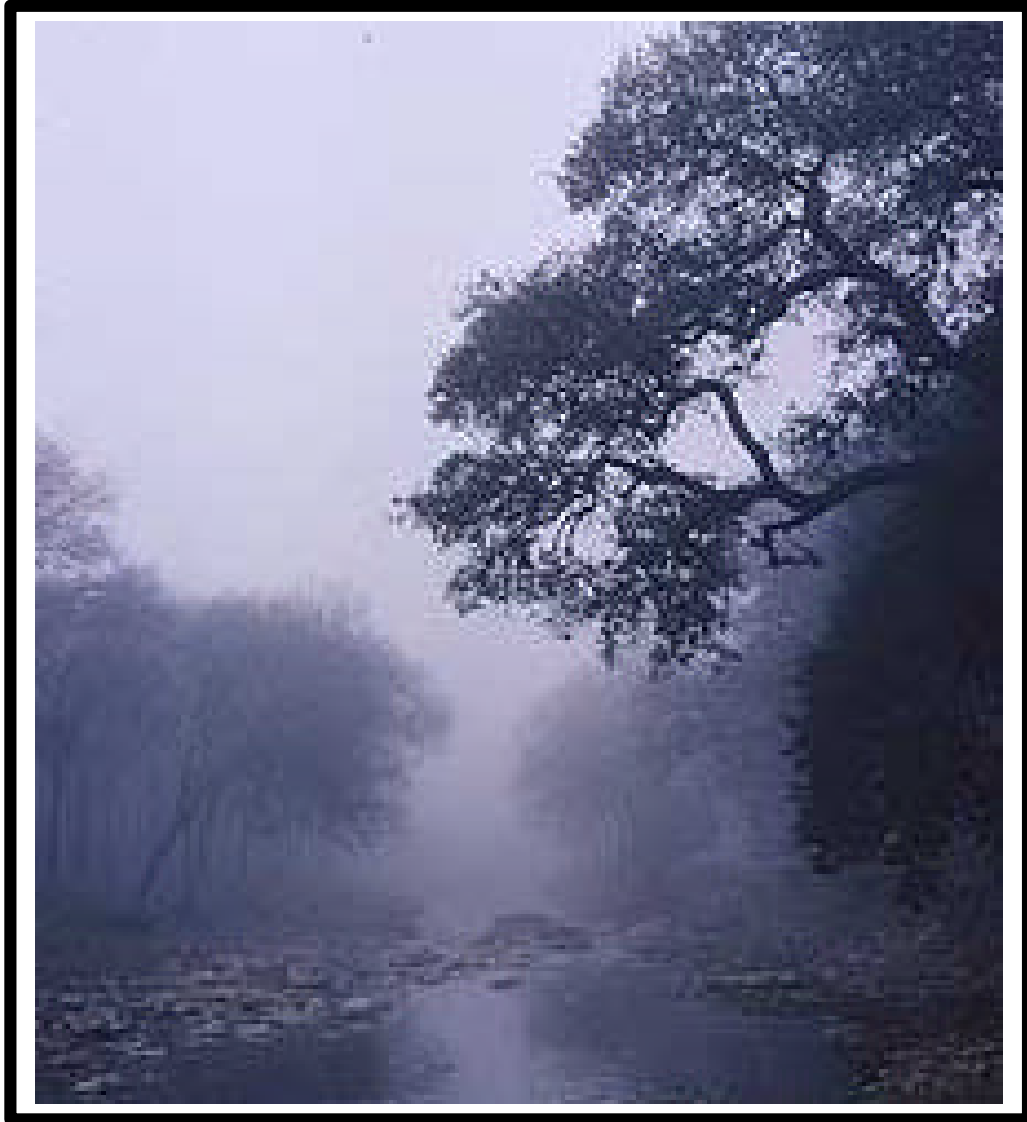




Area Study: North-Central Texas Area

*Evaluation of Selected Natural Resources in Part of the
North-Central Texas Area*





**RESOURCE PROTECTION DIVISION:
WATER RESOURCES TEAM**

*Evaluation of Selected Natural
Resources in Part of the
North-Central Texas Area*

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EXECUTIVE SUMMARY

This report is an evaluation of selected natural resources of the North-Central Texas area. Senate Bill 1 (75th Texas Legislature, 1997) mandated the completion of pending Priority Groundwater Management Area (PGMA) studies that were called for by House Bill 2 (69th Texas Legislature, 1985). The purpose of the PGMA program is to identify and evaluate areas of Texas that are experiencing, or are expected to experience, critical groundwater problems within the 25-year planning horizon. The PGMA process is intended to encourage local and regional governments to address identified groundwater problems and consider appropriate management options.

The study area is located in North-Central Texas. It includes all or parts of 19 counties: Collin, Cooke, Dallas, Delta, Denton, Ellis, Fannin, Grayson, Hood, Hunt, Johnson, Lamar, Montague, Navarro, Parker, Red River, Rockwall, Tarrant, and Wise counties. The economy of the area consists primarily of agribusiness, manufacturing, and tourism.

Extensive recreational facilities contribute substantially to the area's economy. Numerous lakes provide opportunities for fishing, boating, and other water sports. Several state parks are also located in the area.

The study area contains a portion of the Red, Sulphur, Sabine, Trinity, and Brazos River basins. Drainage of the study area is to the east and southeast by the Red, Sulphur, Sabine, Trinity, and Brazos rivers and their tributaries. The study area includes parts of the Blackland Prairie, Eastern Cross Timbers, Grand Prairie, Mesquite Plains, Oak Woodlands, and Mixed Pine-Hardwood Forest natural subregions.

The Brazos River from Possum Kingdom Dam downstream 90 miles to Lake Granbury is a smallmouth bass fishery and a striped bass spawning run, as well as a prime recreational spot for the region's residents. Sanchez Creek from the headwaters to the confluence with the Brazos River, is a pristine and historic area.

Within the Trinity River Basin, the Elm Fork Trinity River (headwaters to Ray Roberts Lake), West Fork Trinity River (Lake Bridgeport tailrace to Eagle Mountain), Big Sandy Creek (Amon G. Carter Reservoir tailrace to West Fork of the Trinity River), Spring Creek (Dallas County near Garland), and Tenmile Creek have high water quality, exceptional aquatic life, and high aesthetic value.

Within the Red River Basin, the significant stream segments are the following: the Red River, upstream 225 miles from Lake Texoma, which is a striped bass spawning and migration segment, with unique saltwater springs; the Red River from Lake Texoma Dam downstream to the Louisiana border, which harbors paddlefish and blue sucker; Shawnee Creek from the Lake Texoma spillway to the Red River (overflow basin), which harbors paddlefish; Rock Creek in the headwaters to the Red River (8 miles), North Fish Creek, and South Fish Creek, upstream 8 miles from Lake Moss, unique segments; and Bois d'Arc Creek, where the Caddo Wildlife Management Area, a unique state holding, is located.

Evaluation of Selected Natural Resources in Part of the North-Central Texas Area

INTRODUCTION

Purpose

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

Senate Bill 1 (75th legislature, 1997) placed priority on the completion of pending PGMA studies that were called for by House Bill 2 (69th Legislature) in 1985. TNRCC and TWDB identified all or parts of North-Central Texas counties for continued monitoring. The study area was not designated as a critical area for a PGMA study in 1990, but TWDB and TNRCC were to continue monitoring groundwater levels and local groundwater management initiatives. A groundwater study was initiated in 1989 with TNRCC requesting a groundwater resource and availability study from TWDB. TWDB completed the report *Evaluation of Water Resources in Parts of North-Central Texas* (TWDB Report No. 318, Baker et al.) in January 1990.

Location and Extent

The study area is located in the North-Central Region of Texas as shown in Figure 1. It includes all or parts of 19 counties: Collin, Cooke, Dallas, Delta, Denton, Ellis, Fannin, Grayson, Hood, Hunt, Johnson, Lamar, Montague, Navarro, Parker, Red River, Rockwall, Tarrant, and Wise counties. This area is located within the Red, Sulphur, Sabine, Trinity, and Brazos River basins.

Geography and Ecology

Drainage of the study area is to the east and southeast by the Red, Sulphur, Sabine, Trinity, and Brazos rivers and their tributaries. Elevations range from about 1,300 feet in the western part of the area to about 280 feet along the Trinity River near Ellis-Navarro County line (Baker et al. 1990). The study area includes parts of the Blackland Prairie, Eastern Cross Timbers, Grand Prairie, Mesquite Plains, Oak Woodlands, and Mixed Pine-Hardwood Forest natural subregions (Lyndon B. Johnson School of Public Affairs 1978; Fig.2). The land surface of the area is generally flat to undulating in the east, becoming gently rolling westward and giving way to hilly terrain along the westernmost margins of the study area (Baker et al. 1990).

Climate

Long, hot summers and short, mild winters characterize the study area's weather. The average daily minimum temperature for January ranges from 32°F in the northwest to 36°F in the southeast. The average maximum temperature for July is about 96°F throughout the study area. The average annual precipitation ranges from 30 inches in the northwest to 45 inches in the northeast (Dallas Morning News 1997). The average annual gross lake surface evaporation, for the period 1940-70, ranged from 78 inches in the north-central area to 61 inches in the southeast (Baker et al. 1990).

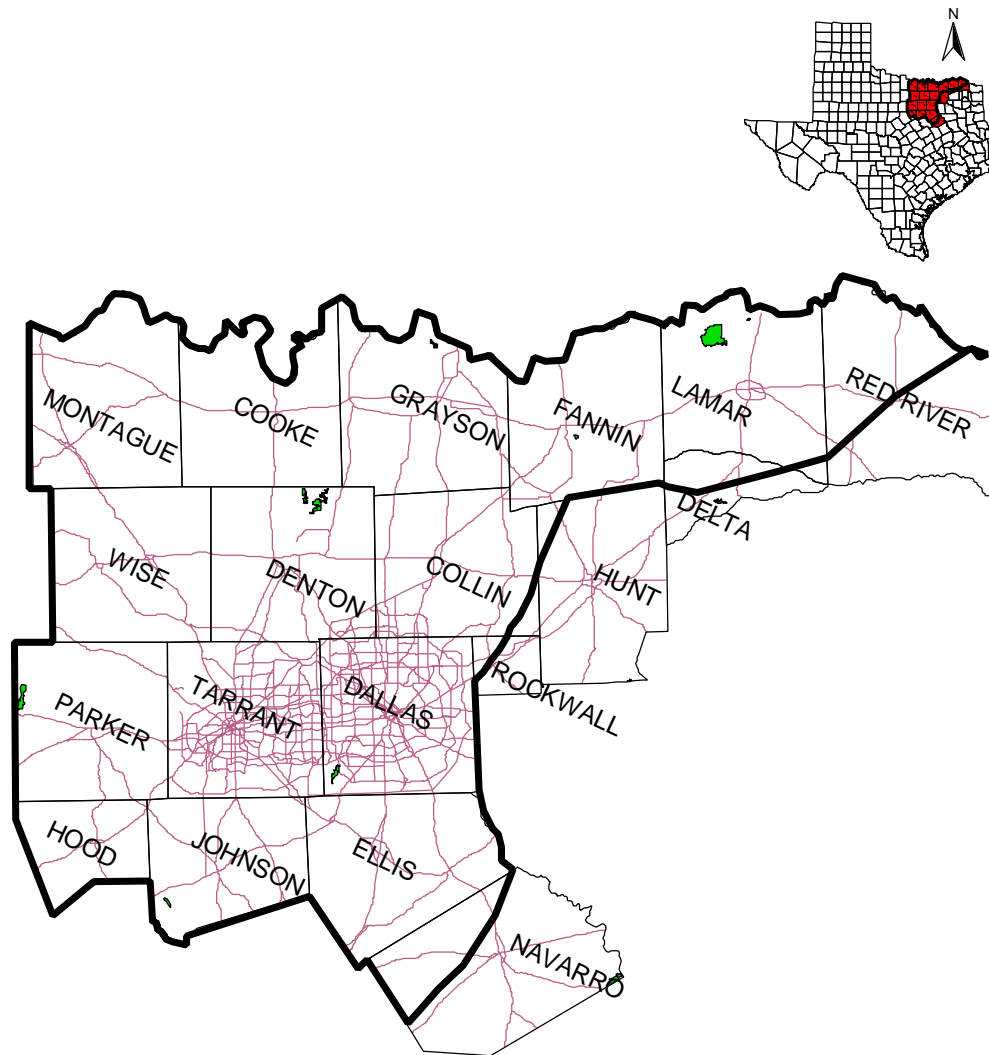
Population

The exact population of the study area as a whole is not readily available. The population of counties that are entirely or partially within the study area is given in Table 1.

Table 1. Projections for Population Growth in the Study Area (Texas Water Development Board 1998)

| Year ⇒ Locality ↓ | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 |
|----------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Collin | 264,036 | 387,598 | 527,712 | 706,997 | 873,323 | 1,019,350 | 1,162,482 |
| Cooke | 30,777 | 32,139 | 33,714 | 35,241 | 36,360 | 37,142 | 37,821 |
| Dallas | 1,852,810 | 2,074,858 | 2,286,828 | 2,556,793 | 2,784,704 | 3,045,931 | 3,259,995 |
| Delta | 4,857 | 4,845 | 4,832 | 4,848 | 4,812 | 4,710 | 4,560 |
| Denton | 273,525 | 385,876 | 523,205 | 679,279 | 845,595 | 985,370 | 1,135,566 |
| Ellis | 85,167 | 106,921 | 130,867 | 156,521 | 181,711 | 194,893 | 205,487 |
| Fannin | 24,804 | 26,692 | 26,966 | 27,408 | 27,835 | 28,173 | 28,396 |
| Grayson | 95,021 | 102,119 | 106,277 | 110,643 | 114,702 | 117,864 | 120,982 |
| Hood | 28,981 | 35,954 | 44,229 | 53,440 | 62,658 | 68,568 | 72,353 |
| Hunt | 64,343 | 71,333 | 78,035 | 83,252 | 87,034 | 88,519 | 91,693 |
| Johnson | 97,165 | 119,478 | 145,452 | 172,168 | 199,726 | 223,955 | 244,001 |
| Lamar | 43,949 | 46,148 | 48,553 | 51,303 | 54,061 | 56,792 | 59,499 |
| Montague | 17,274 | 16,583 | 16,243 | 15,911 | 15,228 | 14,566 | 13,869 |
| Navarro | 39,926 | 42,411 | 45,665 | 48,265 | 50,691 | 51,563 | 53,312 |
| Parker | 64,785 | 80,436 | 99,095 | 118,287 | 139,094 | 156,023 | 171,216 |
| Red River | 14,317 | 13,871 | 13,529 | 13,113 | 12,277 | 11,395 | 10,483 |
| Rockwall | 25,604 | 41,174 | 61,392 | 88,135 | 121,288 | 160,588 | 203,530 |
| Tarrant | 1,170,103 | 1,415,759 | 1,594,218 | 1,798,893 | 1,915,375 | 2,111,193 | 2,205,610 |
| Wise | 34,679 | 39,743 | 45,428 | 50,540 | 55,596 | 56,476 | 56,631 |

Figure 1. Location of the Study Area



50 0 50 Miles

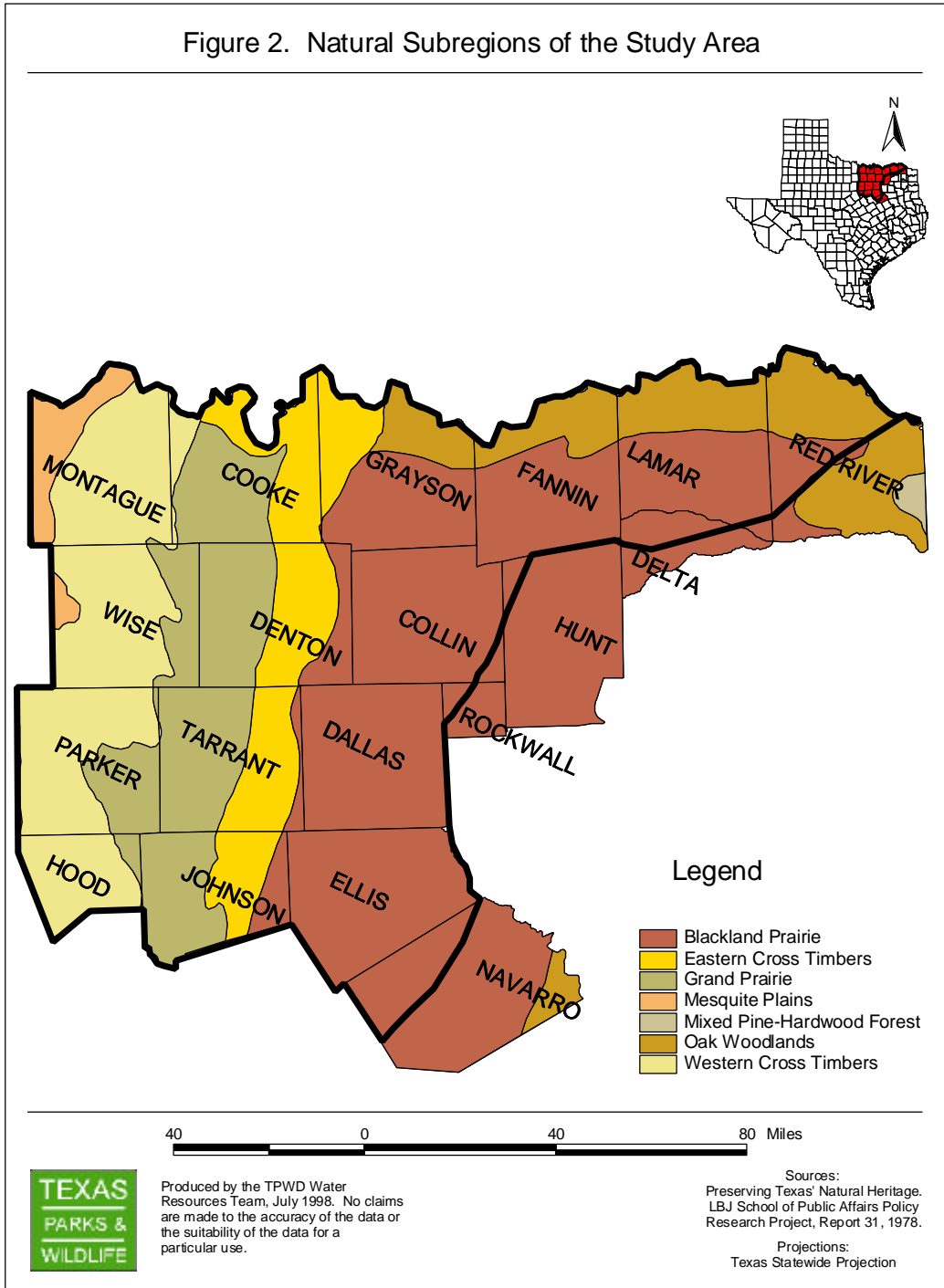


Produced by the TPWD Water Resources Team, July 1998. No claims are made to the accuracy of the data or the suitability of the data for a particular use.

Sources:
TPWD GIS lab archives data 1998.

Projections:
Texas Statewide Projection
(Lambert Conformal Conic)

Figure 2. Natural Subregions of the Study Area



Economy and Land Use

The economy of the area consists primarily of agribusiness, manufacturing, and tourism (Dallas Morning News 1997). Agricultural production is extensive and varied. Johnson County is a leading dairy producing county in the state. Dallas and Tarrant counties are major telecommunication, electronics, and data processing centers, with major concentrations in the Dallas-Fort Worth metroplex. The metroplex is a center for national and international trade, commerce, and finance.

Extensive recreational facilities contribute substantially to the area's economy. Numerous lakes provide opportunities for fishing, boating, and other water sports. Several state parks are also located in the area. These parks are listed on page 21 of this report.

SELECTED NATURAL RESOURCES*

Vegetation and Soils

The natural regions of Texas were delineated largely on the basis of soil types and major vegetation types. Soils in the North-Central Texas area vary from moderately deep to deep soils with loamy surface westward, to soils with loamy or sandy surface layers centrally, to dark, calcareous, mostly cracking clay soils eastward (Godfrey et al. 1973).

As stated in the introduction, the study area includes parts of the following natural subregions: Blackland Prairie, Eastern Cross Timbers, Grand Prairie, Mesquite Plains, Oak Woodlands, and Mixed Pine-Hardwood Forest natural subregions (Figure 2). The topography of the area is generally flat to undulating in the east, becoming gently rolling westward and giving way to hilly terrain along the westernmost margins of the study area (Baker et al. 1990).

The major vegetation types within the study area are: Post Oak Forests-Woods-Grasslands; Silver Bluestem-Texas Wintergrass Grassland; Bluestem Grasslands; Oak-Mesquite-Juniper Parks and Woods; Mesquite-Lotebush Shrub; Live Oak-Ashe Juniper Parks; Pine-Hardwood Forests (McMahan et al. 1984). The scientific names of plants mentioned in this section are listed in Appendix A.

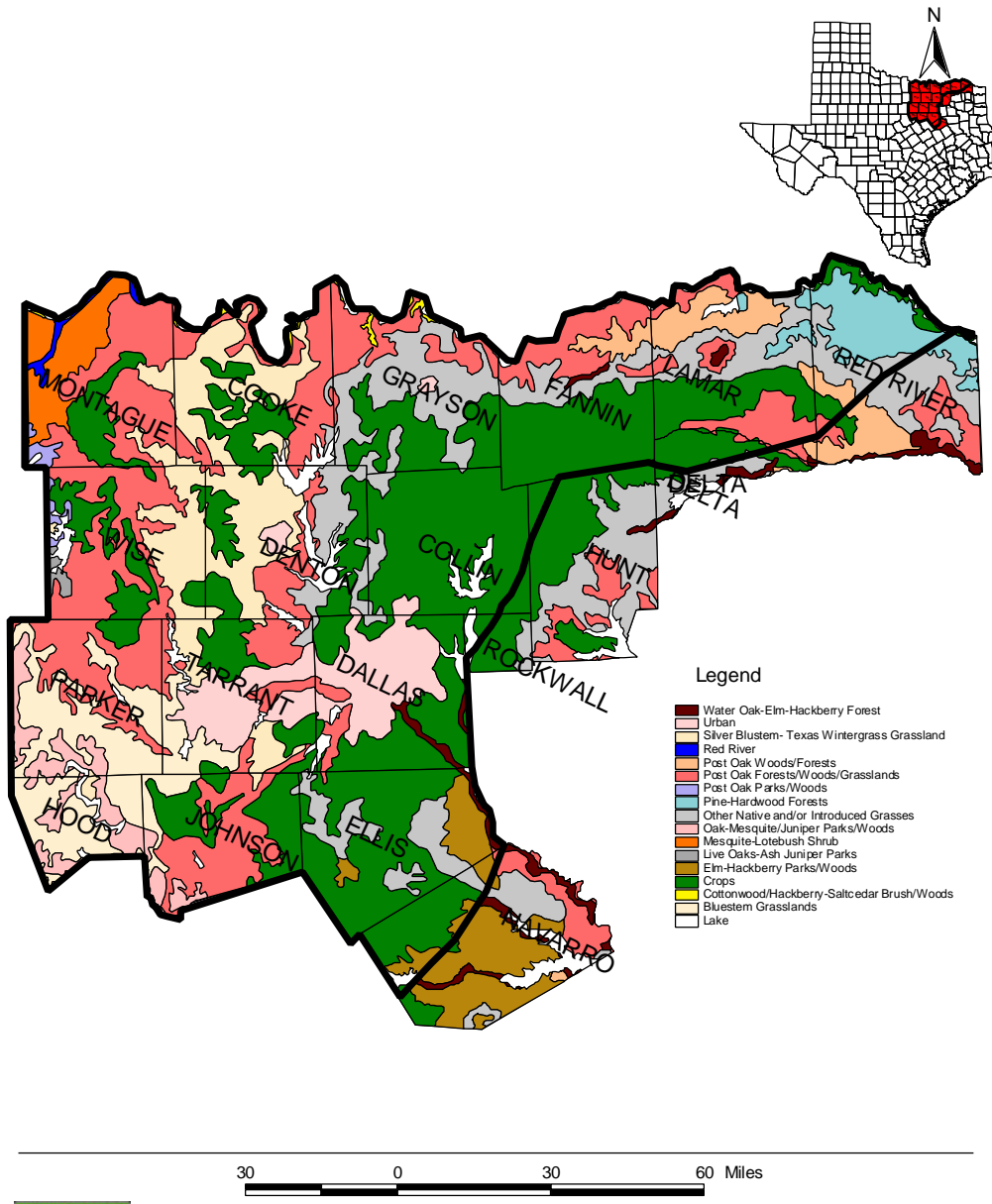
The vegetation map (Figure 3) shows that the Post Oak Forests-Woods-Grasslands type, the Silver Bluestem-Texas Wintergrass Grassland type, and the Bluestem Grasslands type are the dominant or co-dominant types in the study area. The Post Oak Forests-Woods-Grasslands type occurs throughout the study area. Associated species include blackjack oak, eastern redcedar, mesquite, black hickory, live oak, sandjack oak, cedar elm, hackberry, yaupon, poison oak, American beautyberry, hawthorn, supplejack, trumpet creeper, dewberry, coral-berry, little bluestem, silver bluestem, sand lovegrass, beaked panicum, three-awn, spranglegrass, and tickclover (McMahan et al. 1984).

The Silver Bluestem-Texas Wintergrass Grassland type occurs mostly in the northern parts of the study area. Associated species include little bluestem, sideoats grama, Texas grama, three-awn, hairy grama, tall dropseed, buffalograss, windmill grass, hairy tridens, tumblegrass, western ragweed, broom snakeweed, Texas bluebonnet, live oak, post oak, and mesquite (McMahan et al. 1984).

The Bluestem Grassland type occurs extensively in the southwestern part of the study area. Associated species include: bushy bluestem, slender bluestem, little bluestem, silver bluestem, three-awn, buffalograss, bermudagrass, brownseed paspalum, single-spike paspalum, smutgrass, sacahuista, windmill grass, southern dewberry, live oak, mesquite, huisache, baccharis, Macartney rose (McMahan et al. 1984).

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

Figure 3. The Vegetation Types of the Study Area



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

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

Springs

The distribution and size, as of 1980, of springs and seeps in the area are given by county in Table 2 (Brune 1981). Flowing springs are indication of the connection between ground and surface water. Most springs emanate from the top of the groundwater reservoir, so changes in the water table elevation generally have an immediate impact upon spring discharge rates.

Ground water in the area is divided between having high concentrations of calcium bicarbonate and having high concentrations of sodium bicarbonate. Sulfate, fluoride, and iron have been detected in high concentrations in some of the springs. The water for the most part is fresh, moderate hard to hard, and of varying pH (Brune 1981).

Table 2. Distribution and Estimated Size (in 1980) of Springs and Seeps in the Study Area (Brune 1981)

| County | Large | Moderately large | Medium | Small | Very small | Seep | Former |
|-----------|-------|------------------|--------|-------|------------|------|--------|
| Collin | 0 | 0 | 0 | 3 | 10 | 1 | 4 |
| Cooke | 0 | 0 | 0 | 3 | 9 | 3 | 1 |
| Dallas | 0 | 0 | 2 | 6 | 2 | 0 | 4 |
| Delta | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| Denton | 0 | 0 | 0 | 3 | 8 | 1 | 1 |
| Ellis | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Fannin | 0 | 0 | 0 | 3 | 6 | 3 | 1 |
| Grayson | 0 | 0 | 0 | 2 | 12 | 1 | 1 |
| Hood | 0 | 0 | 1 | 1 | 1 | 2 | 1 |
| Hunt | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Johnson | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Lamar | 0 | 0 | 2 | 3 | 2 | 0 | 1 |
| Montague | 0 | 0 | 0 | 2 | 4 | 8 | 2 |
| Navarro* | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Parker | 0 | 0 | 0 | 8 | 3 | 2 | 6 |
| Red River | 0 | 0 | 0 | 1 | 2 | 0 | 1 |
| Rockwall | 0 | 0 | 0 | 0 | 1 | 0 | 2 |
| Tarrant | 0 | 0 | 3 | 6 | 1 | 3 | 5 |
| Wise | 0 | 0 | 0 | 7 | 4 | 3 | 2 |

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

Codes:

Large = 280 to 2,800 cfs

Moderately large = 28 to 280 cfs

Medium = 2.8 to 28 cfs

Former = no flow or inundated

Small = 0.28 to 2.8 cfs

Very Small = 0.028 to 0.28 cfs

Seep = less than 0.028 cfs

A decline in the groundwater table has been noticed throughout the entire study area (Brune 1981). Many of the springs that once were present in the area have now completely dried up. Excessive groundwater pumping and sediment fill-up caused by surface erosion has led to the disappearance of many springs. There has been a noticeable decline in spring-associated riparian habitats in the region (Brune 1981). Better management of groundwater in this region could alleviate this problem

Rivers

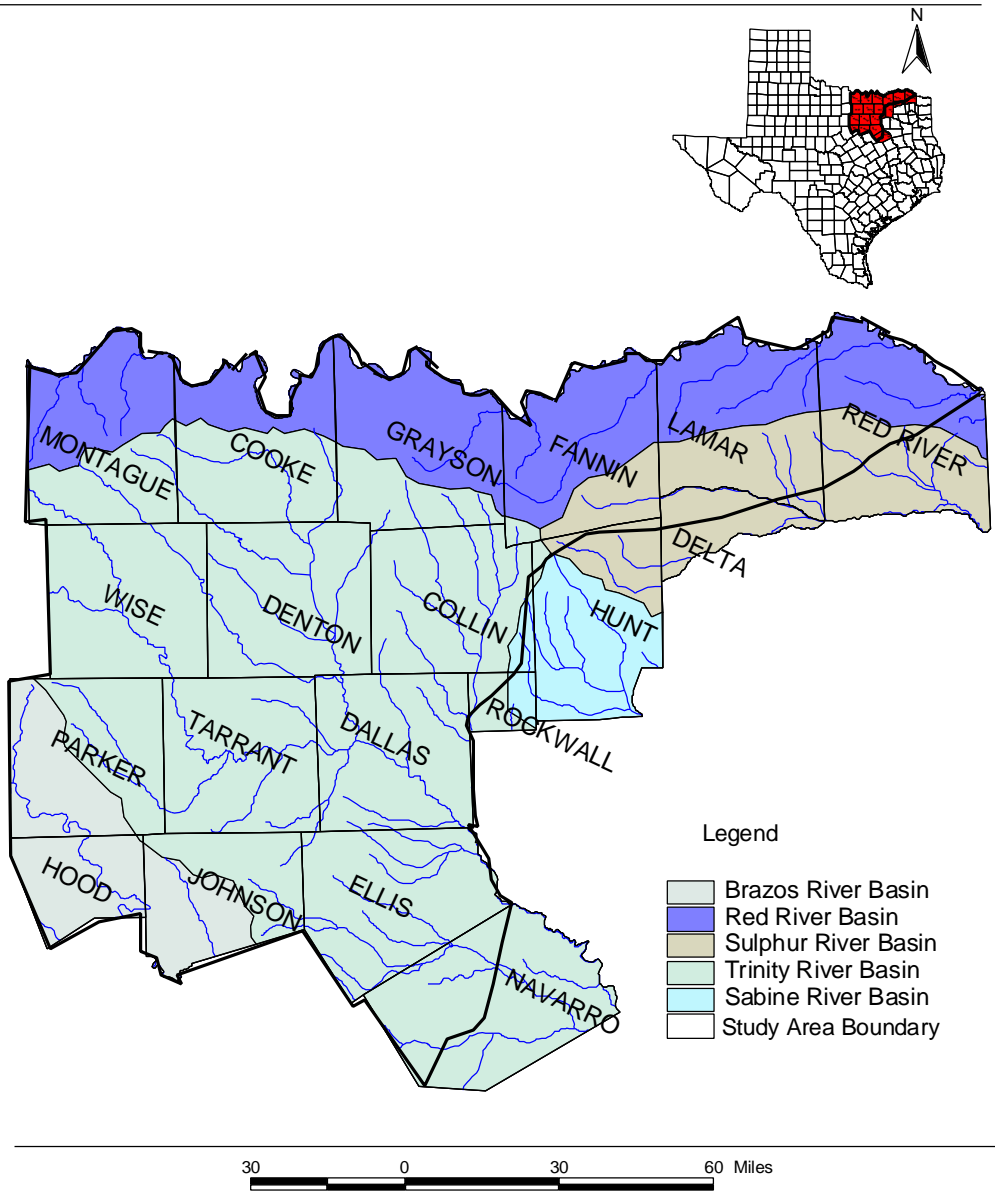
The study area includes four major river basins: the Brazos, Red, Trinity, and Sulphur River basins (Fig. 4). Three major rivers run through the study area (Figure 5). The Brazos River, in the southwest portion of the study area, the Trinity River, from the northwest to the southeast, dividing the study area into two sections, and the Red River along the northern border of the study area.

The Brazos River from Possum Kingdom Dam downstream 90 miles to Lake Granbury is a smallmouth bass fishery and a striped bass spawning run, as well as a prime recreational spot for the region's residents (Bauer et al. 1991). Sanchez Creek from the headwaters to the confluence with the Brazos River, is a pristine and historic area (Bauer et al. 1991).

Within the Trinity River Basin, the Elm Fork Trinity River (headwaters to Ray Roberts Lake), West Fork Trinity River (Lake Bridgeport tailrace to Eagle Mountain), Big Sandy Creek (Amon G. Carter Reservoir tailrace to West Fork of the Trinity River), Spring Creek (Dallas County near Garland), and Tenmile Creek have high water quality, exceptional aquatic life, and high aesthetic value (Bauer et al. 1991).

Within the Red River Basin, the significant stream segments are the following: Red River, upstream 225 miles from Lake Texoma, which is a striped bass spawning and migration segment, with unique saltwater springs; Red River, from Lake Texoma Dam downstream to the Louisiana border, which harbors paddlefish and blue suckers; Shawnee Creek, from the Lake Texoma spillway to Red River (overflow basin), which harbors paddlefish; Rock Creek, headwaters to Red River (8 miles), North Fish Creek, and South Fish Creek, upstream 8 miles from Lake Moss, which are unique segments; and Bois d'Arc Creek, where the Caddo Wildlife Management Area, a unique state holding, is located.

Figure 4. River Basins of the Study Area

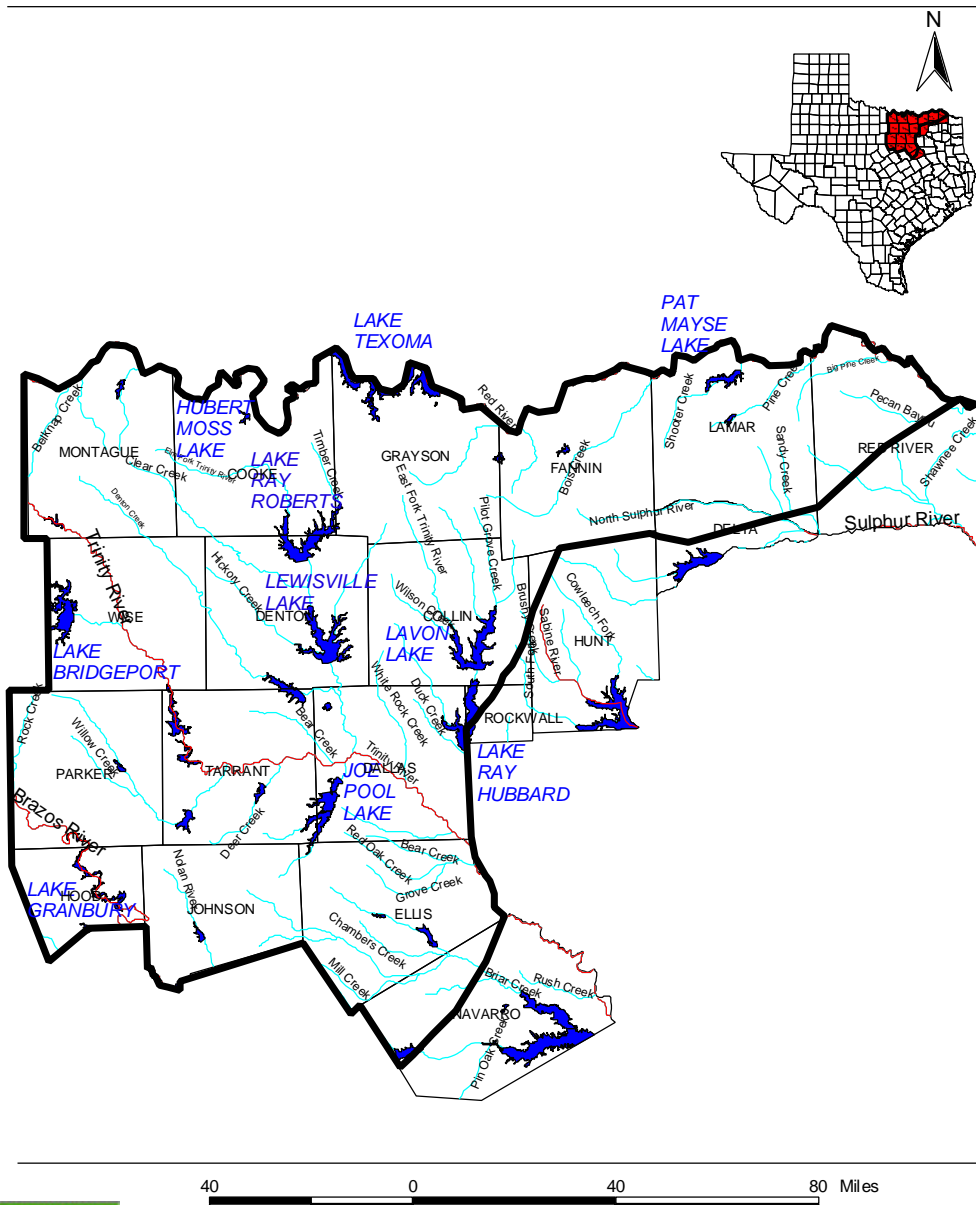


Produced by the TPWD Water Resources Team, July 1998. No claims are made to the accuracy of the data or the suitability of the data for a particular use.

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

Projections:
 Texas Statewide Projection

Figure 5. Surface Water Resources of the Study Area



40 0 40 80 Miles



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

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

Projections:
Texas Statewide Projection

Freshwater Mussels

Freshwater mussels (Family Unionidae) are sensitive biological indicators of environmental quality and are often the first organisms to decline when environmental quality of aquatic ecosystems begins to degrade (Howells 1997). Consequently, freshwater mussels have become important elements of environmental impact considerations. Surveys of mussels in Texas show many of the 52 species recognized in the state have declined greatly in recent years. These population declines probably reflect poor land and water management practices and subsequent loss of mussel habitat (Howells et al. 1997). Over-grazing, the clearing of native vegetation, the design and construction of highways and bridges, and general land clearing and development have contributed to the increase of runoff and scouring floods. Scouring in upstream reaches often results in excessive deposits of soft silt or deep shifting sand on downstream substrates, eliminating mussel habitat. Mussels recently collected in the study area are shown in Table 3.

Table 3. Freshwater Mussels and Asian Clam Recently Collected in the Study Area (Howells In Press)

| Scientific Name | Common Name |
|-------------------------------|---------------------------|
| <i>Amblema plicata</i> | Threeridge |
| <i>Anodonta grandis</i> | Giant floater |
| <i>Anodonta imbecillis</i> | Paper pondshell |
| <i>Arcidens confragosus</i> | Rock-pocket book |
| <i>Arkansia wheeleri</i> | Ouachita rock-pocket book |
| <i>Corbicula</i> sp. | Asian clam |
| <i>Lampsilis hydiana</i> | Louisiana fatmucket |
| <i>Lampsilis teres</i> | Yellow sandshell |
| <i>Leptodea fragilis</i> | Fragile papershell |
| <i>Obliquaria reflexa</i> | Threehorn wartyback |
| <i>Potamilus amphichaenus</i> | Texas heelsplitter |
| <i>Potamilus ohiensis</i> | Pink papershell |
| <i>Potamilus purpuratus</i> | Bleufer |
| <i>Quadrula apiculata</i> | Southern Mapleleaf |
| <i>Quadrula</i> spp. | Pimpleback spp. |
| <i>Toxolasma parvus</i> | Lilliput |
| <i>Toxolasma texasensis</i> | Texas lilliput |
| <i>Truncilla truncata</i> | Deertoe |
| <i>Unio</i> spp. | Pondhorns |

Fish

The study area's rivers and streams support a variety of native and introduced fishes. Table 4 includes a list of the fish species reported from the study area in a number of documents. Six of these species are included on the Special Species List (Table 5) produced by the Texas Parks and Wildlife Department's Wildlife Diversity Program (1998a). These species include the blue sucker, creek chubsucker, western sand darter, blackside darter, paddlefish, and shovelnose sturgeon. All these but the western sand darter are state listed threatened species (Texas Parks and Wildlife Department 1998a). In addition, Hubbs *et al.* (1991) consider logperch and goldeye as species of special concern given their limited distribution in the state (only occurring in the Red River Basin). Blackside darter and shovelnose sturgeon also follow this distribution pattern within the state in that they only occur in the Red River (Hubbs *et al.* 1991). Shovelnose sturgeon have apparently been extirpated from the Red River drainage system upstream of Lake Texoma (Wilde *et al.* 1996).

Table 4. Fish Species Reported in the Study Area (Bayer et al.1992; Hubbs et al. 1991; Kleinsasser and Linam 1992; Linam et al. 1996a; Linam et al. 1996b; Linam and Kleinsasser 1987; Texas Parks and Wildlife Department 1998a)

| Scientific Name | Common Name |
|-------------------------------|-----------------------|
| <i>Ameiurus melas</i> | Black bullhead |
| <i>Ameiurus natalis</i> | Yellow bullhead |
| <i>Ammocrypta clara</i> | Western sand darter |
| <i>Aplodinotus grunniens</i> | Freshwater drum |
| <i>Campostoma anomalum</i> | Central stoneroller |
| <i>Carpionodes carpio</i> | River carpsucker |
| <i>Cycleptus elongatus</i> | Blue sucker |
| <i>Cyprinella lutrensis</i> | Red shiner |
| <i>Cyprinella venusta</i> | Blacktail shiner |
| <i>Cyprinus carpio</i> | Common carp |
| <i>Dorosoma cepedianum</i> | Gizzard shad |
| <i>Dorosoma petenense</i> | Threadfin shad |
| <i>Erimyzon oblongus</i> | Creek chubsucker |
| <i>Etheostoma chlorosomum</i> | Bluntnose darter |
| <i>Etheostoma gracile</i> | Slough darter |
| <i>Etheostoma spectabile</i> | Orangethroat darter |
| <i>Fundulus notatus</i> | Blackstripe topminnow |
| <i>Gambusia affinis</i> | Western mosquitofish |
| <i>Hiodon oblongus</i> | Goldeye |
| <i>Ictalurus furcatus</i> | Blue catfish |
| <i>Ictalurus punctatus</i> | Channel catfish |
| <i>Ictiobus bubalus</i> | Smallmouth buffalo |
| <i>Lepisosteus oculatus</i> | Spotted gar |
| <i>Lepisosteus osseus</i> | Longnose gar |
| <i>Lepisosteus spatula</i> | Alligator gar |
| <i>Lepomis auritus</i> | Redbreast sunfish |

Table 4 continued

| | |
|-------------------------------------|-----------------------|
| <i>Lepomis cyanellus</i> | Green sunfish |
| <i>Lepomis gulosus</i> | Warmouth |
| <i>Lepomis humilis</i> | Orangespotted sunfish |
| <i>Lepomis macrochirus</i> | Bluegill |
| <i>Lepomis megalotis</i> | Longear sunfish |
| <i>Lepomis microlophus</i> | Redear sunfish |
| <i>Menidia beryllina</i> | Inland silverside |
| <i>Micropterus salmoides</i> | Largemouth bass |
| <i>Minytrema melanops</i> | Spotted sucker |
| <i>Morone chrysops</i> | White bass |
| <i>Morone mississippiensis</i> | Yellow bass |
| <i>Morone saxatilis</i> | Striped bass |
| <i>Notemigonus crysoleucas</i> | Golden shiner |
| <i>Noturus gyrinus</i> | Tadpole madtom |
| <i>Noturus nocturnus</i> | Freckled madtom |
| <i>Percina caprodes</i> | Logperch |
| <i>Percina macrolepida</i> | Bigscale logperch |
| <i>Percina maculata</i> | Blackside darter |
| <i>Phenacobius mirabilis</i> | Suckermouth minnow |
| <i>Pimephales vigilax</i> | Bullhead minnow |
| <i>Polyodon spathula</i> | Paddlefish |
| <i>Pomoxis annularis</i> | White crappie |
| <i>Pylodictus olivaris</i> | Flathead catfish |
| <i>Scaphirhynchus platyrhynchus</i> | Shovelnose sturgeon |

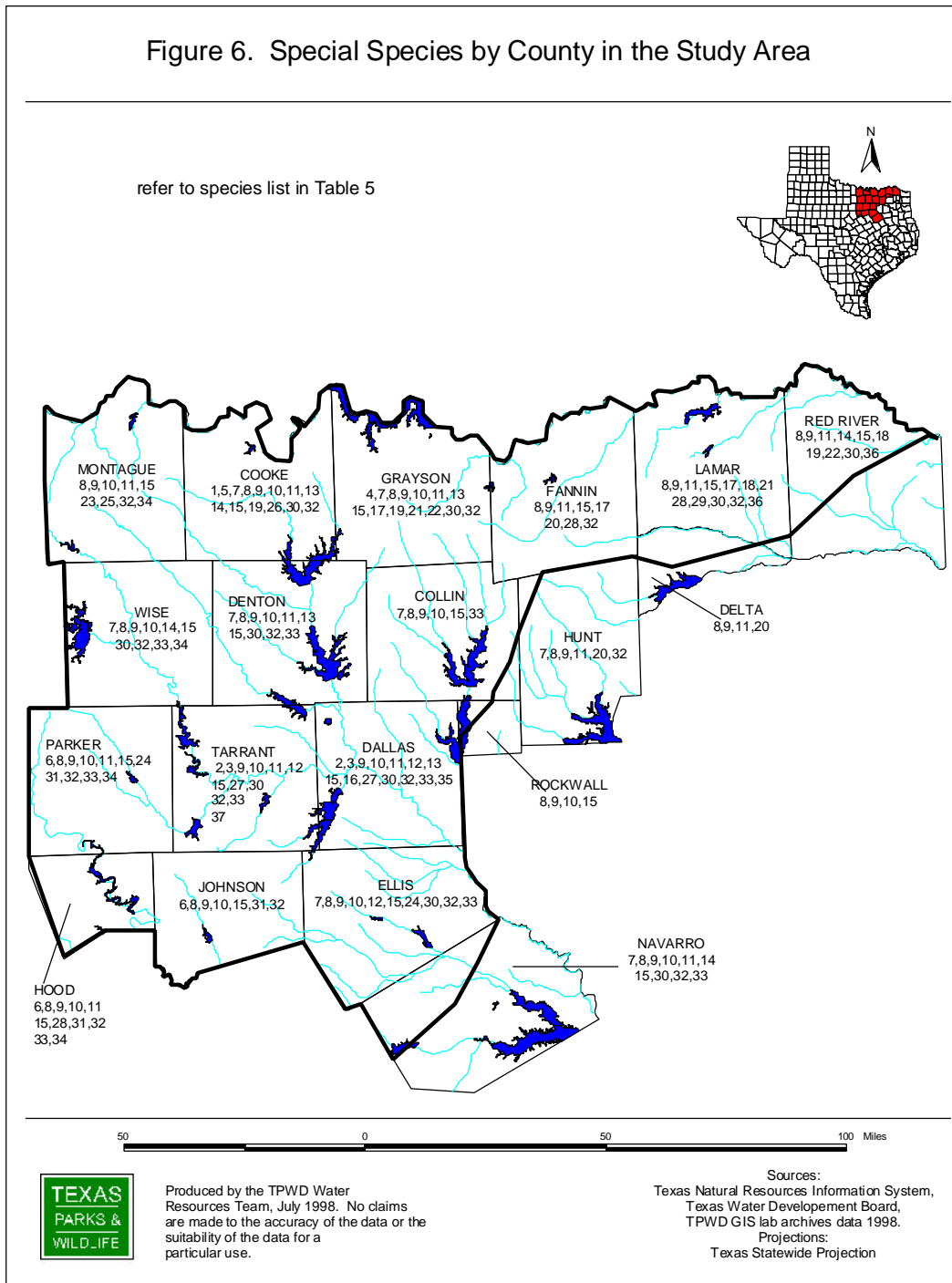
Lake Texoma, an impoundment on the Red River within the study area, is nationally recognized for its striped bass fishery. In 1990, Lake Texoma anglers contributed an estimated \$25.6 million in fishing expenditures to the regional economy; nonregional anglers visiting the reservoir to fish for striped bass accounted for 77 percent of the total expenditures (Schorr et al. 1995).

Table 5. Species** of Special Concern in the Study Area (Texas Parks and Wildlife Department 1998a)

| Map code* | Scientific name | Common name | Fed. Status | State Status |
|------------------------|--|---------------------------------|-------------|--------------|
| BIRDS | | | | |
| 1 | <i>Aimophila aestivalis</i> | Bachman's sparrow | | T |
| 2 | <i>Ammodramus henslowii</i> | Henslow's sparrow | | |
| 3 | <i>Athene cunicularia hypugaea</i> | Western borrowing owl | | |
| 4 | <i>Charadrius melodus</i> | Piping plover | LT | T |
| 5 | <i>Dendroica cerulea</i> | Cerulean warbler | | |
| 6 | <i>Dendroica chrysoparia</i> | Golden-cheeked warbler | LE | E |
| 7 | <i>Falco peregrinus</i> | Pergrine falcon | E/SA | |
| 8 | <i>Falco peregrinus anatum</i> | American peregrine falcon | LE | E |
| 9 | <i>Falco peregrinus tundrius</i> | Arctic peregrine falcon | E/SA | T |
| 10 | <i>Grus americana</i> | Whooping crane | LE | E |
| 11 | <i>Haliaeetus leucocephalus</i> | Bald eagle | LT | T |
| 12 | <i>Lanius ludovicianus migrans</i> | Migrant loggerhead shrike | | |
| 13 | <i>Mycteria americana</i> | Wood stork | | T |
| 14 | <i>Numenius borealis</i> | Eskimo curlew | LE | E |
| 15 | <i>Sterna antillarum athalassos</i> | Interior least tern | LE | E |
| 16 | <i>Vireo atricapillus</i> | Black-capped vireo | LE | E |
| FISHES | | | | |
| 17 | <i>Cycleptus elongatus</i> | Blue sucker | | T |
| 18 | <i>Erimyzon oblongus</i> | Creek chubsucker | | T |
| 19 | <i>Ammocrypta clara</i> | Western sand darter | | |
| 20 | <i>Percina maculata</i> | Blackside darter | | T |
| 21 | <i>Polyodon spathula</i> | Paddlefish | | T |
| 22 | <i>Scaphirhynchus platyrhynchus</i> | Shovelnose sturgeon | | T |
| MAMMALS | | | | |
| 23 | <i>Blarina hylophaga hylophaga</i> | Elliot's short-tailed shrew | | |
| 24 | <i>Canis rufus (extirpated)</i> | Red wolf | LE | E |
| 25 | <i>Dipodomys elator</i> | Texas kangaroo rat | | T |
| 26 | <i>Mustela nigripes</i> | Black-footed ferret | LE | E |
| 27 | <i>Spilogale putorius interrupta</i> | Plain spotted skunk | | |
| 28 | <i>Ursus americanus</i> | Black bear | T/SA | T |
| MOLLUSKS | | | | |
| 29 | <i>Arkansia wheeleri</i> | Ouachita rock-pocketbook mussel | LE | E |
| REPTILES | | | | |
| 30 | <i>Crotalus horridus</i> | Timber/Canebrake rattlesnake | | T |
| 31 | <i>Nerodia harteri</i> | Brazos water snake | | T |
| 32 | <i>Phrynosoma cornutum</i> | Texas horned lizard | | T |
| 33 | <i>Thamnophis sirtalis annectens</i> | Texas garter snake | | |
| VASCULAR PLANTS | | | | |
| 34 | <i>Dalea reverchonii</i> | Comanche peak prairie-clover | | |
| 35 | <i>Hexalectris wanockii</i> | Warnock's coral root | | |
| 36 | <i>Thalictrum arkansanum</i> | Arkansas meadow-rue | | |
| 37 | <i>Tomanthera auriculata (extirp.)</i> | Auriculate false foxglove | | |

* Lookup code for map of Figure 6. **Species on this list are not necessarily riparian or water dependent
 Status Code: LE, LT – Federally Listed Endangered/Threatened; E/SA – Federally Endangered by Similarity of Appearance; E, T – State Endangered/Threatened

Figure 6. Special Species by County in the Study Area



Birds and Waterfowl

Many species of neotropical songbirds, wintering shorebirds, and a large number of waterfowl (Table 6) stopover in the study area to feed and rest along the river banks and creek bottoms. The Special Species Lists (Texas Parks and Wildlife Department 1998a) for the study area includes 16 birds (Table 5), some of which are riparian and/or wetland dependent. The distribution of these species by county is shown in Figure 6. Several of the birds listed in Table 6 occur in the study area only as migrants (i.g. peregrine falcon, whooping crane). Migrating peregrine falcons utilize wetlands as they prey mostly on ducks and shorebirds. Migrating whooping cranes use wetlands for feeding and roosting (Figure 6).

Table 6. Selected Birds and Waterfowl of the Study Area (Pulich 1988)

| Scientific Names | Common Name |
|-------------------------------------|------------------------------|
| <i>Aix sponsa</i> | Wood duck |
| <i>Anas acuta</i> | Northern pintail |
| <i>Anas americana</i> | American wigeon |
| <i>Anas clypeata</i> | Northern shoveler |
| <i>Anas crecca</i> | Green-winged teal |
| <i>Anas platyrhynchos</i> | Mallard |
| <i>Anas strepera</i> | Gadwall |
| <i>Anser albifrons</i> | Greater white-fronted goose |
| <i>Aythya affinis</i> | Lesser scaup |
| <i>Aythya americana</i> | Redhead |
| <i>Aythya valisineria</i> | Canvasback |
| <i>Branta canadensis</i> | Canada goose |
| <i>Bucephala albeola</i> | Bufflehead |
| <i>Bucephala clangula</i> | Common goldeneye |
| <i>Buteo albicaudatus</i> | White-tailed hawk |
| <i>Chen caerulescens</i> | Snow goose |
| <i>Charadrius melodus</i> | Piping plover |
| <i>Dendrocygna autumnalis</i> | Black-bellied whistling-duck |
| <i>Dendroica magnolia</i> | Magnolia warbler |
| <i>Dendroica pensylvanica</i> | Chestnut-sided warbler |
| <i>Dendroica petechia</i> | Yellow warbler |
| <i>Egretta rufescens</i> | Reddish egret |
| <i>Falco peregrinus</i> | Peregrine falcon |
| <i>Falco peregrinus anatum</i> | American peregrine falcon |
| <i>Falco peregrinus tundrius</i> | Arctic peregrine falcon |
| <i>Grus americana</i> | Whooping crane |
| <i>Haliaeetus leucocephalus</i> | Bald eagle |
| <i>Mergus merganser</i> | Common merganser |
| <i>Mergus serrator</i> | Red-breasted merganser |
| <i>Numenius borealis</i> | Eskimo curlew |
| <i>Oxyura jamaicensis</i> | Ruddy duck |
| <i>Parula americana</i> | Northern parula |
| <i>Sterna antillarum athalassos</i> | Interior least tern |

Mammals, Amphibians, and Reptiles

There are at least 64 species of mammals (Table 7) amphibians (Table 8), and reptiles (Table 9), that are either aquatic, semi-aquatic, or in some way wetland-dependent, present in the study area. None of the riparian or water-dependent mammals in Table 7 are on the Special Species List. Table 9 includes two reptiles that are listed in the Special Species List (Table 5), the Brazos water snake and the Texas garter snake. Figure 6 shows the county distribution of those species listed on the Special Species List.

Table 7. Selected Mammals of the Study Area
(Texas ParksAnd Wildlife Department 1998a)

| Scientific Name | Common Name |
|-------------------------------|--------------------|
| <i>Castor canadensis</i> | American beaver |
| <i>Cryptotis parva</i> | Least shrew |
| <i>Mustela vison</i> | Mink |
| <i>Myocastor coypus</i> | Nutria |
| <i>Ondatra zibethicus</i> | Muskrat |
| <i>Oryzomys palustris</i> | Marsh rice rat |
| <i>Pipistrellus subflavus</i> | Eastern pipistrell |
| <i>Scalopus aquaticus</i> | Eastern mole |
| <i>Sylvilagus aquaticus</i> | Swamp rabbit |

Table 8. Selected Amphibians of the Study Area (Texas Parks and Wildlife Department 1998a)

| Scientific Name | Common Name |
|----------------------------------|-------------------------------|
| <i>Acris crepitans</i> | Northern cricket frog |
| <i>Ambystoma maculatum</i> | Spotted salamander |
| <i>Ambystoma opacum</i> | Marbled salamander |
| <i>Ambystoma talpoideum</i> | Mole salamander |
| <i>Ambystoma texanum</i> | Smallmouth salamander |
| <i>Ambystoma tigrinum</i> | Tiger salamander |
| <i>Amphiuma tridactylum</i> | Three-toed amphiuma |
| <i>Bufo americanus</i> | American toad |
| <i>Bufo valliceps</i> | Gulf coast toad |
| <i>Bufo woodhousii</i> | Woodhouse's toad |
| <i>Desmognathus auriculatus</i> | Southern dusky salamander |
| <i>Gastrophyrne carolinensis</i> | Eastern narrowmouth toad |
| <i>Gastrophyrne olivacea</i> | Great plains narrowmouth toad |
| <i>Hyla chrysoscelis</i> | Cope's gray treefrog |
| <i>Hyla cinerea</i> | Green treefrog |
| <i>Hyla squirella</i> | Squirrel treefrog |
| <i>Hyla versicolor</i> | Northern gray treefrog |
| <i>Notophthalmus viridescens</i> | Eastern newt |

Table 8 continued

| | |
|------------------------------|------------------------|
| <i>Pseudacris clarkii</i> | Spotted chorus frog |
| <i>Pseudacris streckeri</i> | Strecker's chorus frog |
| <i>Pseudacris triseriata</i> | Striped chorus frog |
| <i>Rana blairi</i> | Plains leopard frog |
| <i>Rana catesbeiana</i> | Bullfrog |
| <i>Rana clamitans</i> | Green frog |
| <i>Rana palustris</i> | Pickerel frog |
| <i>Scaphiopus couchii</i> | Couch's spadefoot |
| <i>Scaphiopus holbrookii</i> | Eastern spadefoot |
| <i>Siren intermedia</i> | Lesser siren |

Table 9. Selected Reptiles of the Study Area (Texas Parks and Wildlife Department 1998a; Garrett and Barker 1987)

| Scientific Name | Common Name |
|--|-------------------------|
| <i>Agkistrodon contortrix</i> | Copperhead |
| <i>Agkistrodon piscivorus</i> | Cottonmouth |
| <i>Alligator mississippiensis</i> | American alligator |
| <i>Chelydra serpentina</i> | Snapping turtle |
| <i>Deirochelys reticularia</i> | Chicken turtle |
| <i>Eumeces obsoletus</i> | Great plains skink |
| <i>Farancia abacura</i> | Mud snake |
| <i>Graptemys pseudogeographica</i> | False map turtle |
| <i>Graptemys pseudogeographica kohni</i> | Mississippi map turtle |
| <i>Kinosternon flavescens</i> | Yellow mud turtle |
| <i>Kinosternon subrubrum</i> | Eastern mud turtle |
| <i>Nerodia erythrogaster</i> | Plainbelly water snake |
| <i>Nerodia fasciata</i> | Southern water snake |
| <i>Nerodia harteri</i> | Brazos water snake |
| <i>Nerodia rhombifer</i> | Diamondback water snake |
| <i>Nerodia sipedon</i> | Northern water snake |
| <i>Nerodia sipedon pleuralis</i> | Midland water snake |
| <i>Pseudemys concinna</i> | River cooter |
| <i>Pseudemys texana</i> | Texas river cooter |
| <i>Regina grahamii</i> | Graham's crayfish snake |
| <i>Sternotherus carinatus</i> | Razorback musk turtle |
| <i>Sternotherus odoratus</i> | Common musk turtle |
| <i>Thamnophis proximus</i> | Western ribbon snake |
| <i>Thamnophis sirtalis</i> | Common garter snake |
| <i>Thamnophis sirtalis annectens</i> | Texas garter snake |
| <i>Trionyx muticus</i> | Smooth softshell |
| <i>Trionyx spiniferus</i> | Spiny softshell |

TPWD Regional Facilities

Within the study area, TPWD operates six state parks (Figure 7): Bonham State Park (SP), Cedar Hill SP, Cleburne SP, Eisenhower SP, Lake Mineral Wells SP, and Lake Ray Roberts SP. TPWD also operates two Wildlife Management Areas (WMA) (Figure 7): Pat Mayse WMA, and Lake Ray Roberts WMA, and one State Historic Park (SHP), Eisenhower Birthplace SHP. These facilities require water to operate and provide recreational opportunities to the public, as well as to maintain a healthy fauna and flora. Water-based recreation in these public lands draw many visitors.

Bonham SP (261 acres) is located northeast of Dallas in Fannin County. The park consists of rolling prairies, woodlands, and a 65-acre, man-made lake. Bonham SP is situated within the Blackland Prairie Natural Region. Numerous wildflowers and flowering shrubs are present during the springtime. A variety of outdoor activities are available including swimming, fishing, boating, paddle boating, canoeing, camping, and mountain biking (Texas Parks and Wildlife Department 1998b).

Cedar Hill SP (1,826 acres) is located on the east shore of the 7,500-acre Joe Pool Reservoir in Dallas County. The park is an ideal destination for families due to the close proximity to the metroplex. Penn Farm, located within the park, offers a glimpse into agrarian history as machinery took the place of the animal. The park is also home to the premier compost demonstration site in the nation. The site offers step by step examples in the process of composting. The park also offers boating, swimming, mountain biking, bird watching, and picnicking (Texas Parks and Wildlife Department 1998b).

Cleburne SP (528.8 acres) includes a 116-acre, spring-fed lake, located southwest of Fort Worth, in Johnson County. The park offers a variety of activities including hiking, camping, picnicking, swimming, boating, nature study, mountain biking, sand volleyball, softball, and fishing (Texas Parks and Wildlife Department 1998b).

Eisenhower SP (423.1 acres) is located on the shores of Lake Texoma, northwest of Denison, in Grayson County. Park activities include hiking, biking, fishing, picnicking, nature study, boating, water skiing, swimming, camping, and wildlife observation. Eisenhower Yacht Club is located within the park, and provides a variety of boating services (Texas Parks and Wildlife Department 1998b).

Lake Minerals Wells SP (3,282.5 acres) is located east of Mineral Wells in Parker County along Rock Creek, and encompasses Lake Mineral Wells. Park activities include camping, swimming, fishing, boating, rock climbing, mountain biking, equestrian camping, horseback riding, and hiking. Lake Mineral Wells State Trailway is connected to the park, which provides 20 miles of trail for the hiker, equestrian, or mountain biker (Texas Parks and Wildlife Department 1998b).

Ray Roberts Lake SP is located on Ray Roberts Lake in Denton and Cooke counties. The park is composed of two separate units, Isle du Bois (2,263 acres) located on the south side of the lake and the Johnson Branch unit (1,514 acres) located on the north side of the lake.

Park activities include picnicking, camping, hiking, roller blading, swimming, boating, fishing, and backpacking (Texas Parks and Wildlife Department 1998b).

Pat Mayse WMA is located in northwestern Lamar County approximately 12 miles northwest of Paris, Texas. The WMA contains 8,925 acres of land and water. The WMA is adjacent to and includes part of the upper end of Pat Mayse Reservoir. The area contains upland habitat of post oak woods, oil fields, and some creek bottom habitat. Public hunting and fishing is permitted in the area (Texas Parks and Wildlife Department 1998b).

Ray Roberts WMA (41,220 acres) is located adjacent to Lake Ray Roberts north of Denton within Cooke, Denton, and Grayson Counties. Public hunting is permitted for dove, quail, woodcock, snipe, waterfowl, rabbits, hare, feral hogs, squirrels, and frogs. Other activities include hiking, fishing, and wildlife viewing (Texas Parks and Wildlife Department 1998b).

Eisenhower SHP (6 acres) is located off US 75 in Denison, in Grayson County. The tours that are provided to view the birthplace of Eisenhower are the main attraction of the park. Weddings, receptions, and meetings are also held at the park (Texas Parks and Wildlife Department 1998b).

Estimates of the economic importance of some of these parks to the counties of the study area are shown in Table 10 (Crompton et al. 1998). The economic impact parameter estimates the infusion of “new money” into the local economy by out-of-county visitors to the parks. It is a more realistic indicator of economic importance than “economic surge” which also includes expenditures by local visitors. More detailed breakdowns of the data summarized in Table 10 are given in Appendix B. No economic data are available for the WMAs.

These facilities will become more economically important to this region as the metroplex population continues to grow and demand expanded recreational opportunities.

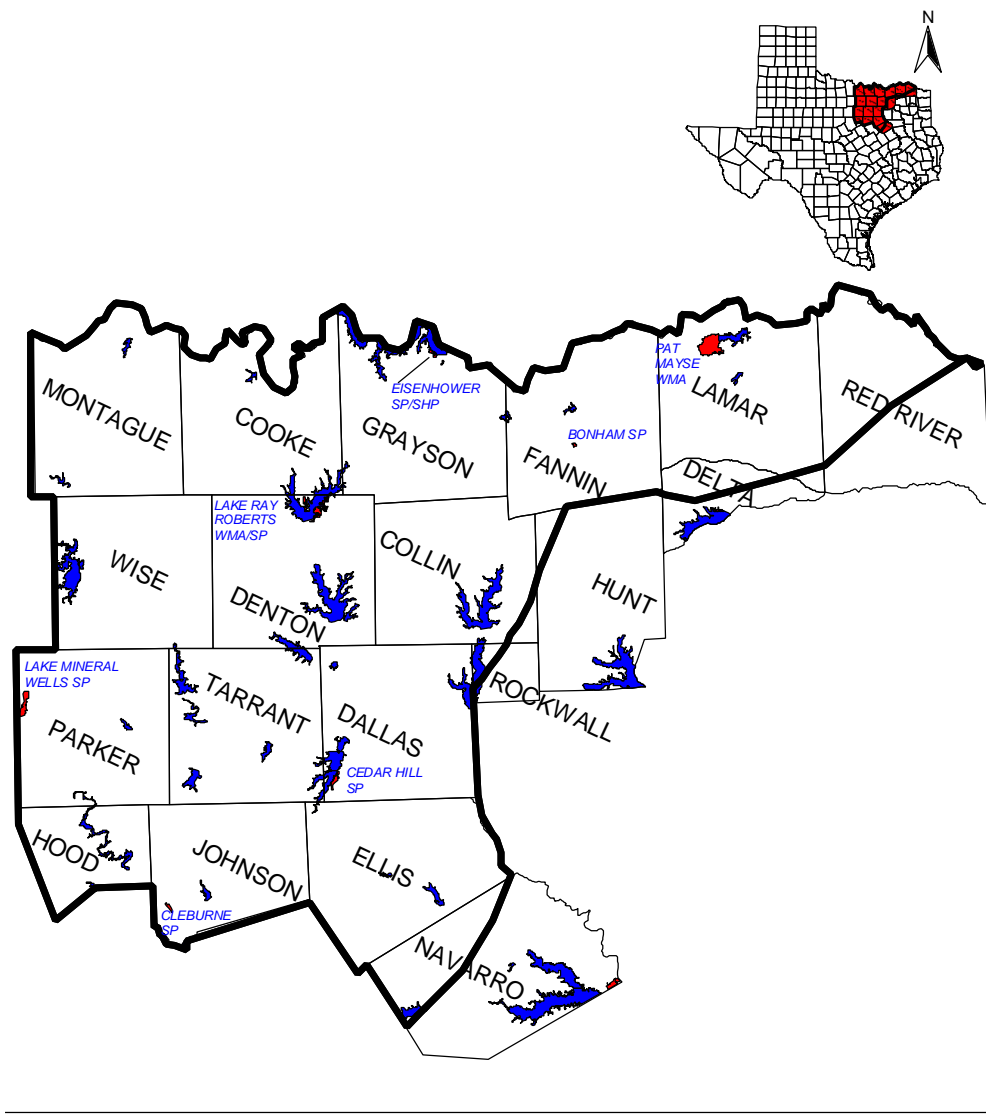
Table 10. Summary of 1997 Estimated Economic Importance (Impact and Surge) of Selected TPWD Facilities in the Study Area (Crompton et al. 1998)

| Facility | Total Visitors | Total Expenditures (\$) | Total Sales (\$) | Total Personal Income (\$) | Total Employment (persons) |
|--------------------------|---------------------------|--|-----------------------------|---|---|
| <u>Lake</u> | | | | | |
| <u>Mineral</u> | | | | | |
| <u>Wells SP</u> | | | | | |
| Impact | 442,629 | 1,735,334 | 3,907,085 | 1,123,284 | 84.9 |
| Surge | 442,629 | 1,941,147 | 4,370,425 | 1,258,736 | 95 |
| <u>Eisenhower</u> | | | | | |
| <u>SRA*</u> | | | | | |
| Impact | 477,806 | 1,827,550 | 3,788,115 | 1,195,496 | 82.3 |
| Surge | 477,806 | 2,641,885 | 5,470,354 | 1,726,868 | 118.6 |
| <u>Eisenhower</u> | | | | | |
| <u>SHP*</u> | | | | | |
| Impact | 35,919 | 279,011 | 577,644 | 180,651 | 12.4 |
| Surge | 35,919 | 310,012 | 641,827 | 200,724 | 13.8 |
| <u>Ray</u> | | | | | |
| <u>Roberts SP</u> | | | | | |
| Impact | ----- | 1,393,483 | 3,765,304 | 1,123,157 | 70.9 |

*SRA - State Recreational Area

*SHP- State Historic Park

Figure 7. Location of TPWD Facilities in the Study Area



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

Sources:
TPWD GIS lab archives data 1998.

Projections:
Texas Statewide Projection
(Lambert Conformal Conic)

Conclusions

While few species are directly dependent upon the groundwater resources of the study area, the springs that emanate from the groundwater reserves contribute to the surface water hydrology and have helped to shape the ecosystems that exist in the study area. Reduced springflow can result from overpumping of the aquifers of the area which can subsequently affect surface water flows. Long term decreases in flow can exacerbate water quality problems and impact the species that are directly and indirectly dependent upon freshwater resources. In addition, human uses can be affected due to diminished recreational opportunities, increased levels of required water treatment, and decreased quantities of usable water. Reduced groundwater reserves and quality also has economic consequences.

There is a trend to less dependence upon groundwater from the Trinity Group aquifer, and more dependence upon surface water. The construction of Joe Pool Lake, Richland-Chambers Reservoir, Cooper Reservoir, and Ray Roberts Lake demonstrate this shift. However, the construction of reservoirs has negative impacts upon some important natural resources. Forested wetlands and other habitats are inundated. Native stream and river fishes are deprived of their natural habitat. Reduced base flows below dams alters downstream aquatic, wetland, and upland habitats. Also, reduced base flows ultimately impact the estuarine habitats of our coastal bays.

Declaration of the study area as a PGMA could lead to a more efficient use of the existing water resources in the area. It could also help protect the ground and surface water quality of the region. However, in an area that is experiencing this type of population growth, conjunctive use and significant water conservation measures will have to be implemented in the near future to stretch the limited water supply.

Protecting the quality and quantity of the ground and surface water of the study area are important goals. The implementation of protection and management strategies will ultimately safeguard other natural and economic resources in the area that are either directly or indirectly influenced by groundwater.

References

- Baker, B., G. Duffin, R. Flores, and T. Lynch. 1990. Evaluation of Water Resources in Part of North-Central Texas. Report 318, Texas Water Development Board, Austin, Texas.
- Bauer J., R. Frye, and B. Spain. 1991. A Natural Resource Survey for Proposed Reservoir Sites and Selected Stream Segments in Texas. Texas Parks and Wildlife Dept., PWD-BK-0300-06 7/91, Austin, Texas.
- Bayer, C.W., J.R. Davis, S.R. Twidwell, R. Kleinsasser, G. Linam, K. Mayes, and E. Hornig. 1992. Texas Aquatic Ecoregion Project: An Assessment of Least Disturbed Streams. Texas Water Commission, Austin. Texas Parks and Wildlife Department, Austin. U.S. Environmental Protection Agency, region VI, Dallas, Texas.
- Brune, G. 1981. Springs of Texas: Vol. I. Branch-Smith, Inc. Fort Worth, Texas.
- Crompton, J.L., T. Var, and S. Lee. 1998. Repositioning TPWD and Local Park and Recreation Agencies. Texas A&M Univ., Dept. of Recreation, Parks and Tourism Sciences, College Station, Texas.
- Dallas Morning News. 1997. Texas Almanac. Texas A&M Consortium, College Station, Texas.
- Garrett J.M. and D.G. Barker. 1987. A Field Guide to Reptiles and Amphibians of Texas. Texas Monthly Fieldguide Series. Gulf Publishing Company. Houston, Texas.
- Godfrey, C.L., G.S. Mackree, and H. Oaks. 1973. General Soil Map of Texas. Texas Agricultural Experiment Station, Texas A&M University and the Soil Conservation Service, U.S. Department of Agriculture.
- Howells, R.G. (In Press). Texas Parks and Wildlife Department.
- Howells, R.G. 1997. Freshwater Mussels of the Wichita River, Texas, with Comments on the Little Wichita and Pease Rivers. Texas Parks and Wildlife Department, Inland Fisheries Division, Management Data Series No. 142, Austin, Texas.
- Howells, R.G., C.M. Mather, and J.A.M. Bergmann. 1997. Conservation Status of Selected Freshwater Mussels in Texas. Pages 117-128 in K.S. Cummings, A.C. Buchanan, C.A. Mayer, and T.J. Naimo, eds. Conservation and Management of Freshwater Mussels II: Initiatives for the Future. Proc. of a UMRCC Symposium, 16-18 Oct. 1995, St. Louis, MO. Upper Mississippi River Conservation Committee, Rock Island, Illinois.
- Hubbs, C., R.J. Edwards, and G. P. Garrett. 1991. An Annotated Checklist of the Freshwater Fishes of Texas, with Keys to Identification of Species. The Texas Journal of Science. 43(4): Supplement.

Kleinsasser, L. J., and G. W. Linam. 1992. Effects of Dechlorination of Municipal Wastewater Effluents on Fish Communities in the Trinity River, Texas. River Studies Report No. 7. Resource Protection Division, Texas Parks and Wildlife Department, Austin, Texas.

Linam, G.W., and L.J. Kleinsasser. 1987. Fisheries Use Attainability Study for the Nolands River (Segment 1227). River Studies Report No. 2. Resource Protection Division, Texas Parks and Wildlife Department, Austin, Texas.

Linam, G.W., J.R. Seaman, L.J. Kleinsasser, and K. Aziz. 1996a. Aquatic Survey Results from Fort Wolters, Parker County, Texas. River Studies Report No. 15g. Resource Protection Division, Texas Parks and Wildlife Department, Austin, Texas.

Linam, G.W., J.R. Seaman, R. Cantu, L.J. Kleinsasser, and K.L. Portis. 1996b. Aquatic Survey Results from Camp Maxey, Lamar County, Texas. River Studies Report No. 15e. Resource Protection Division, Texas Parks and Wildlife Department, Austin, Texas.

Lyndon B. Johnson School of Public Affairs. 1978. Preserving Texas' Natural Heritage. Natural Heritage Policy Research Project Report No. 31, Univ. of Texas at Austin.

McMahan, C.A., R. Frye, and K.L. Brown. 1984. The Vegetation Types of Texas Including Cropland: An Illustrated Synopsis to Accompany the Map. Wildlife Division, Texas Parks and Wildlife Department.

Pulich, W.M. 1988. The Birds of North Central Texas. Texas A & M University Press: College Station, Texas.

Schorr, M.S., J. Sah, D.F. Schreiner, M.R. Meador, and L.G. Hill. 1995. Regional Economic Impact of the Lake Texoma (Oklahoma-Texas) Striped Bass Fishery. Fisheries 20:14-18.

Texas Parks and Wildlife Department. 1998a. Texas Biological and Conservation Data System (TXBCD). Texas Parks and Wildlife Department, Austin, Texas.

Texas Parks and Wildlife Department. 1998b. Texas Parks and Historic Sites. [Online] Available at <http://www.tpwd.state.tx.us/park/>.

Texas Water Development Board. 1998. Counties Population Projections In Texas. [Online] Available at <http://www.twdb.state.tx.us>.

Wilde, G.R., R.R. Weller, C.D. Smith, and R. Jimenez, Jr. 1996. Review and Synthesis of Existing Fish Collection Records for the Upper Red River Basin Above Lake Texoma. Dept. of Range, Wildlife, and Fisheries Management, Texas Tech Univ., Lubbock, Texas.

APPENDIX A

Scientific Names of Plants Mentioned (from McMahan et al. 1984)

APPENDIX A

Scientific Names of Plants Mentioned

| | |
|----------------------|---|
| American beautyberry | <i>Callicarpa americana</i> |
| Baccharis | <i>Baccharis</i> spp. |
| Bermudagrass | <i>Cynodon dactylon</i> |
| Bluebonnet, Texas | <i>Lupinus texensis</i> |
| Bluestem, bushy | <i>Andropogon glomeratus</i> |
| _____, little | <i>Schizachyrium scoparium</i> var. <i>frequens</i> |
| _____, silver | <i>Bothriochloa saccharoides</i> |
| _____, slender | <i>Schizachyrium tenerum</i> |
| Buffalograss | <i>Buchloe dactyloides</i> |
| Coral-berry | <i>Symphoricarpos orbiculatus</i> |
| Dewberry | <i>Rubus</i> spp. |
| _____, southern | <i>R. trivialis</i> |
| Dropseed, tall | <i>Sporobolus asper</i> |
| Elm, cedar | <i>Ulmus crassifolia</i> |
| Gramma, hairy | <i>Bouteloua hirsuta</i> |
| _____, sideoats | <i>B. curtipendula</i> |
| _____, Texas | <i>B. rigidiseta</i> |
| Hackberry | <i>Celtis</i> spp. |
| Hawthorn | <i>Crataegus</i> spp. |
| Hickory, black | <i>Carya texana</i> |
| Huisache | <i>Acacia farnesiana</i> |
| Juniper, Ashe | <i>Juniperus ashei</i> |
| Lovegrass, sand | <i>Eragrostis trichodes</i> |
| Mesquite | <i>Prosopis glandulosa</i> |
| Oak, blackjack | <i>Quercus marilandica</i> |
| _____, live | <i>Q. virginiana</i> |
| _____, post | <i>Q. stellata</i> |
| _____, sandjack | <i>Q. incana</i> |
| Panicum, beaked | <i>Panicum anceps</i> |
| Paspalum, brownseed | <i>Paspalum plicatum</i> |

_____, single-spike
Poison oak

Ragweed, western
Redcedar, eastern
Rose, Macartney

Sacahuista
Smutgrass
Snakeweed, broom
Sprangle-grass
Supplejack

Three-awn
Tickclover
Tridens, hairy
Trumpet creeper
Tumblegrass

Windmillgrass
Wintergrass, Texas

Yaupon

P. monostachyum
Rhus toxicodendron

Ambrosia psilostachya
Juniperus virginiana
Rosa bracteata

Spartina spartinae
Sporobolus indicus
Xanthocephalum spp.
Chasmanthium sessiliflorum
Berchemia scandens

Aristida spp.
Desmondium spp.
Tridens sp.
Campsis radicans
Schedonnardus paniculatus

Chloris spp.
Stipa leucotricha

Ilex vomitoria

APPENDIX B

Estimated Economic Importance of Selected State Parks in the Study Area

(From Crompton et al. 1998)