	√	√			√
			√	Wherever possible, avoid or minimize flowlines, gathering lines, and pipelines crossing waterways, floodplains, and wetlands.		+	√	√	√	√	+	+		√	√

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			√	Where appropriate (i.e., based on site analysis), install flowlines or gathering lines via directional drilling underneath waterways, floodplains, wetlands, and Special Management Areas.		√	√	+	√	+	+	+		√	√
			√	Install flowlines, gathering lines, and pipelines adjacent to access roads to minimize surface disturbance. This strategy also provides easy access for pipeline maintenance or spill response.		√	√	+	√	+	+	+		√	√
			√	When possible, flowlines and gathering lines should parallel drainage divides. When pipelines must deviate from drainage divides, pipelines should trend perpendicular to contour lines.		√	√	+	√	+	+	+		√	√
			√	During placement of flowlines, gathering lines, and pipelines, avoid blocking or filling any natural drainage path.		+	√	+	+	+	+	+			
			√	Where pipelines are proposed to cross streams, assess the potential for site degradation (erosion) and stream migration and design and install pipeline to prevent exposure of the pipeline.		√	√	+	√	+				√	+
			√	Place impermeable plugs in soils where pipelines intersect waterways. Also place impermeable plugs in soils approximately every 1,000 feet across long, straight segments of pipelines to prevent water flow along the pipeline route.		√	√	+	√	+	+	+		√	
			√	Design, operate, and maintain leak detection monitoring and immediate remote shutdown of pipelines in the event of a leak or spill.		√	√	+	√	+	+	+			√
			√	To minimize spills, use block and check valves on pipeline segments that cross waterways, floodplains, and wetlands. Ensure integrity of pipeline joints, especially pipelines crossing these areas.		√	√	√	√	√	+	+			+
			√	Routinely maintain vegetation (trimming, cutting) along pipeline rights-of-way and routes to allow monitoring of pipelines and rapid access in the event of a leak or spill.		√	√	+	√	+	+	+			√
			√	At least annually, check thickness of pipeline to determine extent of internal corrosion.		√	√	+	√	+	+	+			√
			√	Maintain a program of regular visual, electric, magnetic, and/or acoustic inspections of pipelines to assess its integrity under worst case operating conditions of pressure and temperature. If warranted based on the inspection program, conduct mechanical integrity pressure tests in accordance with standard practices.		√	√	+	√	+	+	+			√
			√	Use “smart pig” or other devices to test pipe wall thickness or integrity to determine the need for further pressure testing or pipeline replacement.		√	√	+	√	+	+	+			√
			√	“Pig” and pre-clean pipelines prior to hydrotesting to reduce the toxicity of hydrotest water.		√	√	+	√	+	+	+			√
			√	For aboveground pipelines, partially rotate the lines to extend the life of the line from support contact wear and exposure of the upper half of the line.		√	√	+	√	+	+	+			√
			√	For aboveground lines, provide supports that minimize contact with the pipeline. Supports should not restrict thermal expansion and contraction of the line, be close enough to eliminate sag, and designed for maximum loading conditions.		√	√	+	√	+	+	+			√
			√	Before placing a new line in service or after replacing sections of an existing line, conduct hydrostatic test at pressure 1.5 times the maximum designed working pressure for the system. Pressure should be maintained for at least 8 hours.		√	√	+	√	+	+	+			√
			√	Minimize internal corrosion by keeping both product and pipeline free of water.		√	√	+	√	+	+	+			√

ROADS	DRILLING	PRODUCTION	FLOWLINES/PIPELINES	**DRILLING AND PRODUCTION OPERATIONS** **REQUIRED OPERATING STIPULATIONS** **AND** **RECOMMENDED MITIGATION MEASURES** The primary resource(s) that would be protected by the operating stipulation or mitigation measure are denoted by a √ symbol. Other resources that would benefit from the protective measures are marked with a + symbol. **RESOURCES**	Air Quality	Geologic Resources	Water (Surface and G.W.)	Floodplains	Vegetation	Wetlands	Fish and Wildlife	Species of Special Concern	Cultural Resources	Visitor Use and Experience	Human Health and Safety
			√	Maintain a good protective coating on pipe and joints at all times (both above and underground).		√	√	+	√	+	+	+			√
			√	For underground pipelines, use resistivity testing of soils to forecast external corrosion problems.		√	√	+	√	+	+	+			√
			√	Use cathodic protection for underground or submerged pipelines. Note: A typical cathodic protection system involves connecting the pipeline and a sacrificial anode to a direct current rectifier, thereby corroding the anode instead of the pipeline metal.		√	√	+	√	+	+	+			√
			√	Place and maintain warning signs at each public road crossing, railroad crossing, and trail; and in sufficient number along the remainder of each pipeline so that its location is accurately known. Post warning signs at intersections with roads and trails.										√	√

Table 2.22. Operating Stipulations and Mitigation Measures for Nonfederal Oil and Gas Well Plugging, Abandonment, and Site Reclamation

WELL PLUGGING, ABANDONMENT, AND SITE RECLAMATION REQUIRED OPERATING STIPULATIONS AND RECOMMENDED MITIGATION MEASURES The primary resource(s) that would be protected by the operating stipulation or mitigation measure are denoted by a √ symbol. Other resources that would benefit from the protective measures are marked with a + symbol. RESOURCES	Air Quality	Geologic Resources	Water (Surface and G.W.)	Floodplains	Vegetation	Wetlands	Fish and Wildlife	Species of Special Concern	Cultural Resources	Visitor Use and Experience	Human Health and Safety
REQUIRED OPERATING STIPULATIONS - The applicable legal citation is noted in [parenthesis] after the stipulation.											
Reclamation actions must begin as soon as possible, and no later than 6 months following completion of operations, unless a longer period of time is authorized in writing by the Regional Director. [36 CFR § 9.39(a)]	√	√	√	√	√	√	√	√	√	√	√
Remove from the unit all aboveground structures, equipment, and roads used for operations, except for structures, equipment and roads that are to be used for continuing operations which are the subject of another approved plan of operations or of a plan which has been submitted for approval, or unless otherwise authorized by the Regional Director. [36 CFR § 9.39(a)(2)(i)]		+	+	+	+	+	+	+		√	
Remove all debris resulting from the operations. [36 CFR § 9.39(a)(2)(ii)]										√	
Remove or neutralize any contaminating substances. [36 CFR § 9.39(a)(2)(iii)]		√	√	+	+	+	+	+			
Plug and cap all nonproductive wells and fill dump holes, ditches and other excavations. [36 CFR § 9.39(a)(2)(iv)]										√	√
Restore topographic contours to reasonably conform to the contours that existed prior to initiation of operations. [36 CFR § 9.39(a)(2)(v)]		√	+	+	+	+	+	+		√	
Replace natural topsoil necessary for vegetative restoration. [36 CFR § 9.39(a)(2)(vi)] Topsoil brought in from outside of the Preserve shall be clean of non-native propagules.		+	+	+	√	+	+	+		+	
Re-establish native vegetative communities. [36 CFR § 9.39(a)(2)(vii)]		+	+	+	√	+	+	+		+	
Reclamation must provide for the safe movement of native wildlife, must re-establish native vegetative communities, the normal flow of surface and reasonable flow of subsurface waters, and must return the area to a condition that does not jeopardize visitor safety or public use of the unit. [36 CFR § 9.39(b)]		+	√	+	√	+	√	√		√	
When proposed operations cannot avoid direct and/or indirect impacts on wetlands, the operator shall compensate for direct and indirect impacts on to wetlands by restoring degraded or former wetland habitats. Wetland restoration must, at a minimum, provide for one-for-one (1:1) wetland function replacement (i.e., focus on no net loss of wetland functions, not just wetland acreage). Compensation shall be performed prior to or at the same time impacts associated with approved oil and gas operations occur. [EO 11990, NPS Procedural Manual 77-1 § 5.2 (C)]		+	+	+	+	√	+	+		+	
Plug wells to meet the requirements described in the "NPS well Plugging Guide for Nonfederal Oil and Gas Operations in the State of Texas" (see Appendix I).	√	√	√	√	√	√	√	√	√	√	√

WELL PLUGGING, ABANDONMENT, AND SITE RECLAMATION

REQUIRED OPERATING STIPULATIONS AND RECOMMENDED MITIGATION MEASURES

The primary resource(s) that would be protected by the operating stipulation or mitigation measure are denoted by a √ symbol. Other resources that would benefit from the protective measures are marked with a + symbol. RESOURCES	Air Quality	Geologic Resources	Water (Surface and G.W.)	Floodplains	Vegetation	Wetlands	Fish and Wildlife	Species of Special Concern	Cultural Resources	Visitor Use and Experience	Human Health and Safety
Reclamation activities must re-establish natural functions of wetlands and floodplains. [NPS Procedural Manuals 77-1, 77-2]		+	+	√	√	√	+	+		+	
RECOMMENDED MITIGATION MEASURES											
When plugging wells within geomorphically active zones (e.g., the active meander belt of a river), set adequate surface plugs and cut casing below the expected lateral migration and water level changes of the stream channel to avoid future exposure of the surface plug.			+	+				+	+	+	√
Take necessary precautions to prevent oil, brine, chemicals, and other materials from reaching the ground during well plugging operations. Precautions include the use of plastic liners beneath the rig, pipe racks, and other equipment as necessary.		√	√	+	√	+	+	+			+
Collect all fluids and solids returned to the surface from the wellbore in metal tanks and dispose of them in an approved disposal facility outside of the Preserve.		√	√	+	+	+	+	+			+
Remove all fill material and recontour to natural grade. Soil surveys for the area can assure that the soil profile is re-established after the excavation is completed.		√	+	+	√	+	+	+	+	+	
Repair compacted soils by disking.		√	+	+	+	+	+	+		+	
Restore disturbed soils to original contours.		√	√	+	+	+	+	+		+	
Revegetate cut-and-fill slopes and use good civil engineering practices to maintain disturbed areas in a stable condition to avoid erosion and sedimentation.		√	√	+	√	+	+	+	+	+	
Compost or chip vegetation and use as soil supplement or mulch.		√	+	+	√	+	+	+		+	
Provide for natural succession of vegetative species (herbaceous species, then woody species) and to reduce chance of introduction of exotic plant species by seeding areas with native seed materials.				+	√	+	+	+			
Consider active revegetation and erosion control measures (i.e., reestablishing contours, seedbed preparation, planting seeds, planting or transplanting seedlings, adding mulch or other authorized materials to reduce the potential for erosion, etc.) if natural growth is unacceptable.		√	√	+	√	+	+	+		+	
Optimize survival of vegetation by planting during the fall and winter.		+	+	+	√	+	+	+			
Determine target percent cover for vegetation based on site (pre-operational) analysis. Reclamation of vegetation is acceptable if the canopy cover of native vegetation communities is at least 70 percent and sustained over at least 3 complete growing seasons. Canopy cover is defined as the vegetative cover above the soil surface that intercepts raindrops but does not contact the soil. For example, if the majority of the canopy is composed of grasses and forbs, then that would be the type of canopy used in estimating canopy cover.		+	+	+	√	+	+	+		+	

AFFECTED ENVIRONMENT

CHAPTER 3

CHAPTER 3
AFFECTED ENVIRONMENT

INTRODUCTION

The purpose of this chapter is to describe the resources in the Preserve that may be affected by the alternatives under consideration, and serve as the baseline environment by which to compare the potential effects of the alternatives. The resources or topics covered in this chapter, and Chapter 4, Environmental Consequences, are those that would potentially be affected by the implementation of any alternative considered in this Plan/EIS. These topics are:

- Nonfederal Oil and Gas Development
- Air Quality
- Geologic Resources
- Water Resources
- Floodplains
- Vegetation
- Wetlands
- Fish and Wildlife
- Species of Special Concern
- Cultural Resources
- Visitor Use and Experience
- Adjacent Land Uses and Resources

As described in the last portion of Chapter 1, the following topics were considered and evaluated, but not carried forward for more detailed analysis:

- Local and Regional Economies
- Park Operations for Fire and Facility Management
- Possible Conflicts Between the Proposed Action and Land Use Plans, Policies, or Controls
- Sustainability and Long-term Management, and Energy Requirements and Conservation Potential
- Environmental Justice
- Prime and Unique Farmlands

The description of resources in this chapter also provides a basis for developing the Performance Standards and Mitigation Measures described in Chapter 2, Parts II and III, which are common to all alternatives.

DESCRIPTION OF THE STUDY AREA

The Big Thicket area of East Texas originally covered approximately 3-½ million acres and is characterized by the diversity and beauty of its vegetation. Variations in geology, climate, soils, elevation and drainage have resulted in the biological diversity of the area. Land uses in the region, though benefiting the area economy, have reduced the Big Thicket to mere remnants of its former extent. The Preserve was established to assure the preservation, conservation, and protection of a portion of this once great forest complex.

The Big Thicket, often referred to as a “biological crossroads,” is a transition zone where southeastern swamps, eastern deciduous forest, central plains, pine savannas, and xeric (dry) sandhills intersect. The area provides habitat for rare species and favors unusual combinations of plants and animals.

In recognition of this diversity, the Preserve was designated a Biosphere Reserve in 1978 by the United Nations Educational, Scientific, and Cultural Organization (UNESCO). It shares this distinction among 337 biosphere reserves in 85 countries worldwide. The biosphere reserve program (Man and the Biosphere Program) is based on the concept that it is possible to achieve a sustainable balance between the conservation of biological diversity, economic development, and maintenance of associated cultural values. The validity of this concept is tested, refined, demonstrated, and implemented in the Biosphere Reserves (United States Man and the Biosphere Program, 1994).

The study area includes Big Thicket National Preserve and extends approximately ½-mile outside of the Preserve boundaries to include directional wells sited outside Preserve boundaries. The Preserve contains 15 separate units, comprising 98,735 acres. Approximately 11percent of the total acreage (10,602 acres) is comprised of three units added to the Preserve in 1993. This Plan/EIS does not address the three units included in the Addition Act lands because these areas have not been acquired by the Federal Government and nonfederal oil and gas operations in these units are outside the scope of the 36 CFR 9B regulations. The 9B regulations are triggered when an operator accesses nonfederal minerals on or across federally-owned or controlled lands or waters in a park. When an operator or mineral owner can reach his/her private oil and gas right in a park without such access, the 36 CFR 9B regulations do not apply.

The 12 units of the Preserve covered in this Plan/EIS, lie in East Texas, north of Beaumont and northeast of Houston, and occupy portions of Hardin, Liberty, Orange, Jasper, Polk, Tyler and Jefferson Counties. A Region/Vicinity Map for Big Thicket National Preserve is provided in the Summary chapter, Figure S.1. The following table lists the acreage for each unit.

Table 3.1. Big Thicket National Preserve, Unit Acreages

Preserve Unit	Counties	Acreage
Beaumont Unit	Orange, Hardin, and Jefferson Counties	6,289.00 acres
Beech Creek Unit	Tyler County	5,097.00 acres
Big Sandy Creek Unit	Polk County	14,227.00 acres
Hickory Creek Savannah Unit	Tyler County	705.00 acres
Lance Rosier Unit	Hardin County	24,752.00 acres
Loblolly Unit	Liberty County	551.85 acres
Lower Neches River Corridor Unit	Hardin, Jasper, and Orange Counties	3,291.00 acres
Menard Creek Corridor Unit	Polk, Hardin, and Liberty Counties	3,999.00 acres
Neches Bottom and Jack Gore Baygall Unit	Hardin and Jasper Counties	13,712.00 acres
Pine Island-Little Pine Island Bayou Corridor Unit	Hardin and Jefferson Counties	2,209.21 acres
Turkey Creek Unit Administrative/Visitor Headquarters	Tyler and Hardin Counties	7,949.90 acres 28.10 acres
Upper Neches River Corridor Unit	Jasper, Tyler, and Hardin Counties	5,902.00 acres
Total Acquired Acreage for 12 units		88,132.21 acres
Units authorized by Public Law 103-46 (July 1, 1993). Surface estate has not been acquired.		
Big Sandy Corridor Unit	Hardin, Polk, and Tyler Counties	4,788.10 acres
Canyonlands Unit	Tyler County	1,704.06 acres
Village Creek Corridor Unit	Hardin County	4,109.36 acres
Additional Acreage Authorized		10,601.52 acres
Total Authorized Acreage		98,734.73 acres

Historically, the Big Thicket area was wilderness and remained undeveloped until the early 1800's, when the area gradually was opened to pioneer settlement. Evidence of some of this pioneer way of life still exists today. Logging and the railroad were evident in the 1880's and 1890's. Nearly all of the Big Thicket has been logged at least once over the last two centuries. Much of the land formerly in natural forests is managed today as productive timberland.

NONFEDERAL OIL AND GAS DEVELOPMENT

History of Oil and Gas Development in the Region

In 1866, Lynis T. Barrett of the Melrose Petroleum Company drilled the first productive oil and gas well in Texas. Early development of this field, the Nacogdoches Field, followed in 1887 and 1889 under B. F. Hitchcock of the Petroleum Prospecting Company. Development of the Nacogdoches Field contributed towards establishing many of the petroleum industry's firsts: the auger principle, later employed in the rotary rig; the first cable-tool rig; first lease; oil pipe line; wooden and iron storage tanks; iron drums for transporting crude oil; and the first refinery (Rister, 1949). In 1889, Pattilo Higgins, a young Beaumont man and self-taught geologist, postulated that an abundance of cheap fuel was available just south of Beaumont at Spindletop Hill. Convinced they would become wealthy, Higgins and partners formed the Gladys City Oil, Gas and Manufacturing Company to find oil and to use it to develop a model industrial city – Gladys City. The company started drilling on Spindletop in 1893, but with no success. They continued to look for hydrocarbons in 1895 and 1896, each time failing because of inadequate oilfield equipment.

During 1899, Captain Anthony B. Lucas, a mining engineer and salt dome prospector in Louisiana, leased land in southeast Texas from the Gladys City Oil, Gas and Manufacturing Company. Also convinced there was oil at Spindletop, he began drilling for oil. Lucas' first attempt failed, but on January 10, 1901, while drilling his second well at Spindletop, the famous Lucas gusher blew in. Oil sprayed over 100 feet above the derrick for nine days before the well was capped. As news of the discovery spread, thousands of sightseers, speculators, promoters, fortune seekers and "boomers" poured into the area.

By 1902, 285 active wells were operating at Spindletop and over 600 oil companies had been formed. Companies such as the Texas Company (Texaco), J.M. Guffey Petroleum Company (Gulf), Magnolia Petroleum Company (Mobil), and Sun Oil Company went on to become giants in the oil and gas industry. Although the first commercial oil well is located in Pennsylvania, and Russia could claim the first gushers, the vast quantities of oil at Spindletop made it possible to use oil as an inexpensive, lightweight and efficient fuel to propel the world into the twentieth century.

Spindletop boomed again in 1926 when oil was discovered through deeper drilling on the flanks of the salt dome. The Spindletop Field led others to search for similar oil traps in southeast Texas. Salt domes with vast oil reservoirs were discovered at Saratoga, Sour Lake, and Batson. Salt domes are formed by underground movement of salt at depths of several tens of thousands of feet. Hydrocarbons accumulate above and on the flanks of these subsurface salt structures. Approximately 60 percent of the Preserve lies within the Upper Gulf Coast Salt Basin. Ending near Houston, the basin generally encompasses the counties of Walker, San Jacinto, Polk, Tyler, Newton, Liberty, Hardin, Orange and Chambers (James W. Jones, pers. comm.).

Nonfederal Oil and Gas Development within the Preserve

Within the Preserve, all of the underlying oil and gas resources are non-federally owned. Most of the oil and gas resources are owned by private individuals or companies; but the oil and gas resources beneath the Neches River and navigable reaches of Pine Island Bayou are owned by the State of Texas. Leasing State-owned oil and gas is administered by the Texas General Land Office.

According to Preserve records, between 125 and 155 wells have been drilled within the boundaries of the Preserve. Most had been plugged and abandoned before the Preserve was established in 1974. During the period from 1982 to 1985, the NPS contracted a site inventory of these wells, wellpads and associated access roads and pipeline corridors. The inventory identified and described direct surface disturbance by area and type of operation and includes 125 wellpads, 15 miles of access roads, and 64 miles of pipelines.

Active Oil and Gas Operations. Currently, there are 9 nonfederal oil and gas surface operations in the Preserve with a total direct surface disturbance of 11 acres. These operations consist of 6 wells and associated production facilities, 1 saltwater disposal well, a flowline and tank battery associated with a well located outside the Preserve, and an access road associated with directional wells located outside the Preserve. Eight wells inside the Preserve have been plugged, with ongoing reclamation on 13.2 acres. In addition, 47 directional wells from surface locations outside the Preserve to reach bottomhole targets beneath the Preserve have been issued 36 CFR § 9.32(e) exemption determinations. Of these, 33 wells have been drilled (as of 6/1/2005). In addition, 6 wells were directionally drilled from surface locations outside the Preserve to reach bottomhole targets beneath the Preserve under an approved plan of operations. Current operations are shown below in Table 3.2. Figure 3.1 is a map showing nonfederal oil and gas development. Active, inactive, and abandoned yet unreclaimed nonfederal oil and gas sites in the Preserve, previous seismic surveys; and surface locations outside the Preserve for active directional wells are shown on this map.

Preserve resources, primarily soils, vegetation and water quality, have been affected by leaks and spills of oil and gas, and contaminating and hazardous substances. By utilizing secondary containment, good well maintenance programs, employing conscientious oil and gas employees, and thorough monitoring and enforcement by Preserve staff, the occurrence of leaks and spills at oil and gas sites has been greatly reduced. The primary resource concerns for seismic operations include rutting and compaction of soils, damage to vegetation from off-road vehicle use, and possible cratering and blowouts from the detonation of explosives in seismic shotholes. By utilizing narrow, light-weight vehicles or hand-held drilling equipment, and planning for proper charge size in shotholes, these concerns can be substantially reduced or avoided.

Table 3.2. Nonfederal Oil and Gas Operations

(Operations are organized by Unit and Completion Date.)

No.	Operator	Well Name	Completion Date	36 CFR 9B Compliance Date	Remarks
Beaumont					
1.	Ballard Exploration Co., Inc.	Vastar #1-A	1996	6/5/96	Directional well and production operation located outside Preserve
2.	Ballard Exploration Co., Inc.	Exxon #1	1996	9/9/96	Directional well located outside Preserve on common pad with Vastar #1-A well
3.	Ballard Exploration Co., Inc.	Vastar #2-A	1996	10/17/96	Directional well located outside Preserve on common pad with production facilities for Vastar #1-A well

No.	Operator	Well Name	Completion Date	36 CFR 9B Compliance Date	Remarks
Big Sandy Creek					
4.	Burton Exploration Co.	Kirby #3	1986	09/12/86	Directional well and production operation located outside Preserve
5.	Comstock Oil and Gas, Inc.	Hamman #1	2002	9/5/01	Directional well and production operation located outside Preserve
6.	Comstock Oil and Gas, Inc.	Hamman #2	2003	5/2/03	Directional well and production operation located outside Preserve
7.	Comstock Oil and Gas, Inc.	Collins #2	2004	6/23/03	Directional well and production operation located outside Preserve on common pad with Collins #1 well
8.	Comstock Oil and Gas, Inc.	Collins #3	2004	9/16/04	Directional well and production operation located outside Preserve
9.	Comstock Oil and Gas, Inc.	BSMC Unit D #1	Proposed 2004/2005	11/8/04	Proposed directional well and production operation located outside Preserve
Jack Gore Baygall					
10.	Murphy Exploration and Production Co.	L.L. Williams #2	1952	8/6/91, revised 5/31/95	Well plugged 11/18/1995; reclamation of 1.5 acres ongoing
11.	Merit Energy Co.	James Rafferty Fee #1	1954	9/22/03	Well plugged 5/1/01; reclamation of 2.1 acres ongoing
12.	Premium Exploration Co.	James Rafferty Fee #3	1954	Not in compliance	Transfer on 9/1/98 of existing operations on 1.1 acres inside Preserve. Oil well converted to saltwater injection well in 1977.
13.	Merit Energy Co.	James Rafferty Fee #1-N	1954	9/22/03	Well plugged 4/21/01; reclamation of 1.4 acres ongoing
14.	Merit Energy Co.	James Rafferty Fee #7	1955	9/22/03	Well plugged 4/19/01; reclamation of 1.9 acres ongoing
15.	Buford Curtis, Inc.	James Rafferty Fee #1	1956	10/23/02	Well plugged 12/2/02. Plan of operations required for reclamation on 1.5 acres
16.	Premium Exploration Co.	ARCO Rafferty #1A	1976	Not in compliance	Transfer on 9/1/98 of existing well and production operations on 1.9 acres inside Preserve
17.	Merit Energy Co.	M. J. Cunningham #5	1976	9/22/03	Well plugged 4/10/01; reclamation of 1.2 acres ongoing
18.	Richman Petroleum Corp.	Doty-Jackson Unit #A-1	1985	7/24/03	Well and production operation located inside Preserve on common pad with Omega Energy Corp. Tanton #1 well and production site on 1.5 acres
19.	Omega Energy Corp.	Tanton #1	1997	6/12/02	Directional well and production operation located inside Preserve on common pad with Richman Petroleum Corp. well and production site on 1.5 acres
20.	Davis Bros. Oil Producers, Inc.	Vastar-Johnson #1	2002	5/28/02	Directional well and production operation located outside Preserve
21.	Davis Bros. Oil	Kiamu-Johnson #1	2003	10/4/02	Directional well located outside Preserve on common pad with Vastar-Johnson #1

No.	Operator	Well Name	Completion Date	36 CFR 9B Compliance Date	Remarks
	Producers, Inc.				well
22.	Davis Bros. Oil Producers, Inc.	Cowden-Johnson #1	2003	6/2/03	Directional well located outside Preserve on common pad with Vastar-Johnson #1 well
23.	Davis Bros. Oil Producers, Inc.	Johnson-Elene #1	2004	4/16/04	Directional well located outside Preserve on common pad with Vastar-Johnson #1 well
24.	Davis Bros. Oil Producers, Inc.	Nelson-Allie #1	2005	4/16/04	Directional well and production operation located outside Preserve
25.	Davis Bros. Oil Producers, Inc.	Nelson-Kate STK #1	2005	4/16/04	Directional well located outside Preserve on common pad with Nelson-Allie #1
26.	Union Gas Operating Co.	BP Rafferty A-45 #1	2005	6/1/05	Directional well and production operation located outside Preserve
27.	Davis Bros. Oil Producers, Inc.	Johnson-Hayden #1	Proposed 2004/2005	4/16/04	Proposed directional well and production operation located outside Preserve
28.	Davis Bros. Oil Producers, Inc.	Johnson-Reese #1	Proposed 2004/2005	4/16/04	Proposed directional well located outside Preserve on common pad with Johnson-Hayden #1 well
29.	Davis Bros. Oil Producers, Inc.	Johnson-Whitman #1	Proposed 2004/2005	4/16/04	Proposed directional well located outside Preserve on common pad with Johnson-Hayden #1 well
30.	Davis Bros. Oil Producers, Inc.	Nelson-Emmie #1	Proposed 2004/2005	4/16/04	Proposed directional well located outside Preserve on common pad with Nelson-Allie #1 well
31.	Davis Bros. Oil Producers, Inc.	Nelson-Lynn #1	Proposed 2004/2005	4/16/04	Proposed directional well located outside Preserve on common pad with Nelson-Allie #1 well
32.	Davis Bros. Oil Producers, Inc.	Nelson-Lance #1	Proposed 2004/2005	4/16/04	Proposed directional well located outside Preserve on common pad with Nelson-Allie #1 well
33.	Davis Bros. Oil Producers, Inc.	Nelson-Pidgeon #1	Proposed 2004/2005	4/16/04	Proposed directional well located outside Preserve on common pad with Nelson-Allie #1 well
34.	Union Gas Operating Co.	Bertrand-Nelson #1	Proposed 2005	6/1/05	Proposed directional well and production operation located outside Preserve
35.	Union Gas Operating Co.	BP Rafferty A-45 #2	Proposed 2005	6/1/05	Proposed directional well located outside Preserve on common pad with Union's BP Rafferty A-45 #1
36.	Union Gas Operating Co.	BP Rafferty A-45 #3	Proposed 2005	6/1/05	Proposed directional well located outside Preserve on common pad with Union's BP Rafferty A-45 #1
Lance Rosier					
37.	Caskids Operating	W.R. Carr #1	1983	9/20/94	Well plugged 12/19/95; reclamation of 1.5 acres ongoing

No.	Operator	Well Name	Completion Date	36 CFR 9B Compliance Date	Remarks
	Co.				
38.	COBRA Oil and Gas Corporation	Quinn 2-84 #2	2001	03/12/01	Directional well and production operation located outside Preserve. Well plugged 4/10/2003. Re-drilled in June 2003 and in production since.
Lower Neches River Corridor					
39.	Davis Southern Operating Co.	P.C. Bernal #1	2004	7/14/2004	Directional well located outside Preserve drilled as re-entry into the Duncan Energy Company's P.C. #1 Bernal well. To be P&A'd.
40.	Davis Southern Operating Co.	P.C. Bernal #2	Proposed 2004/2005	7/14/04	Proposed directional well located outside Preserve to be drilled on common pad with P.C. Bernal #1 well
41.	Davis Southern Operating Co.	P.C. Bernal #3	Proposed 2004/2005	7/14/04	Proposed directional well located outside Preserve to be drilled on common pad with P.C. Bernal #2 well
42.	Davis Southern Operating Co.	P.C. Bernal #4	Proposed 2004/2005	7/14/04	Proposed directional well located outside Preserve to be drilled on common pad with P.C. Bernal #3 well
Neches Bottom					
43.	Westport Oil and Gas Co.	Hankamer #1-A	1985	5/7/03	Directional well and production operation that includes the Hankamer #1-B saltwater injection well located outside Preserve. Access road through Preserve on 1.2 acres
44.	Westport Oil and Gas Co.	Hankamer #2	1985	5/7/03	Directional well on common pad with Hankamer #1-A outside Preserve
45.	Westport Oil and Gas Co.	Hankamer #3	1985	5/7/03	Directional well located outside Preserve on common pad with Hankamer #1-A well
46.	Westport Oil and Gas Co.	Hankamer #4	1987	5/7/03	Directional well located outside Preserve on common pad with Hankamer #1-A well
47.	C&E Operating, Inc.	Hankammer Well #1	Proposed 2005	5/10/05	Proposed directional well and production operation located outside Preserve
Pine Island-Little Pine Island Bayou Water Corridor					
48.	Penwell Energy, Inc.	Vastar Fee #2	1996	9/26/96	Directional well and production operation located outside Preserve
49.	Penwell Energy, Inc.	Vastar-Pica Unit #1	2002	11/29/01	Directional well and production operation located outside Preserve on common pad with Vastar Fee #3 well
50.	Century Resources Land, LLC	Black Stone Minerals #3	2003	1/14/03	Directional well outside Preserve located on common pad with Black Stone Minerals #1 well
Turkey Creek					
51.	Milestone Operating, Inc.	William M. Rice Institute B-5	1953	10/9/90	Active well on 1.4 acres
52.	Austral Oil Company, Inc.	Campbell #2	1958	5/26/05	Well located outside Preserve. Produced fluids to flowline and tank battery located inside Preserve.
53.	Austral Oil Company, Inc.	Campbell #3	1959	5/26/05	Suspended well inside Preserve on 0.7 acres
54.	Austral Oil Company, Inc.	Campbell #4	1959	5/26/05	Inactive well inside Preserve on 3.2 acres.

No.	Operator	Well Name	Completion Date	36 CFR 9B Compliance Date	Remarks
55.	Hanson Production Co.	Vastar Fee #307-2	1995	12/20/94	Directional well and production operation located outside Preserve on common pad with Vastar #307-1 well
56.	Hanson Production Co.	Mann Fee #307-1	1997	12/13/95	Dry hole/well plugged on 3/17/97; reclamation of 2.1 acres ongoing

Plugged and Abandoned Oil and Gas Wells. There are approximately 110 plugged and abandoned wells in the Preserve. The acreage directly affected by these well sites or pads totals 211 acres; associated access roads directly disturb another 164.7 acres. Most of the disturbance is located in the Lance Rosier (75 wells), Neches Bottom/Jack Gore Baygall (33 wells), and Turkey Creek (15 wells) Units. Nearly all of these operations were undertaken prior to establishment of the Preserve.

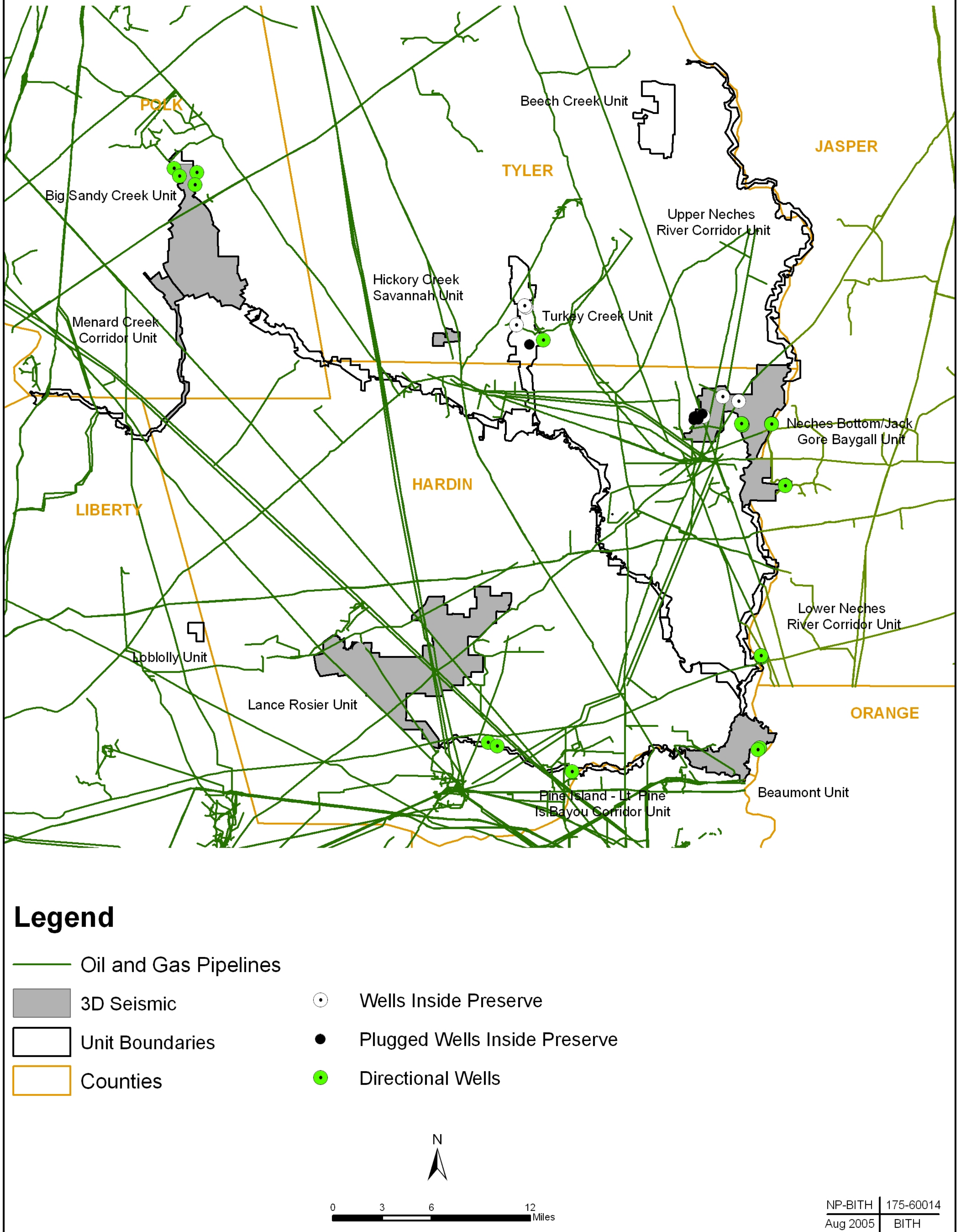
The nature and extent of impacts identified at these sites is limited to the information collected during the 1980's inventory. In general, the NPS documented debris, fill, pits or evidence of pits, and berms. Debris was observed on 60 wellpads and pits or evidence of pits on 71 pads. Debris, found on both wellpads and access roads, included pipe, cable, drums, drilling equipment, pipe racks, fence, and household garbage. Pits, used for a variety of purposes, may have contained saltwater, drilling fluid, cuttings, hydrocarbons, wash water for cleaning drill pipe and other equipment, and other oil and gas wastes. At two of the well sites, the NPS has documented contamination by saltwater, heavy metals, and hydrocarbons.

An estimated 20 of the plugged and abandoned wells are located within the 100-year floodplain and the active meander belt of the Neches River, and could become exposed due to river meandering or migration. Presently, two of the wells are located in the Neches River, approximately 40 feet from the eastern bank. Removal of the well casings in these wells and setting the surface plug to a depth of 50 feet below the surface to meet NPS requirements remains problematic due to engineering, logistical, and financial constraints. Both wells are marked with solar powered warning lights.

On nearly all of these sites, soil and water contamination has not been assessed to determine if any contaminants pose an unacceptable risk to human health and the environment. In fiscal year 2002, the Preserve received funding to investigate soil contamination on 4 abandoned sites. Preliminary review of these data indicates that these sites need to be delineated and characterized before mitigation requirements can be determined. At 3 of the sites, total petroleum hydrocarbon (TPH) levels exceeded State of Texas standards. Metals were detected, and lead concentrations exceeded State standards at all 4 sites. Antimony, chromium, and cadmium exceeded State standards at 2 sites. The Preserve has requested funding to further delineate and characterize contamination on these and additional sites.

Figure 3.1. Nonfederal Oil and Gas Development

Figure 3.1. Nonfederal Oil and Gas Development



Historic Saltwater Disposal Area. Historically, saltwater or brine and other oil and gas wastes from the salt dome area near Saratoga were transported and impounded near Little Pine Island Bayou. Today, the lower end of the impoundment area and containment levees occupies approximately 80 acres within the Lance Rosier Unit. Although most of the impoundment area is outside the Preserve, surface and subsurface water flows across and through the Unit. Elevated chloride levels in the bayou and Pine Island Bayou watershed are partially attributed to oil field brine.

Geophysical Exploration. Geophysical exploration has been conducted within the Preserve since the early 1940's (Peyton Weems, pers. comm.). Three methods of exploration have occurred: cable-only seismic surveys; traditional two-dimensional (2-D) and three-dimensional (3-D) shot-hole seismic surveys; and mini-hole 2-D and 3-D seismic surveys. At least 85 cable-only seismic surveys have been conducted in the Preserve. Cable-only surveys within the Preserve are conducted on foot and involve cutting a minimal amount of vegetation for line-of-sight survey and placement of cables or receivers. Within the Preserve, survey lines have varied in length from a few hundred feet to 8,000 feet.

Traditional 2-D shot-hole operations and 3-D mini-hole operations have been conducted in 6 units since June 1981 (Table 3.3). The traditional shot-hole method involves drilling a single hole per shot-hole location, placing an explosive charge at the bottom of each hole, refilling the hole with cuttings, and detonating each charge to create sound waves. Traditional 2-D shot-hole operations were drilled using tandem buggy mounted equipment. Drill and water buggies are high clearance, four-wheel drive vehicles, and typically weigh 12,000 to 18,000 lbs. Between 1981 and 1987, approximately 46 miles of seismic lines were drilled using this type of equipment.

Since 1984, 2-D and 3-D mini-hole seismic operations have been conducted within the Preserve using all-terrain vehicle mounted equipment, portable "rickshaw" drills, hand portable drills, and boats. Most 2-D mini-hole operations have involved drilling holes 5 to 10 feet deep in a straight line or star-shaped pattern. The number of shotholes per source point or shot-hole location was typically 5 to 7. Shot points were generally spaced 220 to 440 feet apart. Explosive charges placed in each shothole averaged ½-pound (range: 5 oz. to 1 pound). Both shotholes and cables were placed along the same line. Average line width was 3.5 feet.

Two-dimensional (2-D) seismic surveys create an image of the subsurface along a vertical plane, directly below the seismic line. If the subsurface beds dip at an angle to the orientation of the 2-D line, then the image obtained may be inaccurate and not directly below the surface of the line. The end result may be a targeted area actually several hundred feet away from the location identified on the image. The 2-D image also requires that the interpreter determine the subsurface geology between 2-D lines with limited indirect data. Such data limitations may result in the need for additional 2-D programs to fill any data gaps. Approximately 13 miles of 2-D (mini-holes) lines crossed the Preserve from 1984 to 1991.

In contrast, 3-D seismic surveys cover a larger surface area and generate a three-dimensional image of the subsurface. Three-dimensional seismic data help the oil and gas industry to more accurately locate subsurface structures that may contain oil and gas accumulations. Four 3-D mini-hole operations, covering approximately 50 square miles or 40 percent of the Preserve, have been conducted from July 1998 to September 1999. Operations were conducted primarily on foot and by boat using portable drills. On average, ½-pound charges were used in holes from 5 to 10 feet deep. Shothole spacing ranged from 110 to 440 feet between points. Distances between source and receiver lines ranged from 880 to 2400 feet for both lines. Width line averaged 3.5 feet.

In 2004, one 3-D seismic survey was conducted in the Big Sandy Creek, Menard Creek Corridor and Hickory Creek Savannah Units using both shot-hole and cable-only methods. Shotholes were generally spaced 220 feet apart; spacing between both shot lines and receiver lines was 1,760 feet. Using lightweight drilling equipment, shotholes were drilled to 80 feet and 5.5-pound explosives were placed at the bottom of each hole. Shotholes were primarily located in the Big Sandy Unit.

Table 3.3. Two-and Three-Dimensional Seismic Surveys

(Operations are organized by Unit and Permit Date.)

Operator	Line ID	Type	No. of Shothole Locations	Avg. Depth (Feet)	Permit Date	Total Line Length (Feet)	Area of Survey (mi^2)
Beaumont Unit							
Minerals Search, Inc.	1	2-D	205	120	09/23/83	6,600	N/A*
Western Geophysical	83-13	2-D	70	10	06/18/84	7,000	N/A
Western Geophysical	83-14	2-D	55	10	06/18/84	5,400	N/A
Inland Geophysical Services	I/W #3	2-D	126	5	04/08/91	27,710	N/A
Inland Geophysical Services	I/W #21	2-D	57	5	04/08/91	12,430	N/A
Continental Geophysical	N/A	3-D	588	10	07/15/98	N/A	9 mi^2
Spirit Energy	N/A	3-D	470	5	07/30/98	N/A	6 mi^2
Big Sandy Creek Unit							
Arco	1	2-D	144	100	12/08/81	32,000	N/A
Arco	2	2-D	135	100	12/08/81	30,000	N/A
Arco	1	2-D	122	100	06/23/83	15,000	N/A
Seismic Assistants, Ltd.	N/A	3-D	1,860	80	01/23/04	N/A	22 mi^2
Lance Rosier Unit							
Ladd	1	2-D	50	80	06/03/81	30,000	N/A
Seis Pros Inc	2	2-D	78	120	06/09/82	10,700	N/A
Seis Pros Inc	3	2-D	107	120	06/09/82	19,500	N/A
Seis Pros Inc	5	2-D	111	120	06/09/82	21,120	N/A
Geo Seismic Services	2	2-D	29	100	06/14/82	6,300	N/A
Geo Seismic Services	5	2-D	82	100	06/14/82	10,700	N/A
Amoco	A	2-D	35	150	12/16/87	15,400	N/A
Amoco	B	2-D	7	150	12/16/87	2,800	N/A
Amoco	C	2-D	14	150	12/16/87	5,600	N/A
Frontier Geophysical	659312	2-D	227	5	03/03/89	8,000	N/A
Frontier Geophysical	658313	2-D	235	5	03/03/89	8,300	N/A
Cobra Exploration Company	N/A	3-D	1,303	10	6/1/99	N/A	18 mi^2
Menard Creek Unit							
Texaco, Inc	24	2-D	2	Unknown	11/08/78	1,500	N/A
Neches Bottom and Jack Gore Baygall Unit and Lower Neches River Corridor Units							
Arco	1	2-D	65	120-160	06/09/83	14,000	N/A
Shell Oil Company	1	2-D	145	120	06/17/83	22,000	N/A
Seismic Exchange, Inc.	N/A	3-D	1,083	6	01/15/99	N/A	22 mi^2

* N/A - Not Applicable

Existing Transpark Oil and Gas Pipelines and Associated Rights-of-Way. There are 71 oil and gas pipeline segments crossing units of the Preserve within rights-of-way totaling 101 miles of pipelines, and occupying approximately 589 acres. These rights-of-way existed prior to establishment of the Preserve, and acquisition of the surface estate was made subject to these encumbrances. Rights-of-way widths are variable and range from 30 to 150 feet.

Pipelines are used to transport saltwater, crude oil, natural gas, liquid petroleum gas and natural gas liquids within or through the Preserve, and may or may not be associated with nonfederal oil and gas rights within the Preserve. New rights-of-way for a limited number of purposes, such as public utilities, may be permitted under NPS regulations at 36 CFR Part 14. However, pipeline rights-of-way in any park unit may be granted only under specific legislative authority from Congress. At present, no statutory authority exists for granting new trans-park oil and gas rights-of-way within the Preserve. Table 3.4 lists the pipelines crossing units of the Preserve. Several pipelines cross more than one unit. There are no pipelines crossing the Loblolly or Beach Creek Units.

Table 3.4. Existing Transpark Oil and Gas Pipelines within Big Thicket National Preserve

(Pipelines are organized by Unit and Preserve Identifier.)

No.	Operator	Product	Preserve Identifier[1]	Size of Pipeline (Inches)	Date Constructed
Beaumont					
1.	Centana Intrastate Pipeline LLC	Natural Gas	B-2	1-6"	1959
2.	Houston Pipe Line Company	Not in Service	B-3	1-6"	1961
Big Sandy Creek					
3. 4. 5.	Tennessee Gas Pipeline Company	Natural Gas	BS-1	1-24" 1-31" 1-30"	1944 1949 1952
6. 7.	El Paso Field Service LP	Natural Gas	BS-2	1-4" 1-3"	1983-1984 1996
Hickory Creek Savannah					
8.	El Paso Field Services	Natural Gas	HC-1	1-8"	1949
9.	Houston Pipe Line Company	Not in Service	HC-4	1-6"	1949
10.	Energy Transfer Company	Natural Gas	HC-5	1-10"	1929-1930
11.	Tennessee Gas Pipeline Company	Not in Service	HC-6	N/A	
Jack Gore Baygall/Neches Bottom					
12.	El Paso Field Services	Natural Gas	JG-1	1-4"	1945
13.	El Paso Field Services	Natural Gas	JG-2	1-4"	1949
14.	Lion Oil Company	Crude Oil	JG-3	1-10"	1932
15.	El Paso Field Services	Natural Gas	JG-4	1-8"	1961
16.	Oxy Petroleum Company	Not in Service	JG-5	1-2 1/2	1954
17.	Black Lake Pipeline	NGL	JG-6	1-8"	1967
18.	El Paso Field Services	Natural Gas	JG-7	1-6"	Unknown
19.	El Paso Field Services	Natural Gas	JG-8	1-8"	Unknown
Lance Rosier					
20.	Black Lake Pipeline	NGL	LR-1	1-8"	1967
21.	Sunoco Pipeline LP	Crude Oil	LR-2	1-6"	1950
22.	Black Hills Operating Co., LLC	Crude Oil	LR-3	1-12"	1930s
23.	Chevron Pipe Line Company	Empty	LR-4	1-12"	1931
24.	Sunoco Pipeline LP	Crude Oil	LR-5	1-10"	1931
25.	Mobil Pipe Line Company	Crude Oil	LR-6	1-20"	1954
26. 27.	Kinder Morgan Texas Pipeline, LP	Natural Gas	LR-7	1-18" 1-20"	1954
27.	Sunoco Pipeline LP	Crude Oil	LR-8	1-6"	1950
28.	Chevron Pipe Line Company	Not in Service	LR-9	1-12"	Late 1920s
29.	Sunoco Pipeline LP	Crude Oil	LR-10	1-26"	1953
30.	Sunoco Pipeline LP	Not in Service	LR-11	1-6"	1952
31.	SETEX Oil and Gas Company	Not in Service	LR-12	1-4"	1952
33.	Big Thicket Pipe Line LLC	Natural Gas	LR-13	1-6"	2000
Lower Neches River Corridor					
34. 35.	Trunkline Gas Company	Natural Gas	LN-1	2-24"	1950 & 1966
36.	Gulf State Pipe Line Co., Inc.	Naptha	LN-2	1-8"	1974
37.	Transcontinental Gas Pipe Line Corporation	Natural Gas	LN-3	1-30"	1949
38.	Houston Pipe Line Company	Natural Gas	LN-4	1-8"	1961
39.	Lion Oil Company	Crude Oil	LN-5	1-10"	1932

No.	Operator	Product	Preserve Identifier[1]	Size of Pipeline (Inches)	Date Constructed
40.	Houston Pipe Line Company	Natural Gas	LN-6	1-30”	1974
Menard Creek Corridor					
41.	Mobil Pipe Line Company	Crude Oil	MC-1	1-20”	1954
42. 43.	Kinder Morgan Texas Pipeline, LP	Natural Gas	MC-2	1-18” 1-20”	1954
44.	Sunoco Pipeline LP	Crude Oil	MC-3	1-26”	1953
45. 46 47. 48.	Chevron Pipeline Company	Not in Service LPG	MC-4	2-14” 2-10”	1957 1970
49.	Louis Dreyfus Pipeline LP	NGL	MC -5	1-12”	1971
50.	TE Products Pipeline Co LP	NGL	MC-6	1-10”	1993
51.	Mustang Pipeline Company	HVL	MC-7	1-10”	1995
Pine Island Bayou-Little Pine Island Bayou Corridor					
52.	Unocal Corporation	Crude Oil	PI-1	1-10”	1929-1930
53. 54.	Kinder Morgan Texas Pipeline, LP	Natural Gas	PI-2	1-18” 1-20”	1954
55.	Mobil Pipe Line Company	Crude Oil	PI-3	1-20”	1954
56.	Link Energy Texas LLC	Crude Oil	PI-4	1-8”	1930’s
57.	Transcontinental Gas Pipe Line Corporation	Natural Gas	PI-5	1-30”	1949
58.	Houston Pipe Line Company	Natural Gas	PI-6	1-12”	1959
59.	Transcontinental Gas Pipe Line Corporation	Natural Gas	PI-7	1-10”	1949-1950
60.	Houston Pipe Line Company	Natural Gas	PI-8	1-4”	1981
61.	El Paso Field Services	Natural Gas	PI-9	1-8”	Unknown
62.	Kinder Morgan Texas Pipeline, LP	Natural Gas	PI-10	1-4”	1929
Turkey Creek					
63.	Houston Pipe Line Company	Natural Gas	TC-1	1-4”	1968
64.	Houston Pipe Line Company	Natural Gas	TC-2	1-10”	1952
65. 66.	Enterprise Products Operating LP	Natural Gas Not in Service	TC-3	1-6” 1-6”	1956
67. 68.	El Paso Field Services	Not in Service	TC-4	2-4”	1956
69.	Driscoll	Natural Gas	TC-5	1-2”	1977
70.	El Paso Field Services	Natural Gas	TC-6	1-8”	1978
Upper Neches River Corridor					
71.	Black Lake Pipeline	NGL	JG-6	1-8”	1967

[1]**Preserve Identifier:**

B = Beaumont Unit
BS = Big Sandy Creek Unit
HC = Hickory Creek Savannah Unit
JG = Jack Gore Baygall Unit
LN = Lower Neches River Corridor Unit
LR = Lance Rosier Unit
MC = Menard Creek Corridor Unit
PI = Pine Island Bayou-Little Pine Island Corridor Unit
TC = Turkey Creek Unit
UN = Upper Neches River Corridor Unit

Natural gas, crude oil, liquid petroleum gas (LPG), natural gas liquids (NGL), and refined products (gasolines, diesels, heating oil, and jet fuels) are transported in pipelines. Natural gas is composed mostly of methane, with lesser portions of ethane and propane. Although nearly odorless as it comes from the well or production facility, its characteristics depend on the reservoir from which it is produced. As described in this document, “gas” means natural gas, flammable gas, or gas which is toxic or corrosive. Crude oil is a black or dark brown mixture of hydrocarbons, with relatively small quantities of oxygen, nitrogen, sulfur, salt, water, and trace amounts of certain metals. Similarly, the characteristics of crude oil are dependent on the reservoir. LPG and NGL are referred to as liquefied hydrocarbons and considered highly volatile. They are gases under atmospheric conditions and liquids under pressure (The Pipeline Group, 1995). All categories of hydrocarbons except refined products are transported through the Preserve.

Transpark pipeline rights-of-way are maintained by their owners/operators. Routine maintenance consists of trimming and pruning overhanging tree limbs and mowing within the right-of-way. Removal and maintenance of vegetation is necessary for initial construction of the pipeline, for long-term access to conduct routine maintenance and monitoring, and for rapid response in the event of a rupture or spill.

Hunters commonly use right-of-way corridors during the Preserve's hunting season. Given the rural nature of the area and adjacent land uses, these open corridors may be conduits for unauthorized access on or across Preserve lands. Similarly, these corridors have resulted in the loss of wildlife habitat for some wildlife species, while improving habitat for others.

Pipelines may pose a significant threat to park resources and values if not properly managed and maintained. Given the water-dominated nature of the Preserve, pipeline leaks and spills could considerably harm water quality, aquatic habitat, aquatic life, and adversely impact public use of the Preserve. Although any of the Preserve's water corridors could be affected, the Neches River, because of its size, may represent the greatest flood hazard to oil and gas facilities and be most at risk of pipeline spill or fire catastrophe (Harcombe and Callaway, 1997).

It should be noted that the entire Preserve is a sensitive area, as defined by the Railroad Commission of Texas (Statewide Rule 91). Factors that are characteristic of sensitive areas include the presence of shallow ground water or pathways for communication with deeper groundwater, and proximity to surface water, including lakes, rivers, streams, dry or flowing creeks, irrigation canals, stock tanks, and wetlands. A preliminary assessment of the vulnerability of groundwater to pollution within the Preserve indicates the entire Preserve would be moderately to very vulnerable to pollution from both agricultural and industrial sources (Allen 1999).

Pipeline Incidents. Both the petroleum industry and the regulatory community are aware of the potential for pipeline failures from outside forces, corrosion, operator error, failed pipe, equipment malfunction, failed weld, and other causes of pipeline failure. Despite these problems, industry and federal safety officials believe that underground pipelines are the safest mode of transportation. Accidents are relatively few, given that half of the nation's hazardous liquids move through them (Houston Chronicle, 1997). Natural forces, including excavation activity, are the leading cause of hazardous liquid pipeline failures. Outside forces account for the following incidents.

In 1993, pipeline LN-3 became exposed due to migration of the Neches River. A new segment was installed via directional drilling in 1994, and the abandoned segment was subsequently removed. Reclamation of the easement (approximately 3 acres) continues and has remained difficult due to drought, flooding, herbivory, site disturbance, and the presence of the invasive Chinese tallowtree.

Adjacent to the Menard Creek Unit, an active 10-inch NGL line was damaged during installation of another pipeline within the same right-of-way in March of 1997. This event caused the contents to volatilize, creating dangerously low oxygen conditions that initially delayed emergency responses. Over 250 people were evacuated from a 50-acre area near the Polk/Liberty County line. Evacuation was further complicated by flooding in a nearby subdivision, requiring evacuation of residents by boat. Approximately 80 gallons of oil combined with soil, drilling mud and road materials flowed approximately 1,000 feet down Menard Creek. As a result of aggressive cleanup efforts by the responsible party, surface water samples taken within the Preserve showed contaminant levels were well below all aquatic life standards and below almost all aquatic life and wildlife criteria. However, soil and groundwater sampling and testing continue for benzene. Benzene is carcinogenic and can persist in groundwater longer than in surface water.

In 2000, pipeline segment JG-4 was taken out of service by the operator due to a natural gas leak. No camping permits were issued by the Preserve or burning was permitted in the Neches Bottom/Jack Gore Baygall Unit until the leak was remedied.

Administration of Nonfederal Oil and Gas Program. Management of the oil and gas program in the Preserve is accomplished by staff in the Preserve, with technical support from resource and program specialists in the Regional Office (Santa Fe and Denver) and the Washington Office's National Resource Program Center (Denver and Fort Collins). The majority of fieldwork and coordination with operators is performed by the Preserve's single staff specialist, who typically has other program responsibilities and tasks to perform. When there are multiple new proposals in development, the Preserve's specialist has been unable to address all program needs. Additionally, the Preserve's geographic configuration, wet nature, and relative inaccessibility generally constrain travel and access to project areas. The Preserve recognizes that due to these factors and increased oil and gas activity, additional staff support for the program is needed to ensure timely processing of plans of operations, and to protect Preserve resources and visitor experience.

The NPS has no regulatory authority to accrue fees for the management of its Nonfederal Oil and Gas Rights Regulations (36 CFR 9B), nor for the use of parklands under this regulatory program. The NPS encourages operators to adaptively use disturbed areas for siting new operations where appropriate. Prospective operators would not want to site operations where they may assume liability for cleanup and remediation of contaminated soils if it exists, and the NPS cannot require operators to do so. Where there are valid operators still in existence, the NPS would request the operator's voluntary return to reclaim their previous operations areas. In most cases, the sites were plugged and abandoned prior to the implementation of the 36 CFR 9B regulations, and the NPS lacks the regulatory authority to require further reclamation by the operator. Where reclamation activities were not successful, the NPS would request the operators to return to complete the necessary reclamation requirements. The NPS has funding available to remediate contaminated sites. Where there are no valid operators in existence, or operators do not voluntarily return to reclaim these sites, the Preserve would need to compete with other park units for NPS funds dedicated to disturbed lands and abandoned mine lands reclamation.

AIR QUALITY

The Preserve is located north of the Beaumont/Port Arthur/Orange airshed and northeast of the Houston/Galveston airshed. These are two of the most polluted airsheds in the State, and represent two of five Nonattainment Areas in Texas that exceed National Ambient Air Quality Standards (NAAQs) established by the Environmental Protection Agency (EPA). The Preserve may also be influenced by air pollutants transported from the Lake Charles, Louisiana, petrochemical complex. The primary pollutants transported from airsheds affecting the Preserve are volatile organic compounds (VOCs), and nitrogen oxides (NO_x). Other air pollutants that could affect the Preserve and public health and welfare include carbon monoxide, sulfur dioxide (SO_2), and particulate matter (including heavy metals and lead).

During most of the year, prevailing air flow is from the southeast and Gulf of Mexico, shifting to flow from the northwest during passages of major continental air masses (cold fronts) that generally occur in late fall, winter, and early spring. The airshed of the southern portions of the Preserve is also affected by air currents (inshore/offshore flows) from the Gulf of Mexico with daily heating and cooling. These flow patterns are considered important because they transport various air pollutants from the nearby industrial and urban areas.

The Preserve is designated a Class II area under the Prevention of Significant Deterioration (PSD) provisions of the Clean Air Act (CAA). As such, the Preserve's air quality is protected by allowing limited increases (i.e., allowable increments) over baseline concentrations of pollution for the pollutants sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and particulate matter (PM). The PSD permitting program is administered by the Texas Commission on Environmental Quality (TCEQ) and applies to defined categories of new or modified sources of air pollution with emissions greater than 100 tons per year and all other sources greater than 250 tons per year. Based on level of emissions, oil and gas operations may or may not be subject to the PSD permitting program. Emissions from these and other pollution sources affecting the Preserve will be considered on a project-by-project basis in the assessment of air quality impacts allowed under the PSD increment system. Emission limitations under CAA New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants may apply to certain production facilities.

The Preserve lies within the Nonattainment Area for the 8-hour ozone National Ambient Air Quality Standard (NAAQS) in Hardin, Liberty, Orange, and Jefferson Counties. Ozone can be both phytotoxic (having damaging effects on some vegetation) and injurious to humans and wildlife. Existing ozone levels may be increased by additional emissions of NO_x and VOCs, the primary precursors to ozone formation. Emission limits for ozone precursors must conform with the State Implementation Plan (SIP) to attain the ozone NAAQS in these counties, and more stringent emission controls may be imposed by TCEQ than those required under the PSD program.

In the fall of 1996, particulate matter (PM) was monitored in the Preserve as part of a special study by the TCEQ, NPS, and Mexico to increase understanding of the transport of pollution to the Big Bend area of Texas. The fine fraction of PM (i.e., particles less than 2.5 microns, or $PM_{2.5}$) was measured due to the interest in the dramatic effect this particle size has on visibility. Of the 18 sites monitored on both sides of the U. S. – Mexico border, the Preserve measured the highest levels of $PM_{2.5}$ during a two-month period. Preliminary study findings indicate that fine sulfate particles comprised a significant portion of the $PM_{2.5}$ measured at the Preserve, and that air masses arriving at Big Bend National Park from the Big Thicket area contained some of the highest levels of $PM_{2.5}$ and sulfur compounds.

It is likely that additional industrial activity associated with oil and gas production will contribute to $PM_{2.5}$ formation through emissions of SO_2, NO_x, and VOCs that are transformed in the atmosphere to fine particulate matter. Mean $PM_{2.5}$ 24-hour average levels (16.5 micrograms per cubic meter) measured in the Preserve during 1996 indicate ambient concentrations that exceed the recently promulgated annual average NAAQS for the pollutant (15 micrograms per cubic meter). If these levels are sustained, the Preserve would also be classified as a Nonattainment Area for fine particle NAAQS under EPA's proposed new standard.

The Preserve's fire management program and nonfederal oil and gas operations could locally affect air quality in the Preserve and surrounding area. Industrialization (primarily petrochemical and public utility industries) and urbanization contribute more appreciably to air quality in the vicinity of the Preserve.

GEOLOGIC RESOURCES

Overview

The Preserve lies within the Flatwoods and Lower Coastal Plain geographic areas of southeast Texas. The topography is nearly level in the southern part to gently rolling in the northern part of the Preserve. Slopes in the Flatwoods Area (Beaumont and Lance Rosier Units) are generally less than one percent. Slopes in the Lower Coastal Plain Area (Jack Gore Baygall/Neches Bottom, Turkey Creek, Big Sandy Creek and Beech Creek Units) are generally one to three percent, and range from 0.5 to 12 percent (Table 3.5). Elevation generally rises to the north and west from 5 feet (above mean sea level) in the Beaumont Unit to 365 feet at the northern tip of the Big Sandy Creek Unit and 215 feet at the northern edge of the Beech Creek Unit. Although the units of the Preserve vary widely in topography, soils, and size, most are situated along water corridors or in upland settings, or a combination of both.

Table 3.5. Acreage and Proportion of Slope Classes by Preserve Unit

	Total Acres Per Unit	0-3% slopes (acres)	0-3% slopes (%)	3-5% slopes (acres)	3-5% slopes (%)	5-12% slopes (acres)	5-12% slopes (%)	>12% slopes (acres)	>12% slopes (%)
Beaumont	6,289	5,753	91.5	107	1.7	89	1.4	6	0.1
Beech Creek	5,097	3,103	60.9	1,062	20.8	927	18.2	114	2.2
Big Sandy Creek	14,227	5,810	40.8	2511	17.6	5,107	35.9	918	6.5
Hickory Creek	705	565	80.1	134	19.0	4	0.6	0	0
Lance Rosier	24,752	23,759	96.0	848	3.4	349	1.4	0	0
Little Pine Island – Pine Island Bayou Corridor	2,209	1,420	64.3	429	19.4	356	16.1	4	0.2
Loblolly	552	552	100.0	0	0	0	0	0	0
Lower Neches River Corridor	3,291	1,738	52.8	408	12.4	442	13.4	10	0.3
Menard Creek	3,999	1,537	38.4	666	16.7	1,248	31.2	354	8.9
Neches Bottom/ Jack Gore Baygall	13,712	9,413	68.6	1,757	12.8	2024	14.8	120	0.9
Turkey Creek	7,950	5,698	71.7	1,098	13.8	833	10.5	156	2.0
Administration /Visitor Headquarters	28	27	96.0	1	4.0	0	0.0	0	0.0
Upper Neches River Corridor	5,902	2,301	39.5	664	11.3	1,295	21.9	484	8.2
Total	88,132	61,676	70.0	9,685	11.0	12,674	14.4	2,166	2.5

Subsurface Geology

The geology in the area of the Preserve primarily consists of Pleistocene and Holocene-aged sedimentary deposits. These thick nonmarine fluvial, deltaic, and nearshore marine deposits are exposed at the surface in a series of linear “bands” that run parallel to the coast, decreasing in age seaward. Structurally, these sediments dip towards the Gulf of Mexico at approximately 20 – 30 feet per mile. The thicknesses of the individual formations increase towards the Gulf of Mexico (Teas, 1935). The varied depositional environments resulted in a complex interbedding of lithologies; generally the coarser grained deposits have higher permeability than the finer grained deposits (Williamson et al., 1990).

The youngest and most seaward geologic unit of the Gulf Coastal Plain is the Pleistocene age Beaumont Formation, deposited less than 125,000 years ago. The Beaumont Formation was deposited by deltaic and fluvial (river) processes and consists of predominantly fine-grained deposits, with a reported lithology of roughly 60 percent clay and the remainder composed of silts and sands (Boylan, 1986). Due to the high percentage of clay, the Beaumont Formation acts principally as an aquitard, or geologic unit that inhibits the flow of water. However, sand lenses within the clay beds are likely to act as local aquifers (Enprotec, Inc., 1998).

Moving northward, the older Pleistocene age formations, deposited between 125,000 to 2,500,000 years ago, are the Montgomery and Bentley Formations (also mapped as Upper and Lower Lissie Formations, respectively). These units consist of clay, silt, and sand with minor amounts of gravel. The thickness of each of these units ranges from 75 to 125 feet. The southern part of the Preserve is underlain by the Montgomery and Beaumont Formations.

The oldest Pleistocene (possibly Pliocene) deposit in this area is the Willis Formation. Although composed of somewhat coarser sands and gravels, its lithologies are similar to the Montgomery and Bentley Formations. This deposit reaches a maximum thickness of 75 feet (Geologic Atlas of Texas, 1968). The Willis Formation underlies the Big Sandy Creek and Beech Creek Units of the Preserve.

Structural processes such as faulting, uplift, subsurface salt movement, and subsidence have modified the sedimentary layers throughout the Gulf Coast region. The Sabine Arch and the Houston Embayment are surface expressions of uplift and subsidence, respectively. Movement of salt layers in the subsurface has deformed subsurface sedimentary layers throughout the Gulf Coast region. Salt domes are commonly composed of thick halite (sodium chloride) and sylvite (potassium chloride) beds that deform subsurface sedimentary layers; structures formed as a result of salt movement strongly influence the location of oil and gas reservoirs in the Gulf Coast area. Where salt domes occur near the surface, there may be some surface expression. High Island (Galveston County) and Spindletop (Jefferson County) are two areas that exhibit surface features indicative of salt domes. Fourteen salt domes have been documented within the seven-county area of the Preserve.

Table 3.6. Generalized Stratigraphic Formations in the Vicinity of the Big Thicket National Preserve (revised from Renfro *et. al*, 1973)

Era	System	Series	Time (millions of years ago)	Formation	Group	Approx. Depth
Cenozoic	Quaternary Q	Holocene	0	Deweyville (Qd)		
		Pleistocene	3	Beaumont (Qbc/Qbs) Montgomery Lissie (Ql) Bentley Willis		0-300′
	Tertiary	Pliocene		Citronelle Goliad		
		Miocene	11 25	Legarto Fleming Oakville	Fleming	~1,200′
		Oligocene		Anahuac Catahoula Frio	Catahoula	~1,800′
			40	Vicksburg (subsurface only)	Vicksburg	
		Eocene		Whitsett Manning McElroy Wellborn Cadell-Moody's Ranch	Jackson	
				Yegua-Cockfield Cook Mountain Stone City Sparta Weches Queen City Reklaw Carrizo	Claiborne	6,500′ 8,500′ 9,900′
			60	Wilcox: Calvert Bluff-Sabinetown Simsboro-Rockdale-Pendleton	Wilcox	10,000′
		Paleocene	70	Midway: Hooper-Seguin Wills Point Kincaid	Midway	14.000′ 23,000′
Mesozoic	Cretaceous KI	Upper / Gulfian KU		Navarro: Kemp Corsicana Nacatoch	Navarro	
				Taylor: Marlbrook Pecan Gap Annona Wolfe City Ozan	Taylor	
				Austin: Gober Brownstown Tokio/Blossom Bonham	Austin	
				South Bosque Eagle Ford Lake Waco	Eagle Ford	

Soils

Soils developed on the Pleistocene age Willis, Bentley and Montgomery Formations and Pleistocene to Holocene age (late Pleistocene to less than 10,000 years ago) Deweyville Formation and Quaternary Alluvium. Quaternary Alluvium is thickest within the major active drainages: the Neches and Trinity Rivers. The Deweyville Formation, underlying the Alluvium, is also associated with river and stream drainages. Most soils in the Preserve developed on the Bentley and Montgomery Formations. These formations are exposed at the surface in approximately 70 percent of the Preserve (Saul Aronow, pers. comm.).

Soils formed in floodplains range from loamy to clayey, and occur on old oxbows to moderately well-drained natural levees adjacent to stream channels. Upland soils are generally loamy to sandy in texture and are found on a wide variety of landscapes. Immediately above the floodplains are sandy point bar deposits and low, mounded terraces. Deshotels (1978) described 46 soils (mapping units) in the Preserve.

For purposes of describing the hydrologic characteristics of the soil and evaluating the potential impacts of oil and gas operations, soils have been combined into four major classes based on their infiltration/runoff potential or Hydrologic Group (see Table 3.7 for characteristics of the soil classes described in this Plan/EIS). Hydrologic Group refers to a group of soils having similar runoff potential under similar storm and cover conditions. Secondary characteristics of the soils that are described in the following section, but are not directly attributable to the Hydrologic Group, include water storage capacity, water table, and flooding frequency. Hydrologic soil classes are based on the soil Hydrologic Groups as assigned by the Natural Resources Conservation Service (formerly Soil Conservation Service).

The soils within the Preserve are characteristic of those developed under a mild climate, with abundant rainfall, in a mixed conifer-deciduous forest. Two broad categories of soils are found: a highly leached, acidic, sandy to loamy textured soil with a lower less-permeable zone of clay accumulation; and a more clayey textured, less permeable soil that is subject to either high water tables or periods of extensive flooding. The latter soils shrink and swell with changes in seasonal moisture. In general, the sandier soils tend to occur in uplands, and clayey textured soils are found in swales, lowlands, floodplains, and wetlands. The sandier textured soils typically belong to hydrologic soil classes “A” and “B”, and the more clayey textured soils to classes “C” and “D”.

Over 60 percent of the soils in the Beech Creek, Big Sandy Creek, and Hickory Creek Savannah Units belong to classes “A” and “B”, while Turkey Creek and Lance Rosier have between 40-60 percent. The water corridor units typically have less than 30 percent of classes “A” and “B”, and the majority of soils are within class “D”.

Described below, soil characteristics that are important in assessing the potential impacts of oil and gas operations are: soil erodibility, soil compaction, shrink-swell potential, flooding frequency, recharge potential, and water conditions.

Soil Erodibility. Most of the soils in classes “A” and “B” are low to moderately erodible, while soils in classes “C” and “D” are moderately to highly erodible. Erosion also depends on the rainfall energy, slope, slope length, vegetative cover, and site conservation or management practices. Even though most slopes within the Preserve are relatively flat (less than two percent), soil erosion control is necessary whenever vegetative cover is removed or when water is concentrated and flow velocities are high.

Soil Compaction. Typically, soils with a high clay content are most subject to compaction. Soil compaction resulting from foot travel or vehicle use reduces the pore spaces in the soil and impedes the penetration of rainfall and plant roots (Meek et al., 1992). Even though drying and shrinking of the soils and subsequent wetting and expansion will tend to negate some of the adverse impacts over time, clayey soils should not be traversed when saturated. Vehicular travel on clayey soils under saturated conditions will form compacted tracks. These tracks will have the effect in flat topography of changing surface drainage patterns by forming small drainage channels which can locally modify the hydroperiod (frequency and duration of saturation) of a site. Compaction will also tend to severely reduce the permeability of the soil. Soils within class “D” are most prone to compaction.

Shrink-Swell Potential. Clayey soils that are composed of expansive clays will tend to expand and contract with seasonal moisture variations. Due to the water budget of the area, flat topography, and high seasonal water tables, the depth of shrinkage cracks produced in clayey soils will probably not exceed one to two feet. Soils below the seasonal water table will be saturated and thus swollen. The combined effects of shrink-swell and compaction make road construction difficult in areas where there are clayey soils. Typically, soils in class “D” are more prone to shrink and swell.

Flooding Frequency. Soil maps assign flooding frequencies generally based on soils and vegetation. In the Preserve, flooding frequencies typically range from occasional to frequent in classes “C” and “D”, and from none to rare in classes “A” and “B”.

Frequent flooding infers that flooding is likely to occur often under usual weather conditions; more than a 50 percent chance of flooding in any year, but less than a 50 percent chance of flooding in all months of any year. Soils are covered by flowing water for long durations, generally ranging from seven to 30 days. Soils will typically occur on level or depressional landscapes with restricted surface drainage or restricted permeability. Usually only water tolerant plants will be present.

Occasional flooding infers that flooding is expected infrequently under usual weather conditions, and there is a five to 50 percent chance of flooding in any year or flooding occurs five to 50 times in 100 years. Soils are covered by flowing water for shorter durations, generally ranging from two to seven days. Such soils are typically relatively permeable and occur on level or depressional landscapes, or are soils with restricted permeability on low sloping or swampy terrain. For flooding frequencies from none to rare, the percent chance of flooding in any year ranges from five percent to near zero, respectively.

Recharge Potential and Water Conditions. Recharge is a complex process that is dependent upon many factors such as rainfall amount and duration, soil texture, soil structure, vegetative cover, and soil moisture. As mentioned at the beginning of this section, a simplified index of infiltration and runoff is the soil Hydrologic Group. The infiltration rate is the rate at which water enters the soil at the surface and is controlled by the surface conditions. The Hydrologic Group also indicates the rate at which water moves in the soil. The rate that water moves through the soil is controlled by the composition, textures and structure of the soil.

Soils in Cass “A” have low runoff potential and high infiltration rates even when thoroughly wetted. Typically these soils consist of deep, well to excessively drained sands, loamy sands or sandy loams. Class “B” soils have moderate infiltration rates when thoroughly wetted and consist of moderately deep, well to excessively drained soils with fine to moderately coarse textures such as silt loams or loams. Class “C” soils have low infiltration rates when thoroughly wetted and consist of soils with a water-retardant layer and moderately fine to fine textures such as sandy clay loams. Class “D” soils have high runoff potential and low infiltration rates when thoroughly wetted. Such soils primarily consist of clay soils with high shrink-swell potential, soils with a permanent high water table, soils with a claypan, or clay layer near the surface, and shallow soils over nearly impervious material. Impermeable structures, pads, or roads placed over the more permeable soils will have larger impacts on the water budget than those placed over the less permeable soils.

In relation to recharge, flooding, and water table conditions, Classes “A” and “B” generally have high recharge potential, lower flooding frequencies, and a highly variable water table. Classes “C” and “D” all have a high water table, with over 50 percent of the soils having frequent to occasional flooding frequencies.

The water budget, its components, and their interaction must be known or inferred in order to properly assess the impacts of surface uses. Surface uses and the characteristics of the soils dictate the rainfall runoff relationships of the system. Rainfall of a certain magnitude and duration, soil permeability, and water holding capacity with depth all determine how much water the soil will hold before runoff occurs. The slope and roughness of the land surface and soil will control the general speed of both overland flow and shallow subsurface or lateral flow. Surface uses, soils, and slope will also determine the erodibility of the soil and potential for sediment input into streams. The balance of all of the above will ultimately determine the flow in streams and recharge into aquifers.

Table 3.7. Characteristics of the Soil Classes Described in this Plan/EIS

Hydrologic Soil Class[1]	“A” Soils	“B” Soils	“C” Soils	“D” Soils
Composition	Thick, well to excessively drained, moderately coarse textured (sands, loamy sands, and sandy loams)	Moderately thick, well to excessively drained, moderately fine to moderately coarse textured (silt loams and loams)	High clay content, water retardant layer, moderately fine to fine textured (sandy clay loams)	Fine textured, thin clayey soils with claypan or clay layer near surface
Location	Generally found in upland areas	Generally found in upland areas	Generally found in wetlands and floodplains	Generally found in wetlands and floodplains
Permeability	High	Moderate	Low	Very low
Erodibility	Low to moderate	Low to moderate	Moderate to high	Moderate to high
Compaction	Low	Low	Moderate	High
Shrink / Swell Potential	Low	Low	Moderate	High
Flooding Frequency	None to very rare	rare	Occasional to frequent	Frequent
Run-off Potential	Low	Low	Moderate	High
Infiltration Rate	High	Moderate	Low	Low
Recharge Potential	High	High	Low	Low

[1] Hydrologic soil classes are based on the soil Hydrologic Groups as assigned by the Natural Resources Conservation Service. Other parameters, e.g., flooding frequency and recharge potential, are not directly attributable to soil Hydrologic Group.

Distinctive Landforms

Sand Mounds. Located primarily within the Lance Rosier and Jack Gore Baygall Units, sand mounds (referred to elsewhere as “mima” or “prairie” mounds) are landforms found throughout the gulf coast of Texas and Louisiana. Sand mounds are typically located on low-relief slopes of silts and sands comprising relict meander ridges and barrier islands (Aten and Bollich, 1981). These mounds are largely found on the Montgomery and Bentley formations, and to a lesser extent on the beaumont formation. Based on the 1997 provisional soil survey conducted by the natural resources conservation service, sand mounds occur on approximately 4,000 acres, predominately in the lance rosier unit.

Individual mounds range in height from 6 inches (15 cm) to 60 inches (150 cm), are circular to elliptical in shape, and vary in diameter from 6 feet (2 m) to 180 feet (55 m). Several hypotheses for the formation of these mounds include erosional remnants left after sheetflood erosion or wind deflation, wind-blown sand accumulations around vegetation, and mounds formed by the burrowing of rodents (Louisiana Geological Survey 2001).

The origin of sand mounds has been debated since the mid-19th century, but most experts agree that sand mounds were principally formed in the late Pleistocene and early Holocene epochs; each mound takes 300 to 500 years to form; mounds within the same area did not form simultaneously; and mound terrain has archeological potential. See the section on Cultural Resources in this chapter for a description of temple mounds.

During project planning, if sand mounds are found to contain cultural artifacts or human remains, operations would have to be sited to avoid or mitigate impacts on the cultural resources.

WATER RESOURCES

Water is one of the pervasive resources in the Preserve. Most of the Preserve units either contain or are adjacent to high-order, perennial streams. In fact, four of the existing 12 management units are river/stream corridor units. In addition to these major river/stream reaches, the Preserve contains a wide variety of minor hydrologic features: floodplains, sloughs, oxbows, baygalls, acid bogs, and low-order tributary streams. The origin and occurrence of practically all of these features is strongly affected by the surface and subsurface geology. Furthermore, the occurrence and movement of groundwater within the Big Thicket area is heavily influenced by both the structure and the lithology of the local bedrock. Wetlands, which provide a physical link between the ground and surface water systems, are covered in the following Wetlands section. Soils are covered in the preceding Geologic Resources section, but some information on soils is essential due to the influence different soil types have on the shallow groundwater system. Accordingly, where a mention of soil types is necessary, it has been made.

The surface and subsurface geology are closely interrelated and greatly influence the water resources of the Preserve. The sedimentary formations exposed at the surface also tend to be separated by low cuestas, or scarps, which strongly affect drainage. One of these features (scarps) is visible as an abrupt rise or “break” in topography along U.S. Highways 69 and 287, about 4 miles southeast of Kountze. This “break” represents the change from the Bentley Formation to the Montgomery Formation in this area. Similarly, the contact zone between the Montgomery and Beaumont Formations bisects the Beaumont Unit. Water seepage from the higher sands of the Montgomery Formation discharge over the Beaumont Formation, providing an additional source of water to the system (Blanton & Associates, Inc., 1998).

Climate

The Preserve is located on the western edge of the humid subtropical climatic region. This region is characterized by long, warm to hot humid summers and fairly short, mild winters. Onshore winds from the Gulf of Mexico provide maritime influence during the spring, summer, and fall. Arctic, Rocky Mountain, and Pacific storms occur frequently in the winter months and result in depressed temperatures; however, warming periods usually occur between fronts. Sub-zero temperatures are rare with typically less than a dozen freezing nights per year.

Precipitation is reasonably well distributed throughout the year, ranging from 50 to 55 inches and increasing from west to east. Thunderstorms occur about 60 days each year, and while sustained rainfall and flooding often take place in the winter and spring, the most intense events are associated with tropical storms and hurricanes in the summer and fall (NPS, 1996).

In an area of relatively poor drainage, rains from a tropical storm have the potential to create "catastrophes." In October of 1994, the remnants of Tropical Storm Rosa caused flood waters to rise to a record of 12.5 feet above flood stage on Pine Island Bayou. This flood caused 26 counties to be declared Federal Disaster Areas and, regionally, took 20 lives, forced the evacuation of 14,000 people from their homes, caused over 700 million dollars in damages, closed Interstate 10 between Beaumont and Houston, closed the Port of Houston, and contaminated several areas by dispersing pollutants, fresh water, and mud (Lamar University, 1996).

Major Drainages

All units of the Preserve are located within the watershed or basin of the Neches River, except for the Menard Creek Corridor Unit which is in the Trinity River basin. Both of these drainage basins trend from northwest to southeast and have gentle slopes with channels that meander from their headwaters to the Gulf of Mexico. The Neches and Angelina Rivers constitute the two major rivers within the Neches River basin. The mainstem Neches River headwaters are located in northeast Texas, in Van Zandt, Smith and Henderson Counties. The Angelina River originates in Smith and Rusk Counties.

The Neches River basin is roughly 200 miles long by 50 miles wide, and drains an area of approximately 10,000 square miles. The Angelina River drains the northern one-third of the basin, while the Neches drains the remaining two-thirds before reaching the Gulf of Mexico through Sabine Lake. Major tributaries to the Neches within the Preserve are Big Sandy Creek/Village Creek, Turkey Creek, Pine Island and Little Pine Island Bayous, Hickory Creek, and Beech Creek. The drainages generally follow dendritic patterns which are indicative of horizontal or near horizontal bedrock and gentle sloping topography.

Within the Menard Creek Corridor Unit, Menard Creek is a tributary to the Trinity River. Its headwaters are north of the Dallas-Fort Worth metroplex, in the northwest part of the basin. The Trinity River basin drains approximately 18,000 square miles, encompassing parts of 34 counties before entering the Gulf of Mexico through Trinity Bay and Galveston Bay (TNRCC, 1996).

Minor Hydrologic Features

In addition to these major drainages, the surface water network in all units of the Preserve is composed of numerous unnamed creeks, sloughs, acid bogs, and baygalls that greatly affect both the hydrology and hydrochemistry of the surface and near-surface groundwater environments. The occurrence and function of these hydrologic features are strongly influenced by the local surface and subsurface geology.

Baygalls (named for sweet bay and gallberry holly) occur in depressions formed by abandoned channels on terraces. In the Preserve, baygalls frequently occur in relatively lower depressional areas, where water stands for much of the year (e.g., Lance Rosier Unit). Additionally, baygalls may form at the contact of two geologic formations with differing hydraulic properties. Baygalls accumulate a large amount of organic debris which results in water that is high in organic acids, low in dissolved oxygen and exhibit low pH values.

Similar to baygalls, sloughs channel and capture water. Sloughs however, are located within the active floodplain – and therefore subject to a greater degree of hydrologic exchange with mainstem drainages. In addition to the periodic input of floodwaters, sloughs may receive sediments during floods. Water quality in sloughs can vary from that observed in the mainstem watercourse to that of baygalls depending on the elapsed time between flood events.

Acid bogs generally form at locations where terrace-level tributary streams enter a main drainage. The loss in gradient from terrace to active floodplain results in sediment deposition, long-term aggradation, and shifting channels. Acid bogs are subject to the same water quality controls as baygalls and consequently exhibit low pH waters with organic acid turbidity and low dissolved oxygen. Additionally, acid bogs may be subject to flooding due to their location in floodplains. Acid bogs are similar to baygalls in plant species composition.

Flow: Quantity, Timing, Floodplains, Diversions

The majority of the streams within the Preserve are perennial, free-flowing and non-channelized watercourses. Intense storms result in large magnitude runoff events; however, flood peaks are attenuated by broad flat valleys that produce slow-moving, long-duration floods.

Both the U. S. Geological Survey (USGS) and the U. S. National Weather Service (USNWS) operate a number of stream gages within the Neches River and Trinity River basins. Within the Preserve, USGS operates two gages on the Neches River, one on Pine Island Bayou, and one on Menard Creek. Similarly, USNWS operates two gages on the Neches and one on Pine Island Bayou. Analysis of the 71 year flow record from the USGS gage on the Neches River at Evadale, the gage most central to the Preserve, indicates that peak flows generally occur between February and June, and that 90 percent of these peaks are below 22500 cubic feet per second (NPS, 1995). This summary was derived from flow records that both pre- and post-date dam construction (described below) upstream of this gage.

Within the Neches River basin, two major impoundments are located within 30 river miles upstream of the Preserve. The larger of the two, Sam Rayburn Reservoir, is located on the Angelina River about 25 miles above the confluence of the Neches and Angelina Rivers. It includes parts of five counties and occupies 114,500 surface acres (at normal level). Sam Rayburn provides flood control, sediment control, habitat for fish and wildlife, recreation, and hydropower for generating electricity.

B. A. Steinhagen Reservoir is located upstream of the Upper Neches River Corridor Unit. Situated immediately downstream from the confluence of the Neches and Angelina Rivers, it normally occupies 16,800 surface acres. At Steinhagen, Town Bluff Dam (Dam "B") functions as a regulatory structure for the Sam Rayburn Reservoir, i.e., it serves to control the release of water from Rayburn – since Rayburn is a flood control reservoir and has no real storage capacity (Ed Shirley, pers. comm.). When operated in conjunction with the dam at Rayburn, Steinhagen's surface acreage normally ranges between 11,000 and 14,000 acres. Both dams are operated by the Fort Worth

District of the Army Corps of Engineers. Additional impoundments located above these reservoirs are Athens, Palestine, and Jacksonville reservoirs in the Neches River basin, and Tyler, Striker, Nacogdoches, Kurth, and Pinkston reservoirs in the Angelina basin.

The construction and subsequent operation of Sam Rayburn and B.A. Steinhagen reservoirs have altered the flow characteristics of the Neches River by reducing the frequency and duration of both high and low flows (Gooch, 1996; Hall, 1996). Changes in the duration and frequency of floods have also resulted in changes in species composition and distribution of floodplain forest communities (Hall, 1996).

In addition to the control of these reservoirs, water diversion may also alter the natural flow and behavior of a river or stream. A number of water diversions exist within the Neches River basin. However, an analysis of basin diversions concluded that the amount of water currently diverted annually is relatively small compared to annual flux.

Water Quality

Monitoring Programs/Studies. A relatively large amount of water quality data exists for the major drainages in the Preserve. These data are essentially of two types: (a) studies that were either very limited geographically and/or temporally, or (b) more comprehensive monitoring programs where the period of data collection spanned months or years, and included numerous stations. Separate monitoring programs have been undertaken by both the USGS and NPS.

The USGS has six established water quality stations within the area of the Preserve. Three stations are located on the Neches River and singly on Menard Creek, Village Creek, and Pine Island Bayou. Operation of these stations spans different time intervals with the earliest data beginning about 1967. Presently, only the Evadale station along the Neches River is in operation.

The NPS has established 15 water quality monitoring stations within six Preserve watersheds or subwatersheds: Beech Creek, Mill Creek, Big Sandy Creek/Village Creek, Black Creek, Menard Creek, and Pine Island Bayou. Additionally, there are 5 water quality stations established on the mainstream of the Neches River. Between 1984 and 1994, nearly monthly measurements were made at 14 of the 20 stations resulting in 1,781 records of field parameters and 678 records of lab parameters (Hall and Bruce, 1996).

General Water Quality/Hydrochemical Regime. General conclusions drawn from these studies are that the quality of water resources of the Preserve was fair to excellent, although in some areas water quality has degraded with respect to particular parameters (Harrel, 1985; Flora, 1984; Flora, 1985; Hughes, 1987; Hall and Bruce, 1996). Compared to other rivers in Texas, the Neches River generally has lower values for ion concentrations (especially bicarbonate and calcium), hardness, specific conductance, pH, and total dissolved solids (TDS).

It is apparent that some impacts are related to human activities such as residential development, agricultural activities, logging operations, and oil and gas development. In contrast, previous studies have suggested that reductions in salinity at locations in the Preserve may be the result of improved oil field brine management and reduced disposal within the watershed (Kaiser et al., 1994); or perhaps the reduction in oil and gas activities over the same period may have also contributed to lowering salinity (particularly chloride) concentrations. Parameters of concern have included fecal coliform, low dissolved oxygen (DO) levels, high concentrations of metals, increased salinity, and in at least one case, a dioxin advisory. In addition to these concerns, a number of state water quality standards violations have been recorded within the Preserve. The watercourses where these concerns and violations were observed are described in the Individual Watersheds section below.

Regulatory Framework. Discharges into Texas waterways are regulated through two types of permits: those issued through the Texas Commission on Environmental Quality (TCEQ) as authorized under Sections 5.103 and 26.032 of the Texas Water Code; and those issued through the Environmental Protection Agency (EPA) as authorized by the National Pollutant Discharge Elimination System (NPDES) provisions under Section 402 of the Clean Water Act. Although EPA continues to monitor the NPDES program, EPA delegated this program to the TCEQ during fiscal year 1999. TCEQ now issues and monitors these permits under the Texas Pollutant Discharge Elimination System (TPDES) program, under EPA oversight.

In addition to these discharge permits, the Railroad Commission of Texas (RRC) is the lead agency for spills and discharges from all activities associated with the development of oil and gas resources under Section 401 of the Clean Water Act and Sections 85.042, 91.101, and 91.601 of the Texas Natural Resources Code. Permits issued for oil and gas operations generally prohibit the discharge of any material that would in any way alter the quality of surface or subsurface waters, or contribute to a violation of a water quality standard. However, within the RRC's Statewide Rules, there are provisions for disposal of certain wastes.

The State Soil and Water Conservation Board (SSWCB) oversees a voluntary program for reduction of agricultural and silvicultural (forestry) nonpoint source pollution through the identification of problem areas by the state board or local soil and water conservation districts. Under this program, the SSWCB reviews and certifies water quality management plans – typically prepared by the Board, local soil and water conservation districts, or private entities. Approximately ten percent of these plans are checked for voluntary compliance each year (Larry Gibbs, pers. comm.). Within the area of the Preserve, there are seven soil and water conservation districts.

NPS Stream Categories. The major water resources of the Preserve have been divided into three classes by the NPS based on a combination of ambient water quality and monitoring status. Category 1 waters are those streams whose water quality presently ranges from very good to excellent. Streams in the Preserve included in Category 1 are: Big Sandy Creek, Beech Creek, Turkey Creek, and Black Creek (within the Jack Gore Baygall Unit). Category 2 waters are those already exhibiting water quality degradation for one or more parameters, often due to non-point source pollution and/or legally permitted point-source discharges. Streams in the Preserve included in Category 2 are Little Pine Island Bayou and Menard Creek. Category 3 waters are those major stream segments within the Preserve which are included in the Texas Surface Water Quality Standards (1980) and are routinely monitored by the USGS. Category 3 stream segments that flow through the Preserve are the Neches River, from Town Bluff Dam to the tidal zone (Beaumont Unit area), and Pine Island Bayou (Flora, 1984).

State Designated Stream Segments and Uses. In accordance with EPA guidelines, the TCEQ has classified major stream segments within the State according to designated uses. In order to support or achieve the designated uses of these stream segments, the TCEQ has promulgated specific numerical standards for each use and each segment (Kaiser et al., 1993). The Preserve contains three State-designated stream segments; all other streams are classified as off-segment and are subject to the same controls as the mainstem segment. Designated uses for stream segments of the Preserve are primarily for contact recreation (e.g., swimming, boating), medium-to-high-quality aquatic habitat for protection of aquatic life and riparian vegetation, and for public water supply. In addition to designated uses, each stream segment has a water quality designation indicating the applicable regulatory framework. This may be either "effluent limited" which indicates that the segment is meeting its designated uses, or "water quality limited" which indicates failure to meet designated uses.

Anti-Degradation Policy. The State-established Anti-degradation Policy is designed to protect water quality at existing levels and prevent a deterioration of water quality below achievable uses for a given stream segment. The policy has three levels of protection: 1) existing uses will be maintained and protected, 2) for in-stream segments whose quality exceeds designated uses, degradation may only be allowed for important social and economic development, and 3) no degradation will be allowed for outstanding natural resource waters (ONRW). Presently, no waters in the State are designated as ONRW.

Groundwater

The Preserve is located in the Gulf Coastal Plain, an area characterized by marine and non-marine fluvial and deltaic sedimentary deposits that are highly variable in lithology and hydraulic properties. These geologic deposits, generally consisting of alternating layers of clays, silts, sands and gravels, are hydrologically connected and compose the aquifers in the vicinity of the Preserve. Water from precipitation migrates downward until it reaches a zone of saturation. Groundwater is defined as subsurface water occupying interstices (spaces or voids in rock or soil) in a zone of saturation, and groundwater systems that are economically viable are called aquifers.

The geologic units (further described in the Geology section) composing the aquifers range in age from Miocene to Holocene. Because of the difficulty in differentiating the formations of the subsurface (i.e., aquifers generally consist of parts of more than one geologic formation), the sediment deposits are commonly grouped together and referred to as the Gulf Coast aquifer or Gulf Coast Aquifer System. The Gulf Coast aquifer forms a wide belt along the Gulf of Mexico, extending from Florida to Mexico, and is a major aquifer in the State of Texas.

The Gulf Coast aquifer has been subdivided into three separate aquifers. The following paragraphs focus on the uppermost aquifers because water in the lower Jasper aquifer is generally not used in the area of the Preserve. The two main types of aquifers, water table and artesian, are also discussed.

The Evangeline aquifer, which underlies the Chicot aquifer, is within the upper sands of the Fleming Formation and the lower sands of the Willis Formation. It contains fresh to moderately saline water, and supplies a moderate amount of fresh water for municipal uses in Hardin and Liberty Counties, and for parts of Newton, Jasper and Tyler Counties. Its thickness varies from county to county, but generally increases toward the Gulf.

Overlying the Evangeline aquifer, the Chicot aquifer is a series of sand and clay beds within the Willis, Bentley, Montgomery, and Deweyville Formations, and Quaternary Alluvium. Separated by clay beds approximately 200 feet thick, the Chicot aquifer has been subdivided into upper and lower levels. The total thickness of the Chicot is roughly 425 feet, and both the thinner upper and thicker lower Chicot yield fresh to slightly saline water. The Chicot is the main source of groundwater in Orange County, although small to large quantities of fresh water are recovered in southern Liberty County. Most of the water used is drawn from the lower Chicot.

Aquifers at surface pressures are referred to as water table aquifers or unconfined aquifers, and usually occur at or near the source of recharge (Lamar University, 1996). Both the Evangeline and Chicot are water table aquifers near their recharge areas, but become artesian aquifers as the water migrates downdip toward the coast. Water table conditions exist in recharge areas where surface deposits are permeable enough to allow infiltration of precipitation. Here, water levels in the aquifer fluctuate in response to the volume in storage and oftentimes are very close to the ground surface. Recharge to both aquifers occurs primarily from precipitation, and may also occur through streams, lakes, and lateral flow. More locally, recharge may occur as vertical flow between aquifers – where sands of one aquifer are in contact with sands of another aquifer (Blanton & Associates, Inc., 1998). Conversely, discharge occurs in topographically low areas such as springs, seeps, and streams, and in Hardin County, it represents a major loss of groundwater (Baker, 1964).

In both the Evangeline and lower Chicot aquifers, water occurs under artesian conditions (Williamson et al., 1990; Blanton & Associates, 1998). This does not mean that water will flow to the surface, but rather that groundwater is under sufficient pressure to rise above the top of the aquifer when provided with a conduit. The presence of artesian conditions indicates that the hydraulic gradient in the area increases with depth. Consequently, the preferred direction of flow is from deeper zones to the surface. As mentioned above, these aquifers become artesian aquifers as water migrates downdip toward the coast.

This natural gradient can, and has been reversed in areas of extreme groundwater withdrawals. Overpumping water wells causes cones of depression to form, lowering the effective water level and may cause saltwater contamination. Cones of depression have been observed in the lower Chicot aquifer in the vicinity of Houston, Baton Rouge, and to a lesser extent, Beaumont (Williamson et al., 1990). Similarly, between 1941 and 1963, the industrial use of water in Orange County from the lower Chicot lowered the level of the water table approximately 45 feet (Thorkildsen, 1990). However, during a 10 year period beginning in 1977, decreased water use by industries in Orange County showed a water level increase of approximately 5 to 10 feet (Thorkildsen, 1990). However, in spite of this reverse in gradient, there is no reference to impacts on the water table which is supported by the upper Chicot aquifer. This is likely because of the thick clay layer that separates the upper and lower Chicot aquifers, and the large recharge from precipitation on the surficial aquifer.

Wells. The Gulf Coast aquifer has been utilized extensively for groundwater development. The first wells were drilled to relatively shallow depths, while subsequent wells have been drilled to hundreds of feet and provide water for today's municipal, industrial, and agricultural uses. Approximately half of the water used by the City of Beaumont is drawn from the Neches River, while the remainder is supplied by three wells at Loeb (Hardin County). The cities of Silsbee, Kountze, and Sour Lake also use groundwater from wells in Hardin County.

Domestic water wells in the area support a much smaller number of users. Presumably, most of these wells draw water from the Evangeline or Chicot aquifers. The zones of influence associated with shallow domestic wells are minor compared to municipal and industrial uses.

As mentioned above, water table levels can be depleted when water is withdrawn at a rate that exceeds the recharge rate. Continued overuse by pumping, past the capacity of the system to transmit water, may lower the water table to a point where water can no longer be removed economically. In the past, extensive municipal production from the lower Chicot and the Evangeline aquifers has resulted in extreme drawdowns, gradient reversals, and even land subsidence in some local areas.

Groundwater Quality. Due to the composition and varying depths of the water-bearing formations, a wide range of water quality regimes may be encountered. Total dissolved solids values may vary from near fresh to saline and hypersaline at depth. In general, the freshest water is close to the surface and is likely encountered in the Quaternary Alluvium, near the water table present in the Bentley Formation, or in the sand lenses present in the Beaumont Formation. Water in the aquifers is generally of good quality, and only receives chlorination before use.

Groundwater can be severely impacted by both natural and human causes. Natural contaminants in southeast Texas include salt from salt domes, sulfur and associated mineral deposits, naturally radioactive materials, and the chemicals associated with petroleum deposits (Lamar University, 1996). Human impacts on groundwater include: improper handling, storage, or transport of toxic, hazardous, or other contaminating substances; leaching from septic systems, sewage; agricultural runoff from fertilizer use; and contamination of water supplies by pathogenic (disease-causing) microorganisms.

In summary, the quality and quantity of groundwater in the Gulf Coast aquifer represent an important resource in southeast Texas that can continue to be used for an extended period of time.

Individual Watersheds

This section subdivides the Neches River basin into three primary drainages or individual watersheds within the Preserve: the Neches River, Big Sandy Creek/Village Creek, and Pine Island Bayou. Menard Creek, which occupies its own corridor unit, is part of the Trinity River basin and described last.

The Neches River. The Neches River is the primary drainage, capturing the majority of water from precipitation and overland flow, for most units of the Preserve. The Neches is a large, low gradient river with regulated flow. It also shares certain similarities with blackwater rivers, a subset of coastal plain rivers of the southeastern U. S. Four units of the Preserve are located between the 88-mile segment from Town Bluff Dam (Dam "B") to its confluence with Pine Island Bayou in the Beaumont Unit. Additionally, all three primary drainages join within or near the Beaumont Unit.

Neches River

The tidal portion of the watershed extends from the confluence with Sabine Lake upstream into the southeast portion of the Beaumont Unit. Flows in the Neches River downstream of this area are also influenced by tides, water quality of the ocean, and discharges from the upper watershed. The tidal segment is highly developed, industrialized, and is dredged to maintain a navigation channel. There is a permanent saltwater barrier on the Neches River just south of the Preserve.

Groundwater: The uppermost aquifer underlying the Neches River corridor is the Chicot aquifer. This aquifer includes all of the Quaternary formations including the Quaternary Alluvium. The total thickness of the Chicot aquifer is roughly 425 feet, however it is likely that only the upper Chicot aquifer influences groundwater in this area. Surface deposits, areas likely in the upper reaches of the river where the exposed bedrock is the Bentley Formation, are permeable enough to allow infiltration of precipitation into the upper Chicot aquifer. Additionally, alluvial aquifers associated with the drainages probably serve as freshwater aquifers (Ryder, 1988). The Beaumont Formation, which is exposed in the southern portions of the watershed, generally serves as an aquitard; however, sand lenses that exist within the clay beds may serve as local freshwater aquifers.

Hydrochemical Regime: Previous evaluations of baseline chemistry for the Neches River have concluded that total dissolved solid (TDS) concentrations were relatively low (less than

132 mg/L in 50 percent of samples), dissolved oxygen (DO) was generally close to saturation with a median of over 8 mg/L, and nutrient concentrations were relatively low (total nitrogen and total phosphorus were less than 1.8 mg/L and less than 0.2 mg/L, respectively). There were small declining trends in alkalinity and calcium, and a small increasing trend in sulfate concentration (Wells & Bourdon, 1985). Additionally, data compiled by the NPS (1995) for the Preserve indicate that specific conductance and chlorides appear to have decreased, and pH may have experienced a slight increase since the study began in the early 1960's.

Seasonally, specific conductance, suspended sediment, and to some extent chloride concentrations alternately increased and decreased over the seasons, with high values in the fall and spring. Dissolved oxygen concentrations were highest in the winter; alkalinity appeared to peak in the fall; and sulfate and manganese concentrations seemed to reach the highest levels in the spring (NPS, 1995).

Stream Segments, Uses, And Permits: Texas Surface Water Quality Standards define Segment 602 from a point 7.0 miles upstream of Interstate Highway 10 in Jefferson/Orange Counties to Town Bluff Dam in Jasper/Tyler Counties. The segment is 88 miles long and situated in a broad, low-lying, low gradient valley fed by small streams and sloughs. Village Creek and Pine Island Bayou are major tributaries to this segment. Segment 601 extends from the confluence with Sabine Lake in Jefferson/Orange Counties upstream to the confluence with Pine Island Bayou. Major tributaries to Segment 601 include Ten Mile Creek, Tiger Creek, and Anderson Gully. Water quality of the tidal segment has historically been poor, but improved treatment processes at major domestic and industrial wastewater treatment facilities in the early 1980's have improved water quality in this segment.

Designated uses for Segment 602 are contact recreation, high quality aquatic habitat, and public water supply. Designated uses for Segment 601 are contact recreation and intermediate aquatic habitat.

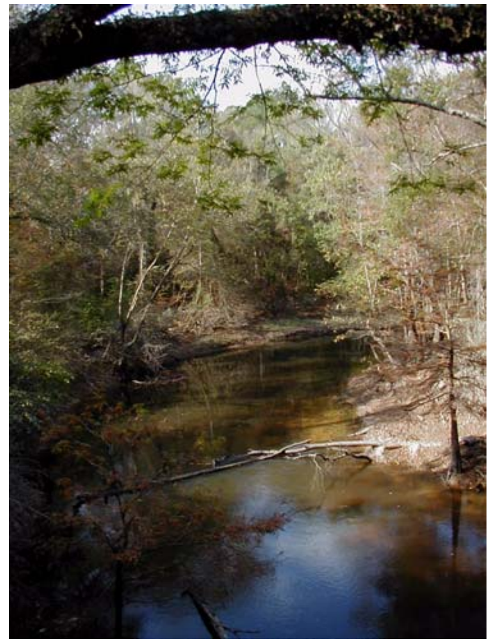
There are three permitted discharges along segment 602: two domestic outfalls, and one industrial outfall. Along segment 601, accidental spills of oil and other contaminants from riverside industries or ships have occurred and continue to threaten water quality on an acute as well as chronic basis (TNRCC, 1996).

Violations/Exceedances/Problems: EPA water quality criteria levels for zinc, cadmium, copper, and lead have been exceeded in some locations along Segment 602. Specifically, mean cadmium concentrations exceeded the chronic criterion in the river near Silsbee, causing nonsupport of the aquatic life designated use in that area of the river. Lead (both total and dissolved) also exceeded EPA water quality criteria for drinking water in 12% and 56% of the samples, respectively. Additionally, sediments have been shown to be high in arsenic, manganese, mercury, nickel, selenium, and methylene chloride (TRNCC, 1996). In the Neches River, downstream of the Preserve (segment 601), EPA water quality criteria for turbidity, pH, dissolved oxygen, chlorides, and sulfates have been exceeded. Fecal coliform counts occasionally exceeded the water quality criterion level of 400/100 ml in this segment.

Big Sandy/Village Creek Watershed. Big Sandy/Village Creek is a naturally flowing creek with base flow supported by the alluvial aquifer and peak flows occurring in response to rainfall events. No water diversions exist within the watershed or on the mainstem of the creek, and therefore, flows are more representative of natural conditions. The upper reaches of the creek is named Big Sandy Creek, but renamed Village Creek upon passing the Hardin/Polk County line.

Preserve units within the watershed are: Turkey Creek, Hickory Creek, Big Sandy Creek, and Beech Creek. The Turkey Creek Unit encompasses 7,784 acres in southern Tyler and northern Hardin Counties. This unit is located on the Bentley Formation just south of the Hockley Scarp, within the recharge zone of the Lissie Sands, a portion of the Chicot aquifer. Three major streams are partially contained within the Turkey Creek Unit: Turkey Creek, Hickory Creek, and Big Sandy/Village Creek. Turkey Creek flows in a southerly direction for about 18 miles before confluencing with Village Creek in the southern portion of the Unit (Flora et al., 1985).

The Big Sandy Creek Unit, the most upstream in the watershed, encompasses 14,346 acres within Polk County. The Big Sandy Creek flows through this unit. The headwaters of both of these streams originate outside of the Preserve. Big Sandy Creek originates in northern Polk County and flows in a southeasterly direction for about 4 miles before entering the Unit. Within the Unit, Big Sandy Creek meanders for about 21.5 miles. The average gradient of Big Sandy/Village Creek through the Unit is 1.1 feet/mile. Reported bed material varies from silt to course sand (Flora et al., 1985). In addition to the main drainages within the Unit, numerous sloughs, baygalls, springs, tributaries and acid bogs exist.



Village Creek

The Beech Creek Unit in Tyler County encompasses 5,206 acres, in the upper Preserve area. The major stream in this unit is Beech Creek which headwaters in eastern Tyler County and flows 32.5 miles before reaching Village Creek. The Beech Creek Unit contains about 6.4 miles of Beech Creek and about 2.5 miles of Little Beech Creek which is tributary to Beech Creek. The gradient of Beech Creek and Little Beech Creek are 10.8 feet/mile and 8.6 feet/mile, respectively (Flora et al., 1985).

Groundwater: In general, the watershed contains two broad categories of soils: upland soils and floodplain soils (see Geologic Resources section). Upland soils are not usually flooded, due largely to higher elevations relative to watercourses. Water table elevations are generally greater than six feet below the surface (Deshotels, 1978). Soils associated with the floodplains are more subject to flooding. Water table elevations are close to the surface, especially in winter months when it occurs within about two feet of the surface (Deshotels, 1978). The bedrock formation underlying the Big Sandy Creek Unit is the Bentley Formation. Many of the Bentley outcrops, especially those containing the Lissie Sands, likely serve as recharge zones for the lower Chicot aquifer. As with all Preserve units that contain a more developed drainage system, there exists a prism of Quaternary Alluvium deposited in river valleys cut through the bedrock. These alluvial deposits generally serve as local freshwater aquifers.

Hydrochemical Regime: In 1981, surface water quality in the Big Sandy/Village Creek watershed was reported as very good. Combined, oxygen and temperature regimes would support a diverse and healthy warm-water aquatic life population. Dissolved oxygen concentrations were consistently above State standards, indicating no substantial organic pollution. Total dissolved solids, specific conductance and chloride concentrations – all indicators of contamination from oil operations – were within a range typical of southeastern Texas streams (Flora et al., 1985). Fecal coliform bacteria concentrations ranged from slight to moderate with only a few violations of State water quality standards for contact recreation, with all of these occurring in the upper portion of the watershed.

The fish and macroinvertebrate populations indicated that Big Sandy/Village Creek was a healthy and unstressed environment, and as of 1981, there was no evidence that human activities were adversely affecting water quality. The nutrients ammonium, orthophosphate, and nitrate were all below levels of concern.

Preliminary screening of TCEQ and USGS data as of 1996 suggested both pH and dissolved oxygen as potential problem parameters within the watershed, and a 1994 basinwide assessment added fecal coliform as a potential problem (Lower Neches Valley Authority, 1994; Hall and Bruce, 1996). Data from 1978 identify nearly 3,800 residents in the Village Creek Watershed as utilizing individual septic systems. Areas of concentrated use are north of Lumberton, north of Silsbee, Honey Island, Village Mills, Hillister, and Doucette. The cities of Silsbee, Kountze and Woodville utilize wastewater treatment facilities (Hall and Bruce, 1996).

Stream Segments, Uses, And Permits: Texas Surface Water Quality Standards define Segment 608 from the confluence with the Neches River upstream approximately 53 miles to Lake Kimball Dam in Hardin County. This segment classification is “effluent limited”, indicating good water quality.

Designated uses for Segment 608 are contact recreation, high quality aquatic habitat, and public water supply. As of 1993, this segment contained 17 permitted NPDES wastewater discharges: 10 municipal outfalls at 2.02 million gallons per day (MGD) and seven industrial outfalls at 0.60 MGD. No information was found regarding the number of water supply intakes present along the drainage. No official swimming beaches exist within the unit and there was no information regarding unofficial swimming (TRNCC, 1996).

Violations/Exceedances/Problems: Exceedances for EPA water quality criteria include total phosphorus (20 percent of the samples), and a sediment sample exceeded acute criteria for aluminum. Overall, indications are that regional water quality has declined somewhat, with the exception of improvements in turbidity and chlorides.

Pine Island Bayou Watershed. Pine Island Bayou watershed drains about 657 square miles before confluencing with the Neches River just upstream of the city of Beaumont. The watershed is largely wooded but also contains substantial industrial and residential development. Three units of the Preserve are contained within the Pine Island Bayou watershed: the Loblolly Unit, Lance Rosier Unit, Little Pine Island-Pine Island Bayou Corridor Unit, and additionally, part of the Beaumont Unit. The watershed slopes in a southeasterly direction and varies in elevation from about 2 feet (above mean sea level) at the confluence to about 160 feet at the watershed divide (ACOE, 1985).

A large number of structures within the watershed are floodprone due to the presence of substantial residential development on the fringes of some of the bayous and creeks. The threshold of flood damages for both Pine Island and Little Pine Island Bayous is the 5-year flood which has been estimated at 8000 and 4000 cfs, respectively (ACOE, 1985). Several flood mitigation plans have been proposed although none at this time have been accepted.

Little Pine Island Bayou and Pine Island Bayou comprise the water corridor unit between the Lance Rosier Unit upstream, and the Beaumont Unit downstream. Little Pine Island Bayou is a tributary to Pine Island Bayou, and the two join upstream or west of the Beaumont Unit near Bevil Oaks. Black Creek, another major tributary to the water corridor unit, joins Pine Island Bayou downstream of Bevil Oaks.

The Lance Rosier Unit, located upstream (west) of the Little Pine Island-Pine Island Bayou Corridor Unit, includes the upper end of the Little Pine Island Bayou. It is the largest unit of the Preserve. Changes in geology, elevation, vegetation, and other transitions across the Lance Rosier Unit influence the type and quality of water resources. As in the water corridor unit, seepage springs form cypress brakes, acid bogs, and baygalls, where the water is typically low in dissolved oxygen concentrations and pH, and decay of organic material creates clear, dark water.

Groundwater: Geologic formations exposed within the Pine Island Bayou Watershed are the Montgomery and Beaumont Formations. In general terms, both of these formations likely serve as aquitards impeding the flow of subsurface water. However, sand lenses likely exist in both of these formations and serve as local freshwater aquifers. Additionally, Quaternary Alluvium deposited along the river corridor probably provides freshwater baseflow to the perennial streams and likely serves as an aquifer.

Hydrochemical Regime: Generally speaking, streams flowing through the Pine Island Bayou watershed are similar to other surface waters in Southeastern Texas in that seasonal flows are variable and total dissolved solids (TDS) concentrations are relatively low (Flora et al., 1984). In addition to natural factors, land use practices in the watershed have influenced area water quality, generally contributing to its degradation.

Hughes and others (1986) summarized water quality monitoring results from 1975 to 1983, and showed that water quality in Little Pine Island-Pine Island Bayou Corridor Unit was moderately degraded with respect to specific conductance and chloride concentrations. An additional observation regarding water quality is that turbidity in Little Pine Island Bayou varied with discharge, from a low during low flows, to a high during high flows (Harrel et al., 1978). Turbidity was lowest at the station near Sour Lake, attributed to contamination with oil field brine (saltwater) which precipitates suspended particles. Dissolved oxygen concentrations were frequently low in Little Pine Island Bayou (minimum of 0.3 mg/L); and were lowest in the summer and highest in the winter.

Stream Segments, Uses, And Permits: Segment 607 is described in Texas Surface Water Quality Standards from the confluence with the Neches River in Hardin/Jefferson Counties to FM 787 in Hardin County. This segment is “water quality” limited due to violations of existing water quality standards (TNRCC, 1996). Designated uses for segment 607 are contact recreation, high quality aquatic habitat, and public water supply. Since Little Pine Island Bayou is an unclassified tributary to Pine Island, it is an off-segment stretch of Pine Island Bayou with the same designated uses. The classification for segment 607 is “water quality limited” due to previous water quality standards violations.

There are three National Pollutant Discharge Elimination System (NPDES) permitted discharges in the water corridor unit for sewage treatment plant effluent from Pinewood Estates, Bevil Oaks and Lumberton. In 1992, eight NPDES municipal wastewater discharge permits were recorded for Pine Island Bayou for a total flow of 3.17 MGD. There are also 11 domestic outfalls into the bayou for a total of 4.94 MGD

Violations/Exceedances/Problems: The Texas Water Commission (1985) identified dissolved oxygen, pH, and fecal coliform as potential problem areas for water quality. Depressed dissolved oxygen concentrations and elevated fecal coliform counts, which occur primarily during summer conditions when streamflows are low and the water is warmer, have resulted in non-support designated uses. Specifically, the middle 26 miles of the segment 607, located downstream of Sour Lake wastewater discharge, has not supported high quality aquatic habitat or contact recreation due to depressed dissolved oxygen and fecal coliform (Adsit and Hagen, 1978). Sediment samples collected during an intensive survey by the Texas Water Commission (TWC) at two sites, one in Pine Island Bayou, and the other in Little Pine Island Bayou, were analyzed for pesticides and metals at both sites, and also for PCBs at Little Pine Island Bayou. Survey results indicated elevated levels of arsenic, manganese, and mercury, but no state or federal standards were exceeded.

Water quality of Little Pine Island Bayou was considered the worst in the region throughout its length (Hall and Bruce, 1996). Little Pine Island Bayou water quality has long been impacted by saltwater (brine) in the Saratoga and Sour Lake area. An influx of brine into Little Pine Island Bayou, either from existing or abandoned oil field operations, increased specific conductance, chloride concentrations, pH, and TDS, and decreased turbidity and color (Kaiser et al., 1993). In July 1985, a pipeline rupture released brine which resulted in exceedingly high specific conductance readings (16,241 mmhos/cm) and a maximum chloride concentration that reached at least 1,400 mg/L in Little Pine Island Bayou. Effects of the spill were studied for 26 months, but persisted beyond that time. Eventually, the brine settled to the bottom of the channel, reducing the specific conductance at the surface to about 2,000 mmhos/cm (Hughes et al., 1987).

In 1978, a study determined that Pine Island Bayou complied with the fecal coliform standard of 200 organisms/100 mL less than 50% of the time during the sampling period during high and low flow conditions (Commander, 1978). Fecal coliform ranged between 0 to 5,880/100 ml, with spikes observed after heavy rains (Harrel and Darville, 1978).

Menard Creek Watershed. Menard Creek originates in central Polk County and flows approximately 48 miles before entering the Trinity River. Menard Creek is an off-stream component of Segment 802 of the Trinity River Basin. Designated uses for this segment are contact recreation, high aquatic life, and public water supply. Two unofficial swimming beaches exist along Menard Creek: Holly Grove and Whoop-N-Holler. These sites have been traditionally used for baptisms in addition to swimming.

Hydrochemical Regime: Menard Creek is among a number of creeks in the Preserve that exhibit low alkalinity and turbidity (Lower Neches Valley Authority, 1992). Additionally, TDS tended to increase on Menard Creek in the downstream direction. Periods of elevated chloride concentrations at Menard Creek have been attributed to contamination by waste brines from the Schwab oil field (Hughes et al., 1987).

Seasonal discharge and stream temperatures were similar to those of Little Pine Island Bayou. Dissolved oxygen concentrations tend to be greater than 5 mg/L, but occasionally drop below 4 mg/L which may be a natural occurrence in streams as influenced by high seasonal water temperatures, concurrent low flows, combined with natural organic loading (e.g., decaying vegetation) (LNVA, 1992). Bacterial counts were not excessive (i.e., mean of 200 fecal coliform/100 mL), but were somewhat elevated.

Data are not available for Menard Creek from water quality assessment reports published by the Trinity River Authority.

FLOODPLAINS

Area topography, soils, and climate all combine to produce a unique flood regime in southeast Texas. The most notable of these factors being its proximity to the Gulf of Mexico moisture source, as well as the effects of tropical storms and easterly waves (Patton and Baker, 1977). Intense storms result in large magnitude runoff events; however, flood peaks are attenuated by broad flat valleys that produce slow-moving, long-duration floods.

In the southern part of the Preserve, the land surface is nearly level and slopes are generally less than one percent. In addition, the high clay and silt content of soils in the area is a major factor contributing to the accumulation of surface runoff. The problems of poor drainage on flatlands cannot be separated from flooding problems.

Floodplains comprise roughly 50 percent of the Preserve, and most of the Preserve's wetlands are located in floodplains. Similarly, the water corridor units and riparian corridors are located in floodplains and consist primarily of floodplain forests. A generalized list of floodplain resources, functions, values and uses includes: food chain production; fish and wildlife habitat; research, educational, and recreational opportunities; hydrologic and sediment modification; groundwater recharge or discharge; water quality; and maintenance of biodiversity.

Floodplains may also benefit agricultural lands, manufacturing, and transportation activities. The scenic qualities of floodplains may be desirable for residential developments. However, when considering floods and floodplain locations there are three important points which should be addressed: (1) flooding in the United States is the most destructive of natural hazards, bringing more loss of life and property damage than any other hazard; (2) approaches for controlling and mitigating losses due to floods have not fully succeeded; and (3) these losses continue to increase (Lamar University, 1996).

Flood Insurance Rate Maps (FIRM), produced by the Federal Emergency Management Agency (FEMA), show several areas of flood hazards. One of these areas is the Special Flood Hazard Area – also referred to as the 100-year floodplain. Areas of 500-year flood are also identified. Figure 3.2 shows the 100-year and 500-year floodplains in the seven-county area of the Preserve. Please note that these maps do not necessarily identify all areas subject to flooding, particularly from local drainage sources, or all surface features outside Special Flood Hazard Areas.

In interpreting the Director's Order 77-2, the construction and operation of flowlines and gathering lines, and roads used exclusively to access oil and gas operations, fall into the Class I Actions category, and the associated regulatory floodplain is the 100-year floodplain. Alternately, actions that would create an added disastrous dimension to the flood event (called critical actions) are Class II Actions, and the associated regulatory floodplain is the 500-year floodplain. Examples of critical actions include well drilling, construction and operation of treatment and storage facilities, and storage of toxic, hazardous and/or water-reactive materials. Most oil and gas operations are classified as critical actions (Class II).

Before an operator is permitted to undertake an action, it will be determined if the proposed action is to occur within a regulatory floodplain. This determination will be made based on the best available hydraulic information, with the FIRM considered the minimal level of information. In the absence of FIRM, the operator will complete an appropriate hydrologic and hydraulic analysis to determine the location of the 100-year and 500-year floodplains within their operations area.

Riparian Corridors

Most riparian corridors in the Preserve lie within the 100-year floodplain. These areas are also referred to as riparian wetlands, bottomland hardwood forests, and floodplain forests. The riparian areas are ecologically important because they:

- Reduce floods by slowing water flow through riparian vegetation including trees.

- Improve water quality when floodwater overflows the banks of the stream or river. Riparian vegetation slows the floodwater so that it can no longer carry its load of sediment that then settles out. The vegetation grows quickly through the sediment, stabilizing it with roots and covering it with plants that utilize the nutrients that could otherwise harm downstream water quality.

- Provide a vital groundwater recharge area when riparian soils absorb excess water during spring snowmelt and other flood events.

- Provide shade that keeps water temperatures cool for fish and vegetative cover for animals looking for food, shelter, and reduced temperatures along the riverbanks.

- Provide key resources that support biological diversity both in the riparian area and nearby uplands.

The Preserve's water corridor units and riparian corridors are composed primarily of floodplain forests. According to Harcombe et al. (1996), floodplains include the broad, flat terraces between the bluffs of the Neches River and along some of the major streams. Floodplain Hardwood Forest occurs on low terraces along the Neches River and in strips along Little Pine Island Bayou, Village Creek and its tributaries, and Menard Creek. Smaller stream floodplains support Floodplain Hardwood Pine Forest.

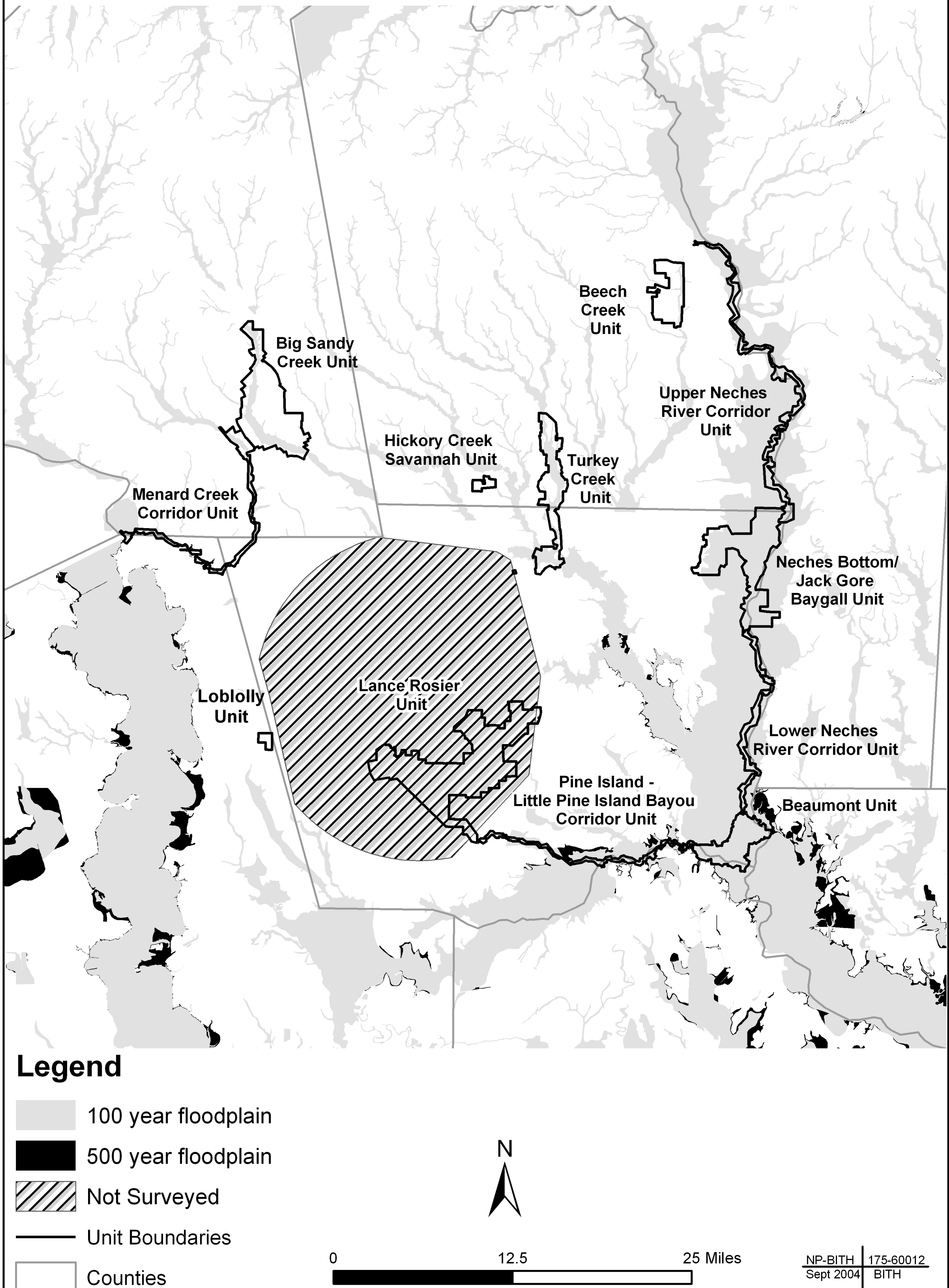
Riparian corridors in the Preserve consist of two distinct biological communities: the bottomland hardwood forest community located on the floodplain terrace adjacent to major streams; and the aquatic community present within the stream. Two vegetation types, Floodplain Hardwood Forests and Floodplain Hardwood Pine Forests, best represent bottomland hardwood forests located on floodplain terraces adjacent to major streams. In addition, complexes (or extensive intermingling) of these vegetation types define the riparian corridor.

In addition, riparian areas exist throughout the Preserve wherever creeks, rivers, or sloughs are found. These areas are best defined as "interfaces between terrestrial and aquatic ecosystems. As ecosystems they encompass sharp gradients of environmental factors, ecological processes and plant communities. Riparian areas or zones are not easily delineated but are composed of mosaics of landforms, communities, and environments within the larger landscape." (Gregory et al., 1991)

Riparian corridors are important in maintaining the ecological integrity of the Preserve. These areas are formally designated as a Special Management Area under Alternatives B and C, and specific protection is provided. The two vegetation classes – floodplain hardwood forests and floodplain hardwood pine forests – can be seen on the vegetation map (Figure 3.3), and the Riparian Corridors Special Management Area are shown on maps provided in Chapter 2, Part I. Where the riparian corridor is not defined by these vegetation types, or complexes of these types, the corridor width is defined as up to 300 feet from the banks of major streams, whichever area is greater.

Figure 3.2. Floodplains Map

Figure 3.2. Floodplains Map



VEGETATION

Vegetation is a fundamental component of the biological diversity of the Preserve. Roughly 1,300 species of trees, shrubs, forbs, and grasses are believed to grow in the Preserve.

A variety of environmental factors including geography, climate, and soil contribute to the botanical diversity of the Preserve. Big Thicket lies at an ecotone between forests to the east and prairies to the west. Moderated by warm Gulf breezes, the climate of the region is sub-tropical with relatively high levels of rainfall that are evenly distributed throughout the year. Just a short distance west, rainfall begins to drop off quickly, and this sudden transition partly explains why Big Thicket is the farthest western extent of many eastern plant species. Edaphic (soil) conditions ranging from relatively impermeable clays to coarse sands also contribute significantly to the floristic diversity of the Preserve. Taken together, the interplay of geography, climate and soils causes abrupt transitions in vegetation: upland pine savannas and sandhills with yucca and cacti often lie just a stone's throw from bottomland hardwood forests and cypress swamps and sloughs.

Numerous vegetation classification systems, descriptive treatments, and maps have been published on forest communities throughout the southeastern United States, including the Big Thicket. Two of the most common broad-based classifications that encompass the Big Thicket region include *The Deciduous Forests of Eastern North America* (Braun, 1950), and *Forest Atlas of the South* (USFS, 1969). Although these classifications have their own unique variations, each includes the Big Thicket Region as a complex of forests dominated by hardwoods on floodplains and pine forests and mixed oak-pine forests on uplands.

Several vegetation classifications specific to the Big Thicket Region have also been published. These include *The Big Thicket Forest of East Texas* (McLeod, 1971), *Big Thicket Plant Ecology: An Introduction* (Watson, 1975), *Wild Flowers of the Big Thicket, East Texas and Western Louisiana* (Ajilvsgi, 1979), and *Forest Vegetation of the Big Thicket, Southeast Texas* (Marks and Harcombe, 1981). Each of these classifications describes vegetation communities in the Big Thicket area by focusing on either dominant vegetation, plant associations, physiognomy (structure or outward appearance), or a combination of these.

The Preserve has relied most frequently on the vegetation classification of Marks and Harcombe (1981) to identify and describe plant communities and to relate the patterns of distribution of species and communities with major environmental gradients. This classification defines and names vegetation on the basis of physiographic position (upland, slope, floodplain, and flatland) and community physiognomy or structure (forest, savanna, or shrub thicket), normally combined with important trees (pine, oak, hardwood). It also emphasizes potential natural vegetation (PNV) rather than existing or actual vegetation, although potential or actual vegetation may be the same in some types. Potential vegetation refers to the structure that would become established if all successional sequences were completed without interference by humans under present climatic and edaphic conditions (including those created by humans) (The Nature Conservancy and Environmental Systems Research Institute, 1994). This classification is applicable to the Preserve because most of the vegetation has been removed in the past. Table 3.8 shows these vegetation types and the approximate acreages found in the Preserve. Figure 3.3 is a Map of Potential Natural Vegetation of Big Thicket National Preserve.

Table 3.8. Potential Natural Vegetation of Big Thicket National Preserve

Physiographic Position	Vegetation Type			
Upland	Sandhill Pine Forest 132 acres	Upland Pine Forest 1,137 acres	Wetland Pine Savanna 1,813 acres	
Slope	Upper Slope Pine Oak Forest 10,342 acres	Mid Slope Oak Pine Forest 4,927 acres	Lower Slope Hardwood Pine Forest 29,522 acres	
Floodplain	Floodplain Hardwood Pine Forest 2,683 acres	Floodplain Hardwood Forest 23,251 acres	Wetland Baygall Shrub Thicket 3,399 acres	Swamp Cypress Tupelo Forest 1,295 acres
Flatland	Flatland Hardwood Forest 8,165 acres			

Upland Vegetation Community

The three upland vegetation types (Upland Pine Forest, Sandhill Pine Forest, and Wetland Pine Savanna) are all strongly influenced by fire and edaphic (soil) conditions. Historically the dominant pine species in the Upland Pine Forest was longleaf pine. In many of these communities, longleaf pine is no longer dominant, however, due to factors such as aggressive fire suppression and logging, and subsequent replanting with faster growing species such as shortleaf pine and loblolly pine. Many Upland Pine stands have converted from longleaf pine to a mixed pine-oak type (Upper Slope Pine Oak) due to the impact of reduced fire frequency.

The Sandhill Pine Forest differs from the Upland Pine Forest in that it is found on very well drained, sandy soils. The term “Sandhill” was borrowed from a similar vegetation type found in the sandhills of the Carolinas. The term is topographically misleading, however, because these communities are actually located on sandy, riverine bluffs and terraces, not hills. In spite of high precipitation, rapid infiltration limits soil moisture, and these areas support a wide variety of plants such as yucca and cacti that are adapted to xeric (dry) conditions and frequent fire. Dominant tree species include post oak (*Quercus stellata*) and bluejack oak (*Quercus incana*). Three types of native pines are also found widely scattered and include longleaf pine (*Pinus palustris*), shortleaf pine (*Pinus echinata*), and loblolly pine (*Pinus taeda*). The past impacts of logging and subsequent fire suppression in these areas may explain why longleaf pine is not the dominant pine species in these communities. The shrub layer, while present, is indistinct in these communities.

Sandhill Pine Forest is the rarest plant community in the Preserve and surrounding Big Thicket region. This community best exemplifies the “Desert Southwest” component of the “Biological Crossroads” paradigm that is often used to describe the ecological setting of Big Thicket. According to Harcombe and Marks (1979), only 132 acres exist in the Preserve; of which 110 acres are found on the Sandhill Loop (trail) in the Turkey Creek Unit, and 22 acres are found in the Big Sandy Creek Unit. Historically, the federally endangered Texas Trailing Phlox was documented in this vegetation community.

Figure 3.3. Map of Potential Natural Vegetation of Big Thicket National Preserve

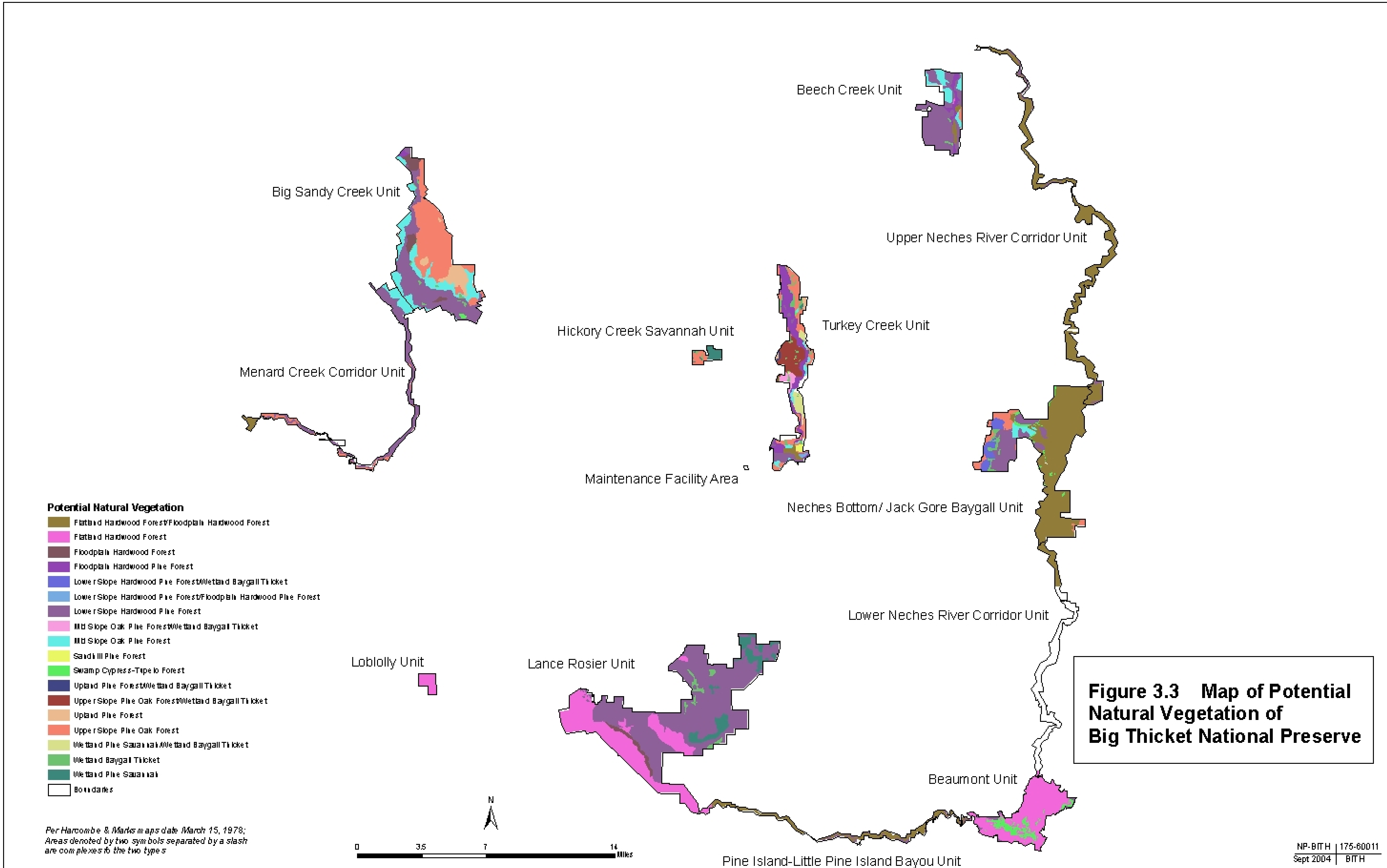


Figure 3.3 Map of Potential Natural Vegetation of Big Thicket National Preserve

Phlox was recently reintroduced to the Sandhills in an attempt to restore this endangered endemic plant. **Given the rarity of this vegetation community and its importance for restoring Texas trailing phlox, Sandhill Pine Forest is designated as a Special Management Area under Alternatives B and C. Sandhill Pine Forest can be seen on the vegetation map (Figure 3.3) and Special Management Areas maps provided in Chapter 2, Part I.**

Texas Trailing Phlox

Sandhill Pine Forest

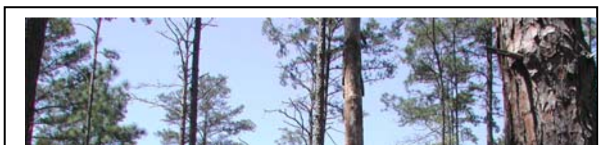
In contrast to well-drained, sandy soils of the Sandhill Pine Forest type, Wetland Pine Savannas are found on poorly drained soils, with seasonal ponding. The interplay of wetland conditions and frequent fires in these systems is believed to inhibit the invasion of trees. Wetland Pine Savannas are among the rarest plant communities in the southeast and in the Preserve. Over the past two centuries, these communities have been significantly degraded due to human settlement and fire suppression; less than 3 percent of these communities remain. Compared with all other plant communities in the Preserve, wetland pine savannas contain the richest botanical diversity; roughly 100 species of forbs per acre can be found.

Fire plays a critical role in preventing fire-intolerant trees and plants. Unfortunately, the effects of 75 years of aggressive fire suppression in the Big Thicket region has made these plant communities among the rarest in the Preserve, due to invasion by shrubs and trees. The Preserve is using prescribed fire and mechanical thinning as a tool to restore and to maintain these botanically rich communities.

Due to their rarity, Wetland Pine Savanna is designated as a Special Management Area under Alternatives B and C. Wetland Pine Savannas can be seen on the vegetation map (Figure 3.3) and Special Management Areas maps provided in Chapter 2, Part 1.

Wetland Pine Savannah

The third type of upland plant community is



Upland Pine Forest. These pyric (fire-dependent) communities are found on dry uplands and interdistributary ridges. Soil type and past disturbances such as logging and fire are important factors in determining the age and abundance of tree species in these forests. A prototypical stand of Upland Pine Forest is dominated by longleaf pine, and to a lesser extent by loblolly pine and shortleaf pine. Several species of oaks are commonly associated with this community including post oak, bluejack oak, and blackjack oak (*Quercus marilandica*). In stands where fire has burned at frequent intervals, the woody understory is largely absent, and the forest is open and park-like with a rich herbaceous layer of grasses and forbs. Absent frequent fire, the woody understory quickly encroaches and is dominated by species such as flowering dogwood (*Cornus florida*), flame-leaf sumac (*Rhus copallina*), American beautyberry (*Callicarpa americana*), wax-myrtle (*Myrica cerifera*), and yaupon (*Ilex vomitoria*). **Upland Pine Forest is designated as a Special Management Area under Alternatives B and C. Upland Pine Forests can be seen on the vegetation map (Figure 3.3) and Special Management Areas maps provided in Chapter 2, Part 1.**

Upland Pine Forest

Slope Vegetation Community

The slope community contains three distinct vegetation types: Upper Slope Pine Oak Forest, Middle Slope Oak-Pine Forest, and Lower Slope Hardwood Pine Forest. The transition from dry to mesic (moist) soil conditions generally results in a shift from upland forest communities to slope communities. This increase in soil moisture is reflected in the shift from longleaf pine to loblolly pine and shortleaf pine. The species composition of oaks also shifts, with Southern red oak dominating on the upper slopes and white oak (*Quercus alba*) in high abundance on the wetter, lower slopes. Other significant hardwood species include Southern magnolia (*Magnolia grandiflora*) and American Beech (*Fagus grandiflora*). Given the abundance of these three species, the slope forests are often referred to alternatively as Beech-Magnolia-Loblolly forests. Of all vegetation types in the Preserve, many visitors to the Preserve consider these open forests to be the most beautiful and stately. Aside from their aesthetic qualities, the American Beech-Southern Magnolia Series (as designated by the Texas Natural Heritage Program) is considered imperiled because of its rarity both statewide and globally. **Due to its rarity, the American Beech-Southern Magnolia-Loblolly Forest is designated a Special Management Area under Alternatives B and C. This community can be seen on the Special Management Areas maps provided in Chapter 2, Part I.**

American Beech-Southern Magnolia-Loblolly Forest

Floodplain Vegetation Community

Floodplain vegetation communities generally occur along river and creek floodplains throughout the Preserve. Four vegetation types are included within the floodplain position: Floodplain Hardwood Pine Forest, Floodplain Hardwood Forest, Wetland Baygall Shrub Thicket, and Swamp Cypress Tupelo Forest. The Floodplain Hardwood Pine Forest type generally grows along smaller floodplains, where the transition from terrestrial to aquatic environments occurs over a relatively short distance. Dominant pine and hardwood species in this vegetation type are loblolly pine and American beech. American hornbeam (*Carpinus caroliniana*) is an abundant understory species.

Moving from lower order to higher order streams, the floodplains increase in size and Floodplain Hardwood Pine Forest is replaced by Floodplain Hardwood Forest community. This vegetation type is often generally referred to as bottomland hardwood forest. Extensive examples of these forests are found along the Neches River floodplain, especially in the Jack Gore Baygall and Neches Bottom Unit. Dominant tree species in this type include sweetgum (*Liquidambar styraciflua*) and water oak (*Quercus nigra*).

Swamp Cypress Tupelo Forest is found in secondary river and creek channels and along the fringe of oxbow lakes and sloughs throughout the floodplain forests of the Preserve. As the name implies, the dominant tree species are baldcypress (*Taxodium distichum*) and tupelo (*Nyssa aquatica*).

Swamp Cypress Tupelo Forest

Over the past 100 years, most of the old growth forest in the region has been removed. Longleaf pine forests were generally logged first, followed by loblolly forests and eventually the bottomland hardwood forests. Accessibility to timber was a major problem in the bottomlands due to periodic flooding and wet conditions. While the Swamp Cypress Tupelo Forest type was logged extensively for cypress, a few of these relic stands (often just a few individuals) escaped harvest. They now represent perhaps the only example of old-growth left in the Preserve. The cypress loop on the Kirby Nature Trail provides an excellent example of some of the remaining old-growth cypress left in the Preserve. These stands are a rare reminder of the extensive primordial forested swamps that once blanketed the Big Thicket region. Very little information on the locations of old-growth cypress stands exists in the Preserve, so mapping all of these areas is not currently possible. However, remaining old-growth stands or individuals are expected to occur in Special Management Areas. **Swamp Cypress Tupelo Forest is designated as a Special Management Area under Alternatives B and C. This vegetation type can be seen on the vegetation map (Figure 3.3) and Special Management Areas maps provided in Chapter 2, Part 1.**

The fourth floodplain community is the Wetland Baygall Shrub Thicket. The term "baygall" is descriptive of the two dominant tree species that are commonly found in these communities: sweetbay magnolia (*Magnolia virginiana*) and gallberry holly (*Ilex glabra*). Baygalls occur most extensively along the broad floodplain of the Neches River in the Jack Gore Baygall. However, they are not restricted solely to floodplains, and can occur out of the floodplain in association with seeps and springs and ponded areas on uplands and on slopes. Patches of baygalls are occasionally found in wetland pine savannas, and some have suggested that their presence is the result of fire suppression. **Due to their rarity, Wetland Baygall Shrub Thicket is designated as a Special Management Area under Alternatives B and C. Wetland Baygall Shrub Thickets can be seen on the vegetation map (Figure 3.3) and Special Management Areas maps provided in Chapter 2, Part 1.**

The Flatland Hardwood Forest type occurs in the Preserve on flat, low elevation areas where drainage patterns are poorly developed and precipitation remains ponded for long periods of time. Of all the vegetation communities in the Preserve, this particular community appears to be endemic to the Big Thicket. Dominant deciduous tree species include swamp chestnut oak (*Quercus prinus*), willow oak (*Quercus phellos*) and laurel oak (*Quercus laurifolia*). An interesting geomorphic feature known as sand mounds are abundant in this community, and the drier microsites on these mounds frequently support loblolly pine. Jungle-like thickets of dwarf palmetto often dominate the understory in flatland forests. Along with baygalls, these dense palmetto thickets perhaps best exemplify the original and seemingly impenetrable "Big Thicket."

Ecological Research and Monitoring Areas

Certain areas of the Preserve serve as ecological research and monitoring areas. Ecological research and monitoring are important for a number of reasons, including:

- To increase the Preserve's understanding of the importance and effects of disturbances such as fire suppression, wind throw and insect infestations,
- To determine the nature and extent of global climate change,
- To understand the effects of invasive exotic species of plants such as Chinese tallowtree, and
- To learn more about the trends in forest ecology such as recruitment and succession.

Under NPS administration, ecological research and monitoring activities have taken place in the Preserve since the mid-1970's. To support these activities, permanent research and monitoring plots are established throughout the Preserve in a variety of vegetation communities and habitats. The knowledge and insight gained from monitoring these areas over time are critical to better understanding, interpreting, and managing the biodiversity and ecology of Big Thicket. These areas provide long-term research opportunities to study and determine how resources are responding to ecosystem processes and management actions. **Ecological Research and Monitoring Plots are designated as a Special Management Area under Alternatives B and C. These plots can be seen on the Special Management Areas maps provided in Chapter 2, Part 1.** There are over 240 ecological research and monitoring plots located within the Preserve. Many have not been mapped using global position system (GPS) coordinates, but are annotated on maps maintained at the Preserve. Only the 59 plots that have been mapped using GPS coordinates are represented on maps and tables in the Plan/EIS.

Fire Monitoring Plots. The Preserve consists of approximately 13,000 acres of land containing vegetation communities that are highly adapted to periodic fire. Aggressive fire suppression in the region for the past 75 years has impacted these fire-adapted communities by favoring the invasion of fire-intolerant plants and trees. To mitigate the impacts of fire suppression, the Preserve is using prescribed fire to restore fire as a dynamic natural process. A number of fire-effects monitoring plots are located in various fire management units to monitor and gauge the effects of prescribed fire.

Long-term Monitoring Plots. Aside from monitoring for the effects of fire, many other monitoring plots are located throughout the Preserve. These plots are used for studying how Big Thicket vegetation responds to a variety of ecological processes such as forest succession, non-native species invasion and response to disturbances such as tornadoes and global climate change.

The Royal Fern Bog Research Plot. Located in the east corner of the Beaumont Unit, the Royal Fern Bog is a fascinating area both botanically and geomorphically. According to Watson (1982), the Royal Fern Bog area is unique in all of Big Thicket National Preserve. It is a true acid bog, but of much more extensive proportions than the small ones found in other units. Common arrowhead (*Sagittaria latifolia*) and royal fern (*Osmunda regalis*) found rarely and sparsely in other areas, grow here in dominant profusion. As the bog nears the vicinity of the river, it grades from acid bog into slough rather than into baygall as is the case on higher terraces. In recognition of the bog's unique character, the NPS designated the bog as a Research Natural Area (NPS, 1980). Under this management zone, management emphasis is placed on non-manipulative research within undisturbed ecological communities. Access to the bog is limited to NPS personnel and researchers only.

WETLANDS

> "Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification, wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year." (Classification of Wetlands and Deepwater Habitats of the United States (Cowardin et al., 1979)).

Wetlands are significant in that they produce a large amount of primary production and provide important habitat for the wildlife of the Preserve. All types of wetlands act as a nutrient source, sink, or transformer, and their role may change for different nutrients or for the same nutrient during different seasons (National Research Council, 1995). In general, wetlands function as nutrient cycles and various wetland types maintain different cycle rates. Floodplain wetlands tend to be high-nutrient and bogs are usually low-nutrient. The availability of nutrients in the system, in turn, affects the productivity and biodiversity of the wetland (National Research Council, 1995). Some functions of wetlands are interdependent with the surrounding landscape. For example, wetlands dampen the effects of storms by reducing flood crests and flow rates, thereby reducing flooding in surrounding areas. A variety of amphibians, reptiles, birds, and mammals require wetlands during substantial parts of their lives, and depend on wetlands spaced throughout the landscape. Other creatures have adapted to wetlands that maintain standing water for only a few weeks to a month during the year, and remain dry the rest of the year (National Research Council, 1995). Wetlands also provide essential habitat for 60 percent of all threatened and 40 percent of all endangered species (Feierabend, 1992). Overall, each type of wetland may provide similar functions but for different organisms.

At least 40 percent of the Preserve is comprised of wetlands that can be classified in three systems: palustrine, riverine, and lacustrine wetlands. Table 3.9 lists the acreage of Cowardin classification wetlands by wetland type. Wetland types are combined in Figure 3.4.

Table 3.9. Cowardin Classification System Wetlands in the Big Thicket National Preserve[1]

Wetland Type	Area (Acres)
Palustrine System	31,530
Palustrine System *with two classes (complex)*	180
Riverine System	3,125
Lacustrine System	60
Total	34,895

[1] Based on National Wetlands Inventory maps published in 1987 by the U. S. Fish and Wildlife Service.

Overall, the wetlands currently mapped under the National Wetlands Inventory (NWI) program in the Preserve appear to underestimate the total wetlands acreage. Based on fieldwork during January and February 1999, multiple localities determined to be wetlands in the field were not mapped by the NWI. Additionally, topographic maps (USGS 7.5 minute quadrangle; scale: 1:24000) of the Preserve indicate depressions that are not entirely mapped as wetlands by the NWI. Other studies have also shown wetlands in forested regions to be undermapped (Tiner, 1997; National Resource Council, 1995; and Stolt and Baker, 1995). NWI wetland mapping is difficult in large areas with mineral soils, facultative vegetation, and minor topographic relief (National Resource Council, 1995), conditions similar to those found in the Preserve. The wetland boundaries on the NWI maps are also estimates because the area of the Preserve was mapped from a single air photo for each topographic map; whereas photos taken during each of the seasons may produce different wetland boundaries. Although not all of the existing wetlands of the Preserve are mapped, each of the Cowardin wetland types found illustrates the different habitats and wetlands that occur within the various units of the Preserve. Wetlands are part of the mosaic of plant and animal communities and support a diverse assemblage of life in the Preserve.

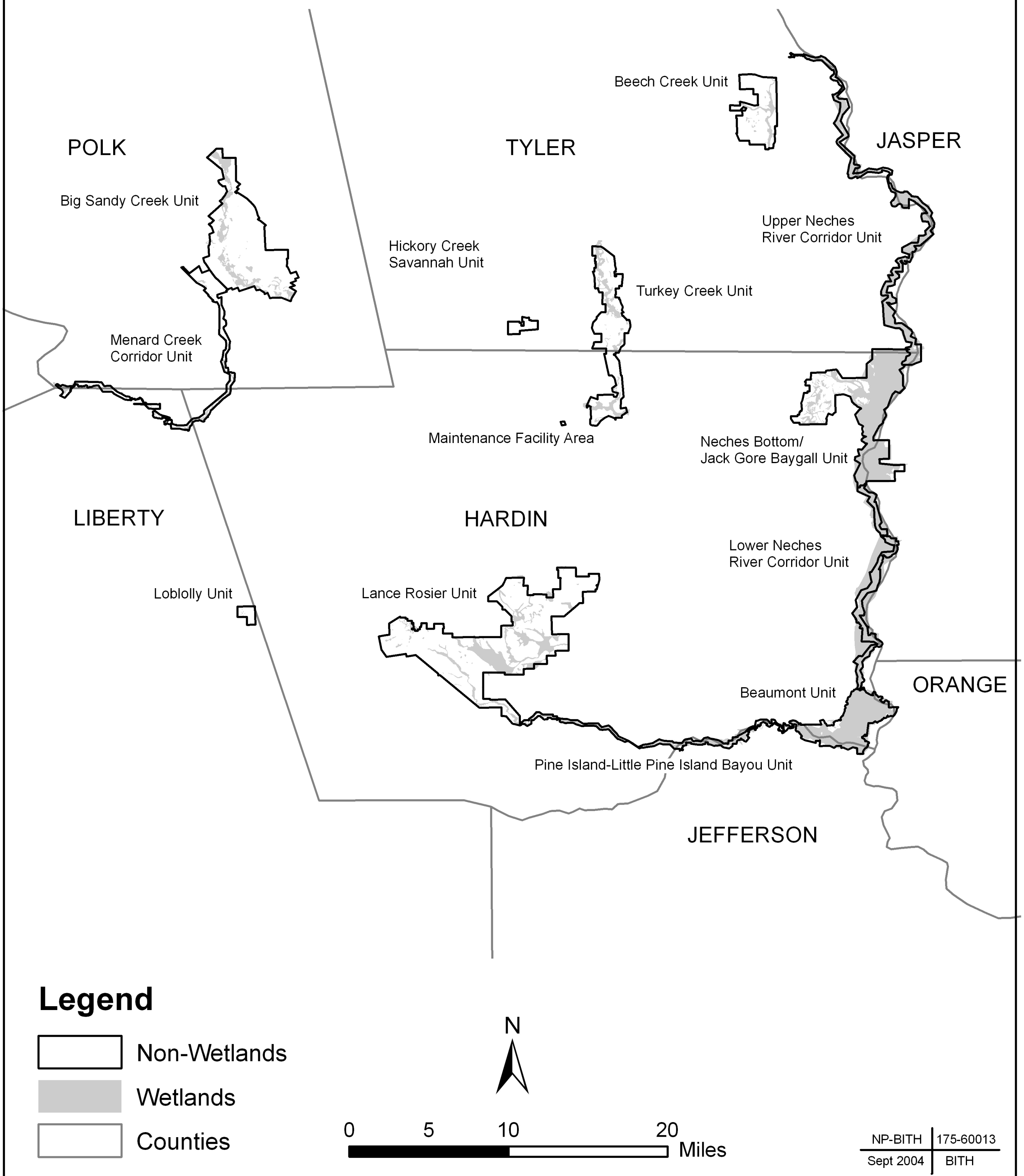
The majority of wetlands in the Preserve fall within the palustrine system (nontidal wetlands dominated by trees, shrubs, or persistent emergents). Non-vegetated wetlands smaller than 20 acres, less than 6 feet deep, lacking a wave-formed or bedrock shoreline, and with low salinity (less than 0.5 ppt from ocean-derived salts), also fall under the palustrine system (Cowardin et al., 1979). The palustrine classes found in the Preserve are forested, scrub-shrub, emergent, unconsolidated bottom (also called open water), or mixtures of classes (i.e., complexes). The open water class was combined with the unconsolidated bottom class in the 1979 publication of the Cowardin classification system (Pipken, pers. comm.), and is now only referred to as "unconsolidated bottom."

The palustrine emergent wetlands of the Preserve contain nonwoody aquatic plants such as rushes (*Juncus* spp.), arrowheads (*Sagittaria* spp.), sedges (*Carex* spp.), grasses, vines, pitcherplants (*Sarracenia alata*), and other plants. Organisms found in emergent wetlands include aquatic invertebrates (e.g., insects, snails, crayfish), aquatic vertebrates (e.g., fish), amphibians (e.g., salamanders, frogs, toads), reptiles (e.g., snakes, turtles, alligators), birds, and mammals (e.g., beaver, muskrat). Emergent wetlands are generally considered to have high productivity rates and act as nutrient pumps as plants take in ions and then release some back to the water and soil when they die (Mitsch and Gosselink, 1993).

The palustrine forested and scrub-shrub wetlands are also referred to as riparian wetlands, bottomland hardwood forests, and floodplain forests. These wetlands tend to be linear in shape as they form in floodplains (Mitsch and Gosselink, 1993). The forested and scrub-shrub wetlands are characterized by a dominance of woody vegetation including baldcypress, tupelo gum (*Nyssa aquatica*), black gum (*Nyssa sylvatica*), oaks (*Quercus* spp.), river birch (*Betula nigra*), sweetgum,

Figure 3.4. Wetlands Map

Figure 3.4. Wetlands Map



sweetbay (*Magnolia virginiana*), sycamore (*Plantanus occidentalis*), American hornbeam, baygall holly (*Ilex coriacea*), red maple (*Acer rubrum*), and red bay (*Persea borbonia*). They also contain some nonwoody vegetation such as various grasses, vines, mosses, and other hydrophytes. They have high biodiversity, and more substances flow through these riparian wetlands than other types (Mitsch and Gosselink, 1993). The hydrology of these wetlands is sustained by a high water table and flooding. Additionally, the functioning of these areas is connected to the physical, chemical, and biological processes of the nearby streams (National Resource Council, 1995).

The palustrine unconsolidated bottom wetlands consist of less than 30 percent vegetative cover (Cowardin et al., 1979). The types of vegetation, if any, at these sites is similar to vegetation found in forested, scrub-shrub, and emergent wetlands. These wetlands are essentially small, shallow ponds that provide water and nutrients to organisms. While some of these sites in the Preserve qualify under the Cowardin definition of wetlands used by the NPS, they do not qualify as U.S. Army Corps of Engineers wetlands under the Corps' wetlands definition, because of the lack of vegetation and/or the water is too deep. The Corps does, however, consider these areas to be "waters of the U.S." and jurisdictional (33 CFR 328.3). The ponded sites that are isolated from streams often offer crucial habitat for migrating waterfowl (National Resource Council, 1995). The unconsolidated bottom wetlands also provide habitat for aquatic invertebrates and vertebrates, reptiles, amphibians, birds, and mammals.

The riverine system consists of wetlands and deepwater habitats within stream channels. The riverine classes found in the Preserve are unconsolidated bottom and unconsolidated shore. The majority of the riverine wetlands lie within the Neches River corridor, including the Jack Gore Baygall and Neches Bottom Unit. Besides the river and some other channels, additional riverine wetlands are pointbars and sites located immediately along the Neches, Little Pine Island Bayou, and Pine Island Bayou. While the Neches River qualifies under the Cowardin definition of wetlands used by the NPS, it does not qualify as U.S. Army Corps of Engineers wetlands under Section 404 of the Clean Water Act – because of the lack of vegetation and/or the water is too deep. However, the Corps does consider it a "water of the U.S." and jurisdictional (33 CFR 328.3).

Wetlands larger than 20 acres, situated in topographic depressions or a dammed river channel, and with vegetation covering less than 30 percent, are classified as lacustrine wetlands (Cowardin et al., 1979). Only two localities in the Preserve are currently categorized as lacustrine, with classes of unconsolidated bottom or unconsolidated shore. These sites provide habitat for various organisms, hunting opportunities, and the possibility for nature trails.

The following rare vegetation communities are found in wetlands areas and are designated as Special Management Areas: Wetland Baygall Shrub Thicket, Wetland Pine Savanna, Swamp Cypress Tupelo Forest, and Royal Fern Bog.

FISH AND WILDLIFE

Introduction

The Big Thicket region has long been recognized for possessing a diverse array of fauna and flora. This area provides habitat for plant and animal species of the southeast swamps, pineywood forest, post-oak belt, Great Plains, southwest deserts, and the coastal prairie.

The abundant and diverse vegetation of the Preserve supports aquatic and terrestrial habitats for a variety of fish and wildlife. Many studies of specific types of wildlife, such as inventories of mammals, have been performed in the Big Thicket region over the past century. Some of the most thorough inventories were conducted shortly after the Preserve's establishment in 1974. The following section summarizes these studies, literature reviews, and wildlife observations to describe fauna believed to inhabit the Preserve. Rare, threatened, and endangered species of plants and animals are discussed under the Species of Special Concern section.

Mammals

Of the 181 mammals listed for Texas, 60 are either documented or believed to inhabit the Preserve. Several large species are now extirpated in Big Thicket due to a variety of factors including habitat destruction and overhunting. These include the jaguar, ocelot, red wolf and the Louisiana subspecies of the American black bear. Although occasional sightings of black bears have been reported near the Preserve, no populations are believed to be reproducing in East Texas.

Birds

Birds are the most visible and diverse group of vertebrate fauna found in the Preserve. Currently 176 species have been documented. This figure is thought to be low, because no comprehensive inventory of birds has ever been performed. The Preserve lies on a major migratory flyway, and many species of birds are transient during spring and fall migrations. Birds found in Big Thicket predominantly consist of three categories: passerines (including many neotropical songbirds), raptors and waterfowl. The abundance and variety of birds in the Big Thicket contribute to one of the favorite visitor activities, bird watching.

Reptiles and Amphibians

Approximately 85 species of reptiles and amphibians are believed to inhabit the Preserve (Harcombe et al., 1996). This figure represents roughly 33 percent of the 235 species of reptiles and amphibians in Texas. The most diverse group of reptiles in Big Thicket is snakes. Texas has 68 species of snakes, and half of these inhabit Big Thicket. Other types of reptiles include skinks, lizards, turtles, and the American alligator. Three types of amphibians including frogs, toads, and salamanders inhabit Big Thicket.

Fish

Of all faunal groups in the Preserve, fish are perhaps the most thoroughly inventoried: 92 species are believed to inhabit Preserve waters. In small tributaries, the most abundant species of fish include minnows, darters, bass, and bullhead catfish. This pattern shifts in larger tributaries, which are dominated by channel, blue and flathead catfish; sunfish; largemouth and spotted bass; and crappie.

Invertebrates

A recent inventory of lepidoptera (butterflies, moths, and skippers) has documented over 1,800 species (Bordelon and Knudson, 1999); this is believed to be the greatest species diversity in the contiguous United States. In aquatic environments, insects and mussels are the most thoroughly documented species. Comprehensive inventories in the Village Creek drainage have documented 249 species of common macroinvertebrates including dragonflies, caddisflies, mayflies and stoneflies. Three species of aquatic insects are endemic to the Big Thicket region (Abbott and

Stewart, 1997), and two are candidates for federal listing (see Table 3.10). Thirty-four species of mussels, including the Texas heelsplitter (*Potamilus amphichaenus*) live in the Lower Neches River watershed (Howells, 1996). This portion of the watershed includes most of the units of the Preserve.

Habitat Fragmentation

The Preserve consists of eight discrete land units connected by four narrow water corridor units. The water corridor units, varying in width from 1,000 to 1,500 feet, were established in part to offset the effects of fragmentation by providing ecological connectivity between otherwise isolated units. However, the degree to which these habitat corridors serve as migration routes or enhance the persistence of fish and wildlife species has not been adequately tested.

With few exceptions, the Preserve's land and corridor units are crossed by roads, trails, pipeline and power line corridors, oil and gas operations, and one railway. Therefore, the geographic configuration of the units, along with the further contributions of human-induced developments, result in fragmentation of wildlife habitat. In general, habitat fragmentation has two major interrelated consequences for biological diversity: (1) population isolation and decrease in effective population size, and (2) creation of edge habitat and its effects (Harcombe and Callaway, 1997).

Population Isolation. Habitat fragmentation can result in demographic isolation of populations and/or subpopulations, resulting in inadequate exchange between populations or subpopulations to maintain demographic and genetic viability. Isolated populations are at greater risk of decline due to effects of random events such as storms, drought and reduced food availability. The effects of habitat fragmentation may explain why most of the original predators of the Big Thicket (jaguars, black bears, red wolves, and ocelots) are now extirpated.

Edge Habitat. Another potential effect associated with habitat fragmentation is the creation of "edge" habitat. Edge habitat is produced whenever there is an abrupt discontinuity between vegetative cover (Harris, 1988). Pipeline rights-of-way are a good example of edge habitats, and the Preserve's water corridor units are a long continuous edge zone. Impacts of edge habitats, often referred to as "edge effects" include the movement of exotic species into interior habitats, and increased predation and mortality (e.g., road kill) as animals cross edges between habitats (Harris and Gallagher, 1989). While the impacts of edge effects are known to be ecologically significant, there is no generally accepted threshold of significance. Rather, it is generally accepted that increased edge habitat, often described quantitatively as the edge-to-interior ratio, has a greater ecological impact as the ratio increases.

SPECIES OF SPECIAL CONCERN

Overview of Species

Under the Endangered Species Act of 1973 (ESA), the NPS has responsibility to address impacts to federally-listed threatened, endangered, candidate and species proposed for listing. Also, NPS policy requires that State-listed species, and others identified as species of management concern by the park, are to be managed in parks in a manner similar to those that are federally-listed. Big Thicket National Preserve does not have any species of management concern identified. Thus, federal and State-listed species will be addressed in this Plan/EIS following federal law and NPS policy.

The terms “threatened” and “endangered” describe the official federal status of certain species in the Preserve as defined by the ESA. The term “candidate” is used officially by the U.S. Fish and Wildlife Service (FWS) when describing those species for which the Service has on file sufficient information on biological vulnerability and threats to support issuance of a “proposed rule to list,” but issuance of the proposed rule is precluded. No candidate species are currently believed to inhabit the Preserve. The term “proposed” describes species for which a “proposed rule to list” has been published in the Federal Register, however, a finalized rule has not yet been issued. Texas has enacted regulations similar to the ESA that confer threatened and endangered status to certain species that inhabit areas in the state. NPS policies dictate that federal candidate species, proposed species and State-listed threatened and endangered species are to be managed to the greatest extent possible as federally-listed threatened and endangered species (NPS, 1991). Therefore, these species are included in this discussion. See Appendix G, “U.S. Fish and Wildlife Service County-by-County Listing of Threatened and Endangered Species and Species of Concern,” and Appendix H, “Texas Parks and Wildlife Department Special Species List” for species that occur in the counties where the Preserve is located.

A listing of species of proposed, candidate, threatened and endangered species specific to Big Thicket is problematic to compile because listed species are rare by default, and current, comprehensive inventories of flora and fauna in the Preserve are incomplete. Moreover, the FWS publishes lists by county, and political boundaries do not coincide with natural boundaries such as habitats or ecoregions. Since the Preserve is located in parts of seven east Texas counties, not all of the species listed for these counties (such as marine species) have suitable habitat. Nonetheless, all federally-listed and State-listed species believed to occur permanently or transiently (such as migrating birds) in the Preserve based on past inventories, existing and potential habitat, documented sightings, and professional judgement are listed in Table 3.10.

Table 3.10. State and Federally Listed Candidate, Threatened and Endangered Species Believed To Occur in Big Thicket National Preserve

Status: E=Endangered, T= Threatened, C=Candidate, PDL=Prpoposed for Delisting, N/L=Not Listed.

Common Name	Latin Name (names in italics)	Type	Federal Status	State Status
American Swallow-tailed Kite	*Elanoides forficatus*	Bird	N/L	T
Bachman's Sparrow	*Aimophila aestivalis*	Bird	N/L	T
Bald eagle	*Haliaeetus leucocephalus*	Bird	T/PDL	T
Interior Least Tern	*Sterna antillarum athalassos*	Bird	E	E
American Peregrine Falcon	*Falco peregrinus anatum*	Bird	N/L	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Bird	N/L	T
Brown Pelican	*Pelicanus occidentalis*	Bird	E	E
Piping Plover	*Charadrius melodus*	Bird	T	T
Red-cockaded Woodpecker	*Picoides borealis*	Bird	E	E
White-faced Ibis	*Plegadis chihi*	Bird	N/L	T
Wood Stork	*Mycteria americana*	Bird	N/L	T
Blue Sucker	*Cycleptus elongatus*	Fish	N/L	T
Creek Chubsucker	*Erimyzon oblongus*	Fish	N/L	T
Paddlefish	*Polyodon spathula*	Fish	N/L	T
Louisiana Black Bear	*Ursus americanus luteolus*	Mammal	T	T
Rafinesque's Big-eared Bat	*Corynorhinus rafinesquii*	Mammal	N/L	T
Navasota Ladies'-Tresses	*Spiranthes parksii*	Plant	E	E
Texas Trailing Phlox	*Phlox nivalis var. texensis*	Plant	E	E
Alligator Snapping Turtle	*Macroclemys temminckii*	Reptile	N/L	T
Loiusiana Pine Snake	*Pituophis melanoleucus ruthveni*	Reptile	C	T
Northern Scarlet Snake	*Cemophora coccinea copei*	Reptile	N/L	T

Status: E=Endangered, T= Threatened, C=Candidate, PDL=Prpoposed for Delisting, N/L=Not Listed.				
Common Name	**Latin Name (names in italics)**	**Type**	**Federal Status**	**State Status**
Canebrake Rattlesnake	*Crotalus horridus atricaudatus*	Reptile	N/L	T

Birds

American Swallow-Tailed Kites (*Elanoides forficatus*): American Swallow-tailed kites (State threatened) are migratory raptors that inhabit bottomland hardwood forests along major river bottoms in the southeastern United States and winter in South America. Kites historically bred throughout the southeastern United States, however, populations have declined throughout the southeast in recent years. According to Rappole and Blacklock (1994), kite populations are now considered rare and local in Louisiana, South Carolina, and Georgia; good populations of kites are now only found in Florida. A recent survey of Swallow-tailed kites in East Texas (Shackelford and Simmons, 1999) documented 277 sightings and only one nest. Most sightings of kites in the Preserve have been reported in spring and summer months along the mid- and upper-portions of the Neches River. Although no kite nests have been found, the routine sightings of this species along the Neches strongly suggest that it may be nesting in mature bottomland forests in or near the Preserve.

Bachman's Sparrow (*Aimophila aestivalis*): Bachman's Sparrow (State threatened) is an uncommon, endemic resident of east Texas. Preferred habitat for Bachman's sparrow includes mature longleaf pine savannas, open pine woods and brushy overgrown fields (Rappole and Blacklock, 1994). The sparrow is a documented nesting resident of the Preserve; however, it is rare and secretive – and therefore, nesting and foraging locations are likely to be underreported. The most common sightings of Bachman's sparrow have been along Gore Store road in, or near, the Turkey Creek Unit.

Bald Eagle (*Haliaeetus leucocephalus*): Although formerly common, Bald eagles (federally threatened; State threatened) are rare residents in East Texas. They prefer large lakes and rivers with tall trees along the shoreline. Bald eagles have been sighted most frequently near McQueen's landing in the Upper Neches River Corridor Unit of the Preserve, and at the confluence of Menard Creek and the Trinity River in the Menard Creek Corridor unit.

Interior Least Tern (*Sterna antillarum*): Least Terns are only afforded protection under the ESA for those populations at least 50 miles inland from the coast. They nest on sparsely vegetated sandbars along major river systems. Migratory individuals may occur in the area of the preserve enroute to and from their wintering grounds in central and South America.

Peregrine Falcon (*Falco peregrinus*): Two subspecies of Peregrine Falcon are found in Texas: the American Peregrine (*Falco peregrinus anatum*) and the Arctic Peregrine (*Falco peregrinus tundrius*). Both species were delisted on August, 25, 1999, but remain State listed as endangered and threatened, respectively. The American Peregrine is a resident of the Trans-Pecos region, including Big Bend National Park, and the Chisos, Davis, and Guadalupe mountain ranges. Arctic Peregrines migrate through Texas twice a year to and from their wintering areas in South America. They stop on the Texas Coast to feed before continuing their migration. In Big Thicket, peregrines (most likely the arctic subspecies) have been documented along the Neches River and in or near the Turkey Creek and Hickory Creek Units during spring and fall migrations.

Brown Pelican (*Pelicanus occidentalis*): The Brown pelican (State and federally listed as endangered) is an uncommon permanent resident of the Texas coast. Preserve staff have observed pelicans near the terminus of the Neches River at Sabine Lake and at High Island southeast of Port Arthur; however, no pelicans have been documented in the Preserve. Pelicans might venture up the Neches River into the Beaumont Unit of the Preserve, but this would be a rare occurrence.

Piping Plover (*Charadius melodius*): Piping Plovers (federally threatened and State threatened) are uncommon winter residents along the Texas coast and are considered rare to casual winter transients in the eastern third of the state. Habitat includes sand and gravel shorelines, river sandbars and islands. No piping plovers have been documented in the Preserve; however, the lower Neches River provides a corridor for movement of plovers inland from their coastal habitat. The large sandbars along the Neches River could also provide nesting habitat.

Red-cockaded Woodpecker (*Picoides borealis*): Red-cockaded Woodpeckers (federally endangered, State endangered) are year-round inhabitants of the Pineywoods of East Texas. Red-cockaded woodpeckers prefer open, park-like stands of mature pine maintained by frequent fire. Little of this habitat remains in the Preserve due to the lasting impacts of logging and fire suppression. In time, however, pine forest regeneration and periodic prescribed fire should create more favorable habitat in uplands throughout the Preserve. Until recently, active colonies were documented in upland pine forests in the Big Sandy Unit. These colonies became inactive in the mid-1990's, but the cavity trees and associated habitat remain and could be recolonized in the future.

White Faced Ibis (*Plegadis chihi*): The white-faced ibis (State threatened) is predominately a coastal species that inhabits a wide variety of freshwater and estuarine environments. The south Texas coast appears to be the northern limit of the ibis's breeding range. This species is considered a rare transient in the eastern third of Texas during spring and fall migration (Rappole and Blacklock, 1994), and could be found in the Preserve. To date, no sightings of white faced ibis in the Preserve have been documented.

Wood Stork (*Mycteria americana*): Wood storks (State threatened) have been seen in a variety of wetland and riverine locations throughout the Preserve, including along the Little Pine Island Bayou in the Lance Rosier Unit, the Beaumont Unit, and the Lower Neches River Corridor Unit. Storks in the Preserve are believed to be post breeding transients from populations in southern Mexico. While these populations are considered stable, storks from separate breeding populations in Florida are listed as federally endangered due to habitat loss and low numbers. Storks may have bred historically in Texas, but no breeding populations are currently believed to exist. Preferred inland habitat includes large lakes and forested wetlands (Rappole and Blacklock, 1994).

Fish

Blue Sucker (*Cycleptus elongatus*) and Creek Chubsucker (*Erimyzon oblongus*): No federally-listed fish species are believed to inhabit the Preserve. However, three State-listed species have been documented during past fish inventories and research projects: the blue sucker (Cycleptus elongatus), creek chubsucker (Erimyzon oblongus), and the paddlefish (Polyodon spathula). The blue sucker and creek chubsucker are both listed as State threatened. Creek chubsuckers have been found in relatively high abundances in the upper portions of Big Sandy Creek in the Big Sandy Unit and in Beech Creek in the Beech Creek Unit. Both of these creeks are clean, low-order (i.e., small, low flow) black water systems. In contrast to the abundance of creek chubsuckers, only one blue sucker has been documented in the Preserve. It was found in the Neches River near Highway 1013 (Suttkus and Clemmerer, 1979; Evans, 1977).

Paddlefish (*Polyodon spathula*): Paddlefish (State threatened) generally inhabit large rivers in the Mississippi river drainage and adjacent Gulf coastal plain. Paddlefish have been documented in the Lower Neches River and at the confluence of the Neches River and Little Pine Island Bayou (Seidensticker, 1994). Unlike most large riverine fish, paddlefish are planktivorous as opposed to piscivorous. Paddlefish require cool temperatures, large flows, and gravel bottoms for spawning (Rosen and Hales, 1981). The lower Neches River does not typically have flows of sufficient magnitude, and gravel substrate is uncommon, so spawning habitat is considered marginal. Nonetheless, the backwaters of the Neches could provide important feeding areas for paddlefish during the summer months. The Texas Parks and Wildlife Department recently developed a recovery plan for paddlefish in the Neches River that included annual stocking of paddlefish below Dam “B” on the Upper Neches River corridor. The Texas Parks and Wildlife Department is not doing stocking of paddlefish in the lower Neches River. The effectiveness of paddlefish recovery has yet to be documented.

Mammals

Only two listed mammals are believed to occur in or near to the Preserve. Since the turn of the century, several species of predatory mammals have been extirpated due to a variety of factors including predator control, overhunting and poaching, habitat loss and population isolation. These species include the jaguar, red wolf and ocelot.

Black Bear (*Ursus americanus ssp. luteolus*): The Louisiana black bear is federally listed as threatened and State listed as threatened. The closest known reproducing populations of Louisiana black bears are in the Atchafalaya basin in Louisiana. Occasional sightings of bears have been reported in East Texas, so occurrences of bears in the Preserve (especially wandering males) are possible. Two separate studies aimed at identifying potential habitat for black bear reintroduction have identified suitable habitat in the Neches Bottom/Jack Gore Baygall Unit of the Preserve (Garner, 1996; Epps, 1997). This area could serve as core habitat for bears in the future, through reintroduction efforts or expansion of existing populations in Louisiana. However, any reintroduction effort would require the active participation and support of a number of public and private land management agencies and the public to ensure the provision of sufficient habitat and to prevent poaching and other bear-human conflicts. Continued fragmentation of habitat in the Big Thicket and surrounding region could preclude the possibility of black bear reintroduction.

Rafinesque's Big-eared Bat (*Corynorhinus rafinesquii*): Rafinesque's big-eared bat (*Corynorhinus rafinesquii*) is State listed as threatened. This bat is easily distinguished from other bats by its immense ears. East Texas is considered the western distributional limit of this species. Preferred habitat for this species includes hollow trees, crevices behind bark, and dry leaves, although it is most frequently found in occupied and abandoned buildings (Davis, 1974). A temporary roost of Rafinesque's big-eared bats was documented in the Little Pine Island Bayou Unit in 1995 (Horner and Maxey, 1998), and occurrences elsewhere in the Preserve are likely (Schmidly et al., 1979).

Plants

Navasota Ladies'-Tresses (*Spiranthes parksii*): Navasota Ladies'-Tresses (Spiranthes parksii) is a federally-endangered and State-endangered species of orchid that is endemic to southeast Texas. Navasota ladies'-tresses grows in moist, sandy soils in small openings on gentle slopes and along intermittent tributaries of the Brazos, Navasota and Neches Rivers. The species has a limited range and low population numbers. Reasons for endangerment include habitat loss and degradation due to development and road construction (Fish and Wildlife Service, 1992). Most populations of Navasota Ladies'-Tresses have been documented in post oak savannah vegetation community types west of Big Thicket; however, a separate population exists in northwestern Jasper County just east of the Upper Neches River Corridor Unit. Although this plant has not been documented in the Preserve, it could occur given the close proximity of the Preserve to the Jasper population and the existence of favorable habitat along upper Neches River.

Texas Trailing Phlox (*Phlox nivalis var. texensis*): Texas trailing phlox (*Phlox nivalis var. texensis*) is a federally-endangered and State endangered plant species that is endemic to southeast Texas. Populations of phlox are only currently found in three counties: Hardin, Polk and Tyler. Texas trailing phlox is a fire-adapted plant species that grows in fire-maintained openings in upland longleaf pine savannas or post oak-bluejack oak woodlands on deep sandy soils. Considered very rare and imperiled less than a decade ago, its numbers have increased at some sites during the last few years. This trend may indicate that prescribed burning of its habitat, which allows more light to reach the ground and possibly influences nutrient availability, is essential to its continued survival and recovery (Texas Parks and Wildlife, 1997; Ajilvsgi, 1979). Phlox currently grows in two locations in the Big Sandy Unit and in two locations in the Turkey Creek Unit. The population in the Turkey Creek Unit was established from cuttings taken from plants in Roy E. Larsen Sandylands sanctuary, owned and managed by the Nature Conservancy of Texas.

Reptiles

Alligator Snapping Turtle (*Macroclemys temminckii*): The alligator snapping turtle (*Macroclemys temminckii*) is listed as State threatened. Considered one of the largest freshwater turtles in the world, it lives in deep, fresh waters with muddy bottoms (such as rivers, lakes, oxbows, and sloughs) and occasionally enters brackish water. The species is rare mainly due to international and domestic demand for its meat, although it has also declined as a result of habitat loss from reservoir construction, channelization of streams and rivers, placement of dredge spoil on riverbanks, recreational use of riverbanks and sandbars, removal of snags and water pollution (FWS, 1994; Ernst and Barbour, 1972). Almost all of the units of the Preserve provide habitat for alligator snapping turtles. Alligator snappers have been documented in Turkey Creek, the Neches River and most recently (May, 1999) in Menard Creek. The Menard Creek specimen weighed 116 pounds and had a 26 inch diameter shell.

Louisiana Pine Snake (*Pituophis melanoleucus ruthveni*): The Louisiana pine snake (*Pituophis melanoleucus ruthveni*) is a federal candidate species and State listed as threatened. The Louisiana pine snake mainly uses small mammal (especially pocket gopher) burrows as shelter (Craig Rudolph, pers. comm.), and feeds chiefly on small mammals. The snake is limited to sandy soils in hardwood-conifer forests of western Louisiana and East Texas. Within this broad ecoregion, upland longleaf pine savanna habitat appears to be preferred (Conant, 1975). To date only one Louisiana pine snake has been found in the Lance Rosier Unit of the Preserve, although favorable habitat exists as well in both the Big Sandy and Turkey Creek Units.

Northern Scarlet Snake (*Cemophora coccinea copei*): The northern scarlet snake is listed as threatened by the State of Texas. The northern scarlet snake is considered by the Texas Parks and Wildlife Department as rare or uncommon in the State. Preferred habitat for this species is sandy soil in both pine and hardwood forests. It will avoid wet areas, but can be found along dry sandy ridges in close proximity to baygalls and floodplains (Tennant, 1984). This species has not been documented in the Preserve to date, but potential habitat exists in most of the units.

Timber Rattlesnake (*Crotalus horridus*): The timber rattlesnake (*Crotalus horridus*) is listed as threatened by the State of Texas. In the past, two subspecies of timber rattlesnake were believed to be in East Texas: the canebrake rattlesnake and the timber rattlesnake (Conant, 1975). However, recent research suggests that the canebrake rattlesnake is simply a color variant and not a separate subspecies (Craig Rudolph, pers. comm.). Timber rattlesnakes have been documented in the Lance Rosier Unit, Turkey Creek Unit and Big Sandy Unit of the Preserve.

CULTURAL RESOURCES

Archeological Resources

Archeological resources consist of "any material remains or physical evidence of past human life or activities which are of archeological interest, including the record of the effects of human activities on the environment. They are capable of revealing scientific or humanistic information through archeological research" (NPS 1997:177). A complete inventory of archeological resources within Big Thicket National Preserve has not been conducted, although several surveys have been conducted in recent years ahead of 3-D seismic surveys in the Beaumont, Jack Gore Baygall and Neches Bottom, and Lance Rosier Units. Approximately 30 archeological sites are known within the 151-square-mile Preserve, but none have been evaluated for eligibility to the National Register of Historic Places. Known archeological resources are divided into two categories, as discussed below.

Prehistoric sites, although not numerous, do occur within the Preserve. Based on what is known about the general East Texas regional archeology, prehistoric sites are subdivided into three temporal periods: Paleoindian sites that date to ca. 8,000-6,000 BC; Archaic sites that date between ca. 6,000 BC and AD 100; and Late Prehistoric sites that date to AD 100-1500. Paleoindian and much of the Archaic period sites are known only from the coastal area south of Beaumont with shell middens being the typical early-to-middle Archaic site type. The latter part of the Archaic (ca. 1500 BC to AD 100) was a period of more widespread utilization of areas beyond the coastal zone, including the Neches River and its tributaries. This change is also characterized by the introduction of ceramics, the bow and arrow, and maize agriculture, along with the retention of plant food gathering and shellfish collecting. These new innovations were introduced by the Hopewell Culture of the Lower Mississippi Valley who greatly influenced the local East Texas populations. By the time of European contact, the local populations would be identified as various tribes of the Caddo and Atakapa. Within the Preserve, archeological sites of the prehistoric period are typically buried, with stone flakes and, occasionally, ceramic shards exposed. Such sites often occur on slightly elevated ridges near the watercourses.

In the Pipkin Marsh area of southwest Jefferson County, test excavations at three archeological sites near Big Hill Salt Dome uncovered evidence of human habitation stratified within naturally-formed sand mounds. Datable artifact assemblages indicate the mounds were created between 100 B.C. and A.D. 1300 (Aten and Bollich, 1981). Due to the slightly higher elevation of sand mounds, these features were selected over lower-relief areas for human occupancy and, therefore, have a high potential for the discovery of archeological sites.

Large temple mounds, smaller burial mounds and agricultural villages built by the Caddo Indians and dating from late prehistoric times (A.D. 500–1500) are located in the piney woods of East Texas (http://www.thc.state.tx.us/archeologyaware/aaphsites.html). Located approximately 130 miles northwest of Beaumont, TX is the Caddoan Mounds State Historical Site. Built between A.D. 750 and A.D. 1250, the ceremonial center contains a major village containing ceremonial temple mounds and a burial mound. Arrowheads, axes, copper and quartz pieces, clay pipes, other sacred items, and human remains have been found beneath the mounds at the State Historic Site. (http://www.tpwd.state.tx.us/park/pom/200406.phtml)

If oil and gas operations are permitted on temple mounds or sand mounds in the Preserve, cultural artifacts would be protected by the National Historic Preservation Act, Native American Graves Protection and Repatriation Act and all other applicable laws and regulations.

Historical sites occur throughout the Preserve and consist of material remains of Euroamerican occupation of the Big Thicket from the early 1800's through the mid-20th century. The area was under varying degrees of influence from Spain, France, and England until 1802 when the United States acquired it from France as part of the Louisiana Purchase. No archeological sites from these early historic periods are known, but many remains from the latter half of the 19th and first half of the 20th century can be found throughout the park. Although few have been formally recorded as archeological sites, they include remnants of homesteads; logging camps and mills; hunting camps; river craft; roads, trails, and traces; ferry crossings; steamboat landings; abandoned communities; and early oil and gas production sites. The water transportation sites occur along the Neches River and its tributaries (particularly Little Pine Island Bayou), while other historical archeology sites are scattered throughout the Preserve and reflect economic ventures associated with early homesteading and agriculture/ranching pursuits of the early 19th century, through the timber industry boom of the late 19th century, and the oil and gas boom of the early 20th century. Other sites of the historic period may be related to the immigration of the Alabama and Coushatta tribes whose move into southeast Texas both geographically and temporally paralleled that of early settlers from the United States. Former village sites, hunting camps and other localities of cultural importance undoubtedly occur within the Preserve boundaries, but have not yet been identified.

Historic Structures

Historic structures in the Preserve are those elements of the built environment that have survived relatively intact and which illustrate some historical aspect or association with the region's or Preserve's past. No structure in the Preserve is currently listed in the National Register of Historic Places. The State Historic Preservation Officer (SHPO) deemed the Saratoga School gymnasium eligible for the National Register in 1994. However, the building was deteriorated and declared unsafe and in 1995 the NPS completed the required site documentation and the building was demolished.

The only historic structure potentially significant under the National Register criteria is the Brammer House, immediately adjacent to the Saratoga school property. A rectangular wood frame residence, the building is characterized by wood clapboard siding, a front gabled porch, exposed rafter ends, and double-hung wood windows. It has been included in the List of Classified Structures, and is being considered for listing in the National Register pending SHPO concurrence.

Ethnographic Resources

Ethnographic resources are sites, structures, objects, landscapes, or natural resource features assigned traditional legendary, religious, subsistence, or other significance in the cultural system of a group traditionally associated with it. The decision to call resources "ethnographic" depends on whether associated peoples perceive them as traditionally meaningful to their identity as a group and the survival of their lifeways (NPS 1997:181, 160).

The abundance of game and other foodstuffs in the Big Thicket made it a long-time hunting, fishing and gathering ground for generations of indigenous peoples, early and recent immigrants, and longtime settlers. The region, however, was also impenetrable and downright hostile, and forays into its center and swamps were infrequent and seasonal. Not only was settlement limited into the 20th century, but so was exploitation of its resources.

When Big Thicket National Preserve was established, acquisition procedures, coordinated with local interest groups, generally excluded settlements and farmsteads and, thus, ethnographic resources were mostly avoided. Nonetheless, specific efforts were made to determine the association between the Preserve and traditionally associated communities for the purposes of this Plan/EIS. Historical associations between the Preserve and various communities were researched and reported (Moss, 1998). Subsequent field visits were made in a preliminary effort to identify specific resources that might retain cultural significance to park-associated communities. Additionally, a meeting between park staff and the Alabama and Coushatta tribes was held to determine if the tribes had particular concerns about potential effects of oil and gas development on ethnographic resources. Through the background research, field visits, and meetings, the following park-associated groups were identified:

American Indian Tribes. The Federal Government has specially mandated responsibilities toward American Indian interests, including but not limited to those required by the NHPA. For purposes of this Plan/EIS, it was crucial to determine if there are American Indian tribes that retain customary associations with park land and, if so, if there are places in the Preserve to which they may ascribe cultural significance and which require special management considerations. Further, American Indian tribal identities are often rooted in the landscapes from which their origins derived and are intricately linked with tribal traditional history. These histories are common to the cultural group as a whole and are passed from generation to generation, making the physical places themselves an integral component of cultural continuity. Five tribal groups have historic associations with the Big Thicket and with various units of the Preserve. These include:

Atakapa. Although anthropologists commonly consider descendents of this group to be fully absorbed into other tribes, an effort should be made to determine any continuing affiliations and associations that other American Indian groups may have with the earlier Atakapas and any affiliations they may have with the Preserve.

Caddo. The Caddo Confederacy formed one of the most important and influential groups of Texas Indians and were probably the most complex collection of related groups to occupy the general East Texas region. Although they had linguistic ties to tribes to the north and west, they had stronger cultural affiliation with the Creeks and other tribes to the east, particularly the Natchez of Louisiana. Historically, the Caddo lived on the northern boundaries of the Big Thicket, occupying the "piney woods", while the Atakapa occupied the coastal strip just to the south of the Caddo homeland (Newcomb 1975:279-284). Following years of reduction by disease and warfare with European and Euroamerican groups moving into their homeland, the remnant groups of the Caddo were settled on reservations in Oklahoma in 1859.

Creek. The Creek Confederacy, originally located in Georgia, consisted of various tribes of Muskogean speakers as well as a few non-Muskogean tribes that stretched from Georgia to Texas. In 1826, the core tribes were moved from Georgia to Alabama and, six years later, to land in Oklahoma. The few Creeks that historically lived on the boundaries of the Big Thicket are, today, part of the Alabama and Coushatta tribes or the Creek Tribe in Oklahoma.

Alabama and Coushatta. Both of these groups were members of the Upper Creek Nation and speak a common Muskogean language. After immigrating into East Texas around 1800, both tribes lived in settled groups on the north and west edges of the Big Thicket. Today they occupy the Alabama-Coushatta Indian Reservation, which adjoins the north boundary of the Big Sandy Unit. Because of the tribes' long association with Big Thicket, and their statements about having deep traditional association with park lands, a thorough investigation should be undertaken of the continuing affiliations and associations that the Alabama and Coushatta tribes have with the various units of the Preserve. In particular, they expressed interest in preserving the Coushatta Trace, which bisects the Big Sandy Unit, and pre-contact archeological sites.

Non-Indian Associated Groups. Most other users of the Big Thicket are descendants of Euroamerican settlers who immigrated to the area during the early 19th to early 20th centuries. Small farmers and stockraisers from the Upper South established scattered agricultural homesteads and defined their communities with a church, school and cemetery. While the schools have been consolidated, the churches and cemeteries are still active, although none currently exist within the boundaries of the Preserve. The Big Thicket provided hunting, fishing and gathering grounds for these people, as well as other uses. Examples of such places are the Blue Hole in the Jack Gore Baygall, and Hook's Bear Camp and the Lance Rosier birthplace, both in the Lance Rosier Unit; and other examples may exist (Maxine Johnston, pers. comm.).

Park User/Affinity Groups. A major force behind the dedication of portions of the Big Thicket as a national preserve was the Big Thicket Association, a group with strong continuing associations with the Preserve. Other significant affinity groups that support park programs include the Jack Gore Baygall Association and former Big Thicket Conservation Association. These organizations also serve as a link to knowledgeable local residents who can share the history and ethnographic concerns associated with the Preserve. Other groups with associations to the Preserve include a wide variety of recreational users.

Preliminary research of historical literature, field visits, and meetings have not confirmed specific ethnographic resources that might be affected by oil and gas development; however, this does not conclude that such resources do not exist within the Preserve. As oil and gas operations progress, efforts need to be made to identify ethnographic resources and associated community concerns, including consultations with the Alabama and Coushatta tribes and other park-affiliated communities.

Cultural Landscapes

Cultural landscapes are geographic areas, including both cultural and natural resources and the wildlife or domestic animals therein, associated with a historical event, activity, or person or exhibiting other cultural or aesthetic values. The four general kinds of cultural landscapes, not mutually exclusive, are Historic Designed Landscapes, Historic Vernacular Landscapes, Ethnographic Landscapes, and Historic Sites (NPS, 1997:179).

Considering the variety of cultural meanings given to the Big Thicket, and the dispersion of subsistence and commercial land uses throughout the Preserve over time, the entire Preserve can be considered a cultural landscape. This landscape is made up of more than individual historic sites. It also includes systems of land use; circulation connections such as trails, wagon and lumber roads, the Old Spanish Trail and Coushatta Trace corridors, ferry routes, and tram roads; and vegetation patterns that, for example, indicate previous farming activities and pine plantations.

Although there have been several historical and ethnographic studies of various aspects of the Big Thicket, no detailed examination of the land use history with the Preserve has been completed; nor has a historic context analysis been done. In general, the region has been lightly settled through the historic period. The dense vegetation for which the area is named discouraged extensive farming practices, the mainstay of Texas settlers in the 19th century. Much of the Preserve is in low-lying areas that were inhospitable and unproductive for farming. Additionally, the acquisition of land for the Preserve strove to avoid settlements and unwilling landowners, limiting the presence of cultural landscape elements. Nevertheless, Big Thicket may contain cultural landscapes that are potentially eligible for the National Register of Historic Places and, as described above, associations with several contemporary groups exist.

Association with Native Americans. At least three contemporary American Indian tribes may have direct cultural affiliation with the Preserve. The pre-contact Caddo and Atakapa groups probably occupied seasonal hamlets or camps within the Big Thicket as they hunted, fished and foraged for food stuffs during seasonal rounds. Year-round occupation of the Thicket probably did not occur as the core areas for these groups were to the north and south. The Alabama and Coushatta tribes, having been in Texas since the 1780's and on their reservation adjacent to the Preserve since 1853, have used the Big Thicket for generations and in a manner similar to previous tribes. Although hunting, fishing and foraging have been a part of their livelihood in the Thicket, they have been more permanent residents and can point to such affiliated landscape features as the Coushatta Trace and, perhaps, abandoned village sites within the Preserve. The Creeks may have an affiliation with the Preserve by way of their association with the Alabama and Coushatta.

Association with Euroamericans. Because of the dense vegetation and low-lying areas, the Big Thicket was generally avoided by immigrants during the Spanish and Mexican colonization eras. A few settlers in the Texas Republic and early Statehood periods found their way into the thicket, particularly along major waterways such as the Neches River, and small settlements grew at ferry crossings and, later, steamboat landings. Early settlement additions to the cultural landscape included small, dispersed communities and small isolated farmsteads. Cultural landscape elements characteristic of these patterns include ferry crossing ramps, small community or farmstead structures, outbuildings, field areas, cemeteries, and circulation systems. Ferry landing sites associated with the Preserve include Sheffield Ferry, Town Bluff, Yellow Bluff, Richardson's Ferry and Weiss Bluff. Later transportation elements include the still-active railroad and the old, abandoned highway bridge at Evadale. Specialized settlement sites including hunting sites, particularly bear-hunting camps and grounds, occur in the park. Early settlement/subsistence farming landscapes are associated with the Lilly and Kennedy farmsteads in the Big Sandy Unit; the Rosier, Teel, and Cotton complexes in the Lance Rosier Unit; the King, Richardson, and Sternburg Bluff localities in the Turkey Creek Unit; and the Blue Hole water source and wagon road associated with the Holyfield family in the Jack Gore Baygall Unit.

Association with Transportation Avenues: Waterways and Railroads. With very few exceptions, overland transportation corridors avoided the Big Thicket until the mid-1800's. Waterways were the natural avenues of transportation from pre-contact times through the 1800's. The Antebellum period saw the establishment of several steamboat landings along the Neches River. Goods of all kinds were transported up and down river throughout this period and later. As early trails, and eventually roads, were established through the region, ferry crossings were established to facilitate movement of people and goods across the Thicket. Such access, however, encouraged people to move into the region and their effects on a cultural landscape were generally localized and isolated. Railroads in the Big Thicket region, and smaller rail lines (including tram routes) leading into the Preserve were inspired by the growing demand for timber and resulted in the first major assault on more remote areas of the Thicket. The impacts were directly related to the level of technology. Timber was cut along the routes to provide ties, crude railroad camps were established, and water-stops and towns were built along the way to supply water and fuel. Invariably, roads sprang up along the rail line, which encouraged immigration into the inner parts of the Thicket not previously accessible. All of these features contributed to the evolution of a cultural landscape throughout the Preserve.

Association with 19th and 20th Century Timber Industry. The Big Thicket has been a primary source for timber in Texas since the late 1880's. This industry brought major changes in the cultural landscape. As sawmill towns grew up along the railroad lines, small landholders sold their timber and surface interests, and the cut-over land provided opportunities for additional agricultural development. No unit of the Preserve was untouched by the massive timbering efforts. Most of the virgin hardwood and pine forest was cut, and the population of the region increased to accommodate the industry. When the sawmill towns moved on after the local resources were depleted, much of the new population left, leaving the earlier residents to revert to the subsistence lifestyle and some pick-up work from the reduced timber industry. Locations within the Preserve associated with the timber industry include the sawmill town site of Hicksbaugh and its tram line; the sawmill site at Sternburg Bluff and the Keith/Kirby mill at Voth. Associated landscape features include tram routes (wood and iron rail lines), berms, drainage ditches, and bridges.

Association with 20th Century Petroleum Industry. One of the first oil fields in Texas came in at Saratoga in 1901. Early oil exploration initially concentrated at the southern edge of Big Thicket, pushed north and east in the 1930's, and, by the 1950's most units of the Preserve were home to some level of oil and gas activity. Like the timber industry, oil and gas brought increases in population numbers, but this population was even more ephemeral. The boomtowns of Saratoga, Batson, and Sour Lake faded as quickly as they had boomed as most of the boomers left when the exploration phase waned. The production end of the oil and gas industry, as with the timber industry, provided some work for those left behind. Oil industry-related sites with the Preserve include abandoned well sites in the Saratoga field, the Saratoga School complex, and the Brammer house.

Association with Big Thicket National Preserve. Federal ownership has halted private ownership of surface resources and timber is in recovery. The oil and gas industry still has producing interests within the Preserve. Subsistence aspects of prior cultural use of fish and game have been expanded to be largely recreational with visitors drawn from nearby urban and suburban communities and the State as a whole. Educational, scientific, and recreational uses of the Preserve have increased and include: nature study, research and monitoring, hunting, trapping, fishing, boating, hiking, swimming, picnicking, camping, bird watching, horseback riding, bicycle riding, canoeing, and solitude. While uses of the Big Thicket lands have changed since their inclusion in the national preserve, a number of places still have significant associations for contemporary communities, as described above.

As discussed previously, the various categories of cultural resources vary in type and density across the Preserve. Individually, they all have their particular character, integrity, and information base. The archeological sites, the historic structure, and the ethnographic associations are unique in and of themselves. But they also form individual elements that combine to create the more encompassing cultural landscape of the Preserve, and one category of cultural resource cannot be taken into account without consideration for the others.

VISITOR USE AND EXPERIENCE

Congress provided direction in Section 4 (b) of the enabling legislation, to limit the construction of roads, vehicular campgrounds, employee housing, and other public and administrative facilities in the interest of maintaining the ecological integrity of the Preserve. Therefore, development has followed a conservative approach, with careful siting and sustainable design being applied when development is warranted, to retain natural qualities and processes.

Visitor Use Areas

Each unit of the Preserve is unique and harbors noticeable differences when compared and contrasted. These differences range from floodplain forests to cypress sloughs to savannas to mixed hardwood and pine forests. The trails that have been developed in the units take advantage of this uniqueness and expose trail users to these different environments. The following section lists the recreational attributes found in each unit of the Preserve. These areas include day use areas, hiking trails, canoe routes, and birding hot-spots. **These visitor use areas, in addition to park administrative areas (3), hunting areas, and other use areas (cemeteries (3) and residential homesites (2)) are designated as Protected Areas under Alternative A, and as Special Management Areas under Alternatives B and C. These areas are shown on Figure 3.5; and the Protected Areas/Special Management Areas are shown on maps provided in Chapter 2, Part 1.**

Day Use Areas. There are 26 day use areas located in the following 9 Units:

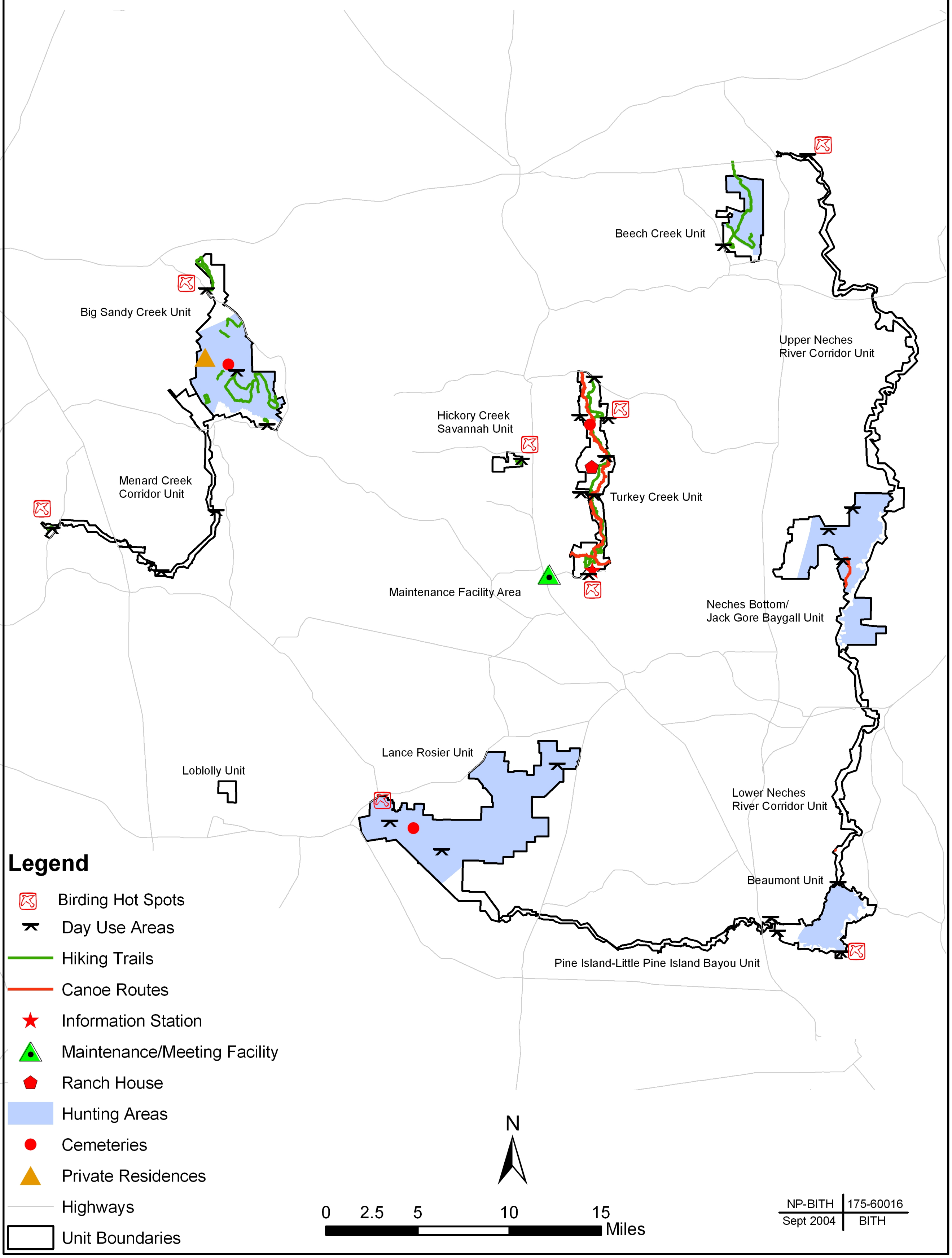
- Beaumont Unit
- Beech Creek Unit
- Big Sandy Creek Unit
- Hickory Creek Savannah Unit
- Lance Rosier Unit
- Menard Creek Corridor Unit
- Neches Bottom/Jack Gore Baygall Unit
- Turkey Creek Unit
- Upper Neches River Corridor Unit

Hiking Trails. There are 9 hiking trails located in the following 5 Units:

- **Beech Creek Unit.** One trail: Beech Woods Trail is a 1-mile loop.
- **Big Sandy Creek Unit.** Three trails: Woodland Trail has three distance options of 3.3, 4.5 and 5.4 miles; the Beaver Slide Trail is 1.5 miles long; and Big Sandy Trail is a "multi-mode" loop trail, 18 miles long for horseback riding, hiking, and off-road bicycle riding.
- **Hickory Creek Savannah Unit.** One trail: Sundew Trail has an inner loop 0.5 miles and an outer loop of 1 mile. The inner loop is designed for full accessibility.
- **Menard Creek Unit.** One trail: Birdwatcher's Trail is at the confluence of Menard Creek and the Trinity River.
- **Turkey Creek Unit.** Three trails: Turkey Creek Trail is 15 miles long with three trailheads; Pitcher Plant Trail is a short spur connecting with Turkey Creek; and the Kirby Nature Trail, which is a two loop trail, with an inner loop 1.7 miles long and an outer loop 2.4 miles long. Fishing and canoeing occurs on Turkey and Village Creeks.

Figure 3.5. Visitor Use, Administrative and Other Use Areas

Figure 3.5. Visitor Use, Administrative and Other Use Areas



Canoe Routes. There are four canoe routes:

- Village Creek,
- Turkey Creek from Gore Store Road to Village Creek,
- Franklin Lake to Johns Lake, and
- Cook's Lake to Scatterman Lake Loop.

Marked canoe routes include: Franklin Lake to Johns Lake, and the Cook's Lake to Scatterman Lake Loop. Most of the creeks and rivers flowing through the Preserve are navigable either year-round, seasonally, or after a significant rainfall. Other canoeable waterways include:

- Some sections of waterways, such as the 40-mile stretch of the Neches River through the Jack Gore Baygall Unit, are nationally publicized for their wild character.
- Aside from the Neches River, Village Creek is also widely publicized as one of the finest canoeing streams in East Texas.
- The lesser known Turkey Creek through the Turkey Creek Unit offers an outstanding experience for those seeking to paddle through riparian forests of hardwood and pine.
- Little Pine Island Bayou through the Lance Rosier Unit is normally unnavigable, but after intense rainfall, it floods the surrounding forest and becomes canoeable.
- For the most intrepid canoeists, the Little Pine Island Bayou offers a challenging two-day journey through one of the least traveled sections of the Preserve.
- The loop from Cook's Lake to Scatterman Lake follows a slough in the Beaumont Unit, and is one of the few loops in the Preserve.

Many other canoeing and boating possibilities exist in secondary channels, sloughs, and oxbow lakes throughout the Preserve.

Birding Hot Spots. Bird migrations through the Preserve peak between late March and early May, and again in October and November. The more sought after birds for bird watchers are the Red-cockaded Woodpecker, the Brown-headed Nuthatch, and the Bachman's Sparrow. The last reported sighting of an Ivory-billed Woodpecker in the Preserve was in May 1971. Dense vegetation can make birding for migratory songbirds difficult in much of the Preserve. The eight (8) birding hot-spots located in the Preserve are listed below.

- **Collin's Pond.** Collin's Pond, located at the head of the Woodlands Trail in the Big Sandy Creek Unit, is good habitat for a variety of song birds and waterfowl: thrushes, warblers, herons, and egrets. The trailhead is located on FM 1276, 3.3 miles south of U.S. 190, or 5.9 miles north of Dallardsville.

- **Birdwatcher's Trail.** Panoramic views of expansive sandbars from high bluffs on the east bank of the Trinity River offer good birding opportunities for shorebirds, raptors and migrant song birds. It is located at the confluence of Menard Creek and the Trinity River, 3.1 miles north of Romayor off of FM 2610 on Oak Hill Drive.

- **Teel House Road.** This road runs through Lower Slope Hardwood Pine Forest in the Lance Rosier Unit. Access is via dirt road that runs south through the Saratoga Oil Field – just east of Saratoga off Highway 770.

- **Pitcher Plant Trail.** This loop trail runs through wetland pine savanna and upland pine habitats, and has good access to floodplain communities. To get there, take FM 1943 4.3 miles east of Warren, turn right and go south 1.9 miles on Pineville Church Road (eastern boundary road of Turkey Creek).

- **Sundew Trail.** This is an open and park-like wetland savanna, and it is good habitat for Pine Warblers and Brown-headed Nuthatches. It is located just off of a dirt road leading to the Sundew Trailhead, off of FM 2827 0.5 mile west of US 69.

- **Kirby Nature Trail.** This is a group of loop trails that go through slope forest, baygall, floodplain, cypress slough and stream bank communities with good access to arid sandhill communities, too. This trail is good for warblers, vireos, woodpeckers and resident song birds. The Kirby Nature Trailhead and information station are located at the southern end of the Turkey Creek Unit on FM 420, 2.5 miles east of the junction of US 69 and FM 420.

- **McQueen's Landing.** This is a canoe and boat launch ramp below the dam at Steinhagen Reservoir. It is a viewing area for bald eagles in the winter. To get there, take FM 777 south to Beech Grove (just east of Martin Dies Jr. State Park). At Beech Grove, take the dirt road toward East End Park until it ends at McQueen's Landing on the Neches River.

- **Cook's Lake.** This is a backwater area off of Pine Island Bayou, not far from its confluence with the Neches River. It is a very scenic area to go birding by canoe. The swamp forest and floodplain forest communities in Cook's Lake provide good habitat for herons, egrets, raptors, and swallows. It is accessible from Interstate 10 and US 69. From there, exit on Highway 105, and continue east 8.2 miles through Vidor. After Vidor, go north on 105 for 4.0 miles to FM 1131. Then go west on FM 1131 for 3.3 miles. Turn left onto a paved road. Go 3.7 miles (pavement ends after 2.7 miles) to a parking area on the right (Confluence Boat Ramp).

Roads. The Preserve maintains 9.5 miles of dirt and gravel roadways. By virtue of the Preserve's configuration, visitors must travel over a road and highway system consisting of farm-to-market roads, county roads (both improved and unimproved), and State and U.S. Highways. For visitors from outside the region seeking the location of a specific Unit, or a specific attraction in a Unit, the effort can easily become a navigational challenge.

Hunting and Trapping. The enabling legislation for Big Thicket National Preserve, while mandating that the Preserve be administered in a manner that will assure in perpetuity the natural and ecology integrity, also directed the NPS to provide for continued traditional recreational uses of the Preserve, including hunting and trapping. The Act further directed that these activities would be "conducted in accordance with applicable laws of the United States and the State of Texas." The NPS was allowed to "designate zones where and periods when, no hunting, fishing, trapping or entry may be permitted for reasons of public safety, administration, floral and faunal protection, and management, or public use and enjoyment." The Act also directed that, "except in emergencies, any regulations prescribing such restrictions relating to hunting, fishing, or trapping shall be put into effect only after consultation with the appropriate State agency having jurisdiction over hunting, fishing, and trapping activities."

The general regulations governing the management and use of NPS-administered areas generally prohibit the consumptive use of resources such as hunting and trapping. In order to implement and guide the consumptive uses authorized in the enabling legislation, the NPS determined that it was necessary to develop special regulations. In 1979, special regulations were developed and implemented in 36 CFR 7.85 to address hunting and trapping activities.

Since 1979, approximately 2,000 permits have been issued each year for hunting. An average of 12 permits for trapping have been issued each year.

Hunters are presently issued permits, on a first-come, first-served basis at annual sign-ups held during July and August. Permitted hunters may hunt in only one of the following open units: Big Sandy Unit, Beech Creek Unit, Lance Rosier Unit, Beaumont Unit, and areas in the Neches Bottom and Jack Gore Baygall Unit. A total of 47,400 acres in these units are open to hunting. Hunting season generally begins October 1 and continues through January 15 each year. Texas State seasons and bag limits are followed during this period. While applying general Texas hunting regulations, the Superintendent applies additional restrictions to hunters in order to protect Preserve resources and provide for additional hunter and visitor safety. Hunting areas are not generally closed to public use during hunting season, except backcountry camping is not permitted in areas open to hunting during hunting season. During the 1997-1998 season, October 1, 1997, to January 15, 1998, 9,896 trips were made by hunters into hunting areas. Hunters harvested 282 deer, 13,851 squirrels, 247 hogs, 285 rabbits, and 291 waterfowl.

Seismic surveys have not been permitted in hunting areas during the Preserve’s hunting season, but have been permitted in non-hunting areas during this period. Seismic surveys have been restricted during this period in order to avoid conflicts and protect visitor safety. Occurring at the same time, both activities could unnecessarily increase the hazards for both hunters and seismic crews.

Trapping is permitted in the Lance Rosier Unit, Beaumont Unit, and areas in the Jack Gore Baygall/Neches Bottom Unit, a total of 35,000 acres. As with hunters, Texas State trapping regulations apply and the Superintendent has implemented additional restrictions to protect Preserve resources and provide for visitor safety. During the 1997-1998 season, December 1, 1998 to January 31, 1999, 126 trips were made into open units with 352 raccoon, 18 opossum, 2 nutria, 5 mink, 2 otter, and one bobcat harvested.

Park Administrative Areas

Park administrative developments include:

- Maintenance and Meeting Facility,
- Turkey Creek Ranch House,
- Big Thicket Information Station, and
- Big Thicket Visitor Center.

The Big Thicket Visitor Center, shown on the right, serves as the primary contact point for all Preserve visitors and is open seven days per week, year-round. The station grounds are the focal point for most environmental educational programs conducted by Preserve staff due to the proximity of the Big Thicket National Preserve Visitor Center Kirby Nature Trail (Turkey Creek Unit). A small book sales area, brochures, limited exhibits, video tape viewing, orientation, outside restrooms, picnic tables and nearby Kirby Nature and Turkey Creek trailheads are found at this location. Average visitation at the Information Station for 1990 – 2000 is 10,843 persons.

Other Use Areas

Cemeteries. There are three cemeteries within the Preserve. They are designated as Special Management Areas under Alternatives B and C.

Inholdings. There are two residential homesites in the Preserve. Both homesites have use and occupancy terms. They are designated as Special Management Areas under Alternatives B and C.

Visitor Use Statistics

Yearly visitation to the Preserve during the period from 1978 to 1996 was approximately 65,000, but generally increased during the period from 1987 to 1996. An average of 87,000 visitors come to the Preserve each year (Table 3.11). Since visitation counts are limited and are largely based on Visitor Information Station counts, the data shown in Table 3.11 may underestimate the number of annual visitors to the Preserve.

The majority of visitor use is regional in nature. Yet, looking at the visitor registration log found at the Information Station, all 50 states and at least 20 countries are represented annually. It is felt that Big Thicket's Biosphere Reserve designation interests international visitors.

Backcountry camping is generally light in the Preserve and must be conducted in designated areas. There are no developed drive-in campgrounds.

Table 3.11. Annual Visitation at Big Thicket National Preserve

Year	Annual Visitation
1990	77,930
1991	64,076
1992	72,269
1993	82,854
1994	127,313
1995	115,466
1996	111,626
1997	77,633
1998	60,087
1999	60,193
2000	62,009
2001	98,526
2002	101,830
2003	101,580
2004	107,782

Data derived from NPS internet website, Public Use Statistics Office.

Seasonal Visitor Use Patterns

Visitor use patterns are not complicated and are predictable during the spring and fall seasons.

Spring is the busiest visitor use period. Early spring travelers, mostly bird watchers from a majority of states and several countries, converge on the general area and Preserve. School groups participating in Preserve educational programs arrive daily in late spring in groups of 100 for several weeks. Weekend use increases as visitors from the region use trails, and go fishing and boating.

Summer use is light because of high temperatures and humidity. Users are families from outside the region on traditional summer family vacations visiting several attractions in a two- or three-week period. Local limited visitation continues with fishing and boating activities.

Fall visitor use is moderate to high consisting of late seasonal travelers and school groups. Depending on weather conditions, regional visitor use can be high as people are enjoying outdoor recreation during cooler temperatures and humidities.

Winter use is light, with seasonal travelers consisting of retirees and some regional visitor use. During hunting season, from October through early January, up to 2,300 permits are issued for hunting in select units. Hunting limits other visitor uses, such as hiking, horseback riding and off-road bicycling, due to safety issues and concerns.

Visual Quality, including Night Sky, as a Component of Visitor Experience

Although the presence of humans is evident in the Preserve and region, the dominant visual elements are water and vegetation on a predominantly flat landscape. While man-made developments are apparent, the relatively flat topography and dense vegetation also reduce these influences within a short distance.

However, only 30 years ago people clearly viewed the night sky from most residential areas. Now the night sky is being obscured by artificial light. In many parts of Southeast Texas, only the moon and brighter planets are visible during the nighttime (David Deming, pers. comm.). The spectacular view of the night sky that our ancestors had on clear nights no longer exists (International Dark-Sky Association, 1996).

Referred to as light pollution, urban sky glow brightens the night sky for everyone, including amateur and professional astronomers. Many advances at the frontiers of astronomy require observations of very faint objects that can be studied only with large telescopes located at prime observing sites, well away from sources of air pollution and urban sky glow (International Dark-Sky Association 1996). The nearest observation sites to the Preserve are the George Observatory at Brazos Bend State Park, and a site regularly used by the Astronomical Society of Southeast Texas near Kirbyville.

The increasing number of people living in nearby Houston and Southeast Texas, particularly the Golden Triangle (Beaumont-Port Arthur-Orange), are expected to continue to decrease the visibility of the night sky. However, light pollution can be minimized without compromising nighttime safety, security, or utility by using night lighting only when necessary, using well designed lighting to direct light where it is needed, and using low pressure sodium light sources whenever possible.

Natural Quiet as a Component of Visitor Experience

Part of the Preserve's resources include the sounds associated with its natural resources, often referred to as "natural sounds" or "natural quiet." Natural quiet generally includes the naturally occurring sounds of winds aloft in the trees, calling birds, as well as the quiet associated with still nights. As with all Preserve resources, natural quiet is part of the visitor experience. The natural sounds of the Preserve contribute to a positive visitor experience and is a component of why many people visit the Preserve. Therefore, noise was evaluated as a component of visitor experience.

During 1998, ambient sounds were monitored and recorded at 11 locations in the Preserve to provide a rationale for protecting natural sounds and natural quiet (Table 3.12). Background sound levels in most of the Preserve are due to wind aloft in the trees (Foch, 1999). A useful measure of background sound level is L90, defined as the sound level that is exceeded 90 percent of the time for the time period under consideration (Canter, 1996). Comparisons of Preserve sound levels to other natural and human-induced sounds, including certain oil and gas operations, are shown in Figure 3.6.

"Noise" can be defined as unwanted sound, and noise levels are most commonly expressed in decibels. Unless otherwise stated, most noise levels are rated using the A-weighting network (dBA). Sources of noise within the Preserve and surrounding areas include automobiles, boat motors, motorcycles, all-terrain vehicles, various types of equipment (e.g., tractors, log skidders, chainsaws, lawn mowers, etc.), power lines and transformers, and firearms. Automobile traffic occurs primarily on the highways and county roads within the Preserve and surrounding areas; however, some vehicular traffic does occur within the Preserve on existing roads. Single automobiles produce noise levels in the range of 70 dBA near the vehicle, while moderately heavy traffic may produce noise levels in the range of 85-90 dBA near the roadway. Boat traffic along the Neches River is another primary source of noise within the Preserve.

Sources of noise within the Preserve are generally localized or seasonal in duration. Examples include the use of all-terrain vehicles, chainsaws, firearms and vehicles and equipment for oil and gas exploration and production. Although short-lived, gunfire produces considerable noise in the range of 130-160 dBA near the weapon (depending on the caliber of the weapon).

Table 3.12. Ambient L90 Sound Levels at Various Locations within Big Thicket National Preserve

Location	DBA
Turkey Creek Unit – Near Sandhill Loop on the Turkey Creek Trail within Sandhill Pine Forest	37
Jack Gore Baygall Unit – within Upper Slope Pine Oak Forest	41
Lance Rosier Unit – At the end of Church House Road within Lower Slope Hardwood Pine Forest	39
Beech Creek Unit – Along Beech Woods Trail 0.8 miles from the parking/picnic area within Lower Slope Hardwood Pine Forest	35
Big Sandy Creek Unit – Along the Big Sandy Horse Trail within Lower Slope Hardwood Pine Forest, 2.9 miles from parking area	41
Turkey Creek Unit – NPS Ranch House within Upper Slope Pine Oak Forest/Wetland Baygall Shrub Thicket	36

The potential effects of noise on visitor experience in visitor use, administrative, and other use areas (e.g., hiking trails, picnic areas, cemeteries, and residential homesites), was one of the main reasons for establishing a 1,500-foot offset for drilling and production operations under Alternatives B and C. The offset distance was determined using sound levels presented in Figure 3.6, and

Figure 3.6. Sound Level Comparison Chart[1]

How it Feels	Equivalent Sounds	Decibels	Sound Levels at Various Locations in Big Thicket National Preserve
Near permanent damage level from short exposure	Large caliber rifles (e.g., .243, 30-06)	140-160	
Pain to ears	.22 caliber weapon	130-140	
Very loud	Air compressor @ 20 ft. Garbage trucks and city buses	100	
Conversation Stops	Power Lawnmower		
	Diesel truck @ 25 ft.		
Intolerable for phone use	Steady flow of freeway traffic 10 HP outboard motor Garbage disposal	90	
	Near drilling rig Automatic dishwasher Muffled jet ski @ 50 ft. Vacuum cleaner	80	
	Drilling rig @ 200 ft. Window air conditioner outside @ 2 ft.	70	
Quiet	Window air conditioner in room Drilling rig @ 800 ft. Normal conversation	60	
Sleep interference		50	
	Quiet home in evening		
	Bird calls Drilling rig @ 1500 ft. Library	40	Big Sandy Creek along Big Sandy Horse Trail Jack Gore Baygall Unit Lance Rosier Unit – at end of Church House Rd. Turkey Creek Unit on Turkey Creek Trail and at NPS Ranch House Beech Creek Unit along Beech Woods Trail
	Soft whisper	30	
	In a quiet house at midnight Leaves rustling	20	

[1]Modified from Final Environmental Impact Statement, Miccosukee 3-1 Exploratory Well, Broward County, Florida (U.S. Department of the Interior).

assuming noise in visitor use, administrative, and other use Special Management Areas should be kept as close as possible to ambient sound levels in the Preserve.

Visitor Perception of Oil and Gas Operations

There is no specific survey information available regarding visitor expectations about the oil and gas operations. Based on limited sampling during 1992, visitors to the Preserve's Visitor Information Station were from Texas (85 percent), and 76 percent were visiting the Preserve for the first time. Similarly, Gulley (1999) found the typical Preserve visitor was a Texas resident (78 percent), and that most visitors (58 percent) lived within a 2.5-hour drive from the Visitor Information Station. Overall, past and current levels of public use do not appear to have adversely affected Preserve resources, and conflict between public uses or between public uses and nonfederal oil and gas operations has been minimal. Since oil and gas operations have been present in the area since the 1900's, the surrounding public supports these activities to promote the economy of the area. Regarding noise impacts, there have been few complaints registered at the Preserve about oil and gas operations. However, noise from oil and gas operations is an important consideration and can be reduced in visitor use areas.

Human Health and Safety

The NPS policy regarding public health and safety is that the saving of human life will take precedence over all other management actions. The NPS and its concessionaires, contractors, and cooperators will seek to provide a safe and healthful environment for visitors and employees. The NPS works cooperatively with other federal, state, and local agencies, organizations, and individuals to carry out this responsibility. However, Preserve visitors assume a certain degree of risk and responsibility for their own safety when visiting areas that are managed and maintained as natural, cultural, or recreational environments (NPS, 2001). Proper siting of nonfederal oil and gas operations and the application of current legal and policy requirements will guide the NPS and nonfederal oil and gas operators to avoid visitor use conflicts, protect the health and safety of visitors, and to protect visitor use and enjoyment of Preserve resources.

Wild Character – Solitude

As required by the Wilderness Act and the Preserve's enabling legislation, the Preserve was evaluated for its suitability as wilderness in 1979.

Wilderness is defined as:

> "…an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain. An area of Wilderness is further defined to mean…an area of undeveloped federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which: (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least 5,000 acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value." (Public Law 88577, of September 3, 1964, establishing a National Wilderness Preservation System)

The Wilderness Recommendation (December 1980) for the Preserve concluded:

> The national preserve was established in order to ensure the preservation, conservation, and protection of the natural, scenic, and recreational values of a significant portion of the Big Thicket area. This statement by Congress makes it clear that natural values are to be preserved. However, Congress also provided that the mineral estate or existing easements for public utilities, pipelines, or railroads may not be acquired without the consent of the owner, unless the property is subject to uses that would be detrimental to the purpose of the Preserve.
>
> Because of the existing oil and gas operations and the continual development of the mineral estate in the Preserve, management of a specific area as wilderness cannot be ensured. However, the long-range concept is to work toward the restoration of natural conditions as existing operations end. For historically impacted areas, mitigating impacts would be the goal for any future designated wilderness.
>
> Under the long-range concept, it is believed that lands within 6 of the 12 Preserve units may qualify for wilderness at some future time. The lands that may qualify as wilderness have been identified as wilderness objective areas, and total nearly 60,000 acres. The wilderness objective areas identified in the 1979 study included the Beaumont, Lance Rosier, Big Sandy Creek, Beech Creek, and Jack Gore Baygall/Neches Bottom Units. It should be noted that some of the wilderness objective areas include roads, and pipeline and power line rights-of-way. All of these elements are incompatible with wilderness.
>
> While the need for some of these incompatible elements may change or cease, others may continue indefinitely. *Therefore, specific wilderness area adjustments could and should be made, as necessary, in any future studies.*
>
> The remaining six units of the Preserve will be managed to emphasize natural conditions. However, because of their small size or configuration, presence of roads and utility lines, and existing and potential oil and gas development, these units do not have the potential for wilderness designation.
>
> Therefore, after careful evaluation of the wilderness study document; the comments and suggestions received from individuals, groups, and public agencies; the mandates outlined in the establishing legislation; and the definition of wilderness contained in the wilderness act; it has been determined that none of the units within Big Thicket National Preserve are currently suitable for designation as wilderness.

ADJACENT LAND USES AND RESOURCES

The physical configuration of the Preserve, and particularly the narrow water corridor units, are affected by a number of adjacent land uses. Such land uses include residential development, commercial and private forestry, industrial development (oil and gas; forest products), agriculture, and publicly-owned facilities (e.g., Town Bluff Dam, water diversion, and sewage treatment facilities). The existing condition of resources in the Preserve that are described in this chapter in many cases would be similar on adjacent lands.

Residential development in the seven-county area of the Preserve is generally rural; however, there are residential developments adjacent to: Big Sandy Creek (e.g., Alabama-Coushatta Indian Reservation); Hickory Creek Savannah (e.g., Wildwood subdivision); Pine Island Bayou-Little Pine Island Bayou Corridor (e.g., Pinewood Estates and Bevil Oaks subdivisions); and the Beaumont Unit (Cook's Lake Road residents). Oil and gas exploration and development may conflict with homeowners and raise homeowner concerns about regulation, control, and safety of oil and gas activities.

Of land uses immediately adjacent to the Preserve, commercial and private forestry account for approximately 95 percent of the land area (Harcombe and Callaway, 1997). For units of the Preserve along the Neches River, commercial timber and commercial timber with oil account for approximately 90 percent of land uses within a one mile buffer from the center of the Neches River.

Additional issues related to timberlands include encroachment onto Preserve lands, public safety concerns regarding hunting clubs on adjacent timberlands, and public use of timber company roads to access the Preserve (Harcombe and Callaway, 1997).

The industrial base in the area is mostly concentrated to the south and east of the Preserve. Some industrial development, mostly related to forest products, is adjacent to the Preserve.