Area Study: Bastrop, Burleson, Lee and Milam Counties

Evaluation of Natural Resources in Bastrop, Burleson, Lee and Milam Counties

Bastrop State Park

TEXAS PARKS AND WILDLIFE DEPARTMENT
RESOURCE PROTECTION DIVISION:
WATER RESOURCES TEAM

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EXECUTIVE SUMMARY

Burgeoning population growth in Texas has increased demand on the limited water resources of the state. Future exports of water from the Carrizo-Wilcox aquifer in areas of Bastrop, Burleson, Lee, and Milam counties are anticipated. In response to these activities, the TPWD compiled this inventory of natural resources data for the affected counties to help identify potential environmental threats from increased pumping of the Carrizo-Wilcox aquifer.

Increased groundwater use will result in a lowering of aquifer levels and, more than likely, a reduction in flow for the existing springs in the study area. In addition, surface water flows that are presently enhanced by groundwater interactions will be reduced. Additional work is needed to more accurately determine the effects of future pumping on surface waters of the study area. As groundwater pumping exceeds recharge, springs, bottomland, wetland, and riparian habitats are at the greatest risk of impact. Another vegetation-type of concern is the Lost Pines, a unique and disjunct loblolly pine forest found in sandy soils of Bastrop County. A thorough analysis of the relationship between groundwater levels is needed to determine whether and to what extent they will be affected by a lowering of the groundwater table.

The flora and fauna of the four counties is typical of the biotic regions and provinces of the area. Aquatic species are generally consistent with their associated drainages. Of the protected species of potential occurrence in the area, two are dependent upon an aquatic environment: the Blue sucker (*Cycleptus elongatus*) and the Houston toad (*Bufo houstonensis*). While the Blue sucker is dependent upon flows of the Colorado River, the Houston toad needs ephemeral or permanent pools of water to survive. The impacts to these species from increased groundwater pumping are expected to be small. However, a more thorough analysis of the role of groundwater in the habitats utilized by the Houston toad is warranted.

In general, the role of groundwater in shaping and maintaining the biotic communities of the study area is unknown. Lowering of the water table will probably have localized rather than regional effects. However, these effects could be pronounced, especially if they involve unique or threatened biotic resources of the area. In addition, the potential effects of lowering the groundwater level in conjunction with changing land use patterns, habitat loss, habitat degradation, and urbanization needs to be further evaluated.

INTRODUCTION

Increasing population growth in Texas has led to an escalating demand on the limited water resources of the state. According to Dutton (1999), groundwater pumpage from the Carrizo-Wilcox aquifer in the study area increased from about 10,000 to 37,200 acre-feet per year between 1988 and 1996. Projections of additional pumping increases by the year 2050 range from 56,000 to 200,000 acre-feet per year (Dutton 1999). The increased pumping will result from water demand related to growth in population and the expansion of industry within the area; water withdrawal by Alcoa, Inc. for transfer to the San Antonio Water System (SAWS); water demands in Williamson County; and other potential future demands (TWDB 1997, Dutton 1999).

Planning for these demands for water often occurs with limited consideration of the potential environmental consequences of specific actions. This is especially true with regard to groundwater, due in large part to current and historical groundwater law, policy, and regulation. Recently, SAWS contracted with Alcoa, Inc. for up to 90,000 acre-feet per annum of Carrizo-Wilcox groundwater. Additional exports of water from the Carrizo-Wilcox aquifer in areas of Bastrop, Burleson, Lee, and Milam counties have been proposed. In response to these activities, the TPWD compiled this inventory of natural resources data for the affected counties to help identify potential environmental threats associated with increased pumping from the Carrizo-Wilcox aquifer.

STUDY AREA

The study area is composed of Bastrop, Burleson, Lee and Milam counties (Figure 1) in Central Texas. It includes portions of the Brazos, Colorado, and the Guadalupe river basins (Figure 2) and covers 3,199.2 square miles (Dallas Morning News 1997). Four major rivers run through the study area: the Brazos, Little, San Gabriel, and Colorado. The area is underlain by portions of the Carrizo-Wilcox, Trinity, Brazos River Alluvium, Queen City, and Sparta aquifers.

In general, the land surface of the study area is rolling to hilly with partially level terrain in east central Milam County (Dallas Morning News 1997). Elevations range from about 221 feet above mean sea level (msl) in Burleson County to greater than 280 feet msl in Bastrop County (Dallas Morning News 1997).

Long, hot summers and short, mild winters characterize the study area's weather. The average daily minimum temperature for January is about 36°F and the average daily maximum temperature for July is about 94°F throughout the study area. The average annual minimum temperature for the area is approximately 57°F and the average annual maximum temperature is approximately 79°F. The average annual precipitation ranges from 34.2 inches in the northwest to 39.1 inches in the east (Dallas Morning News 1997) with an average annual precipitation for the region of approximately 36 inches per year.

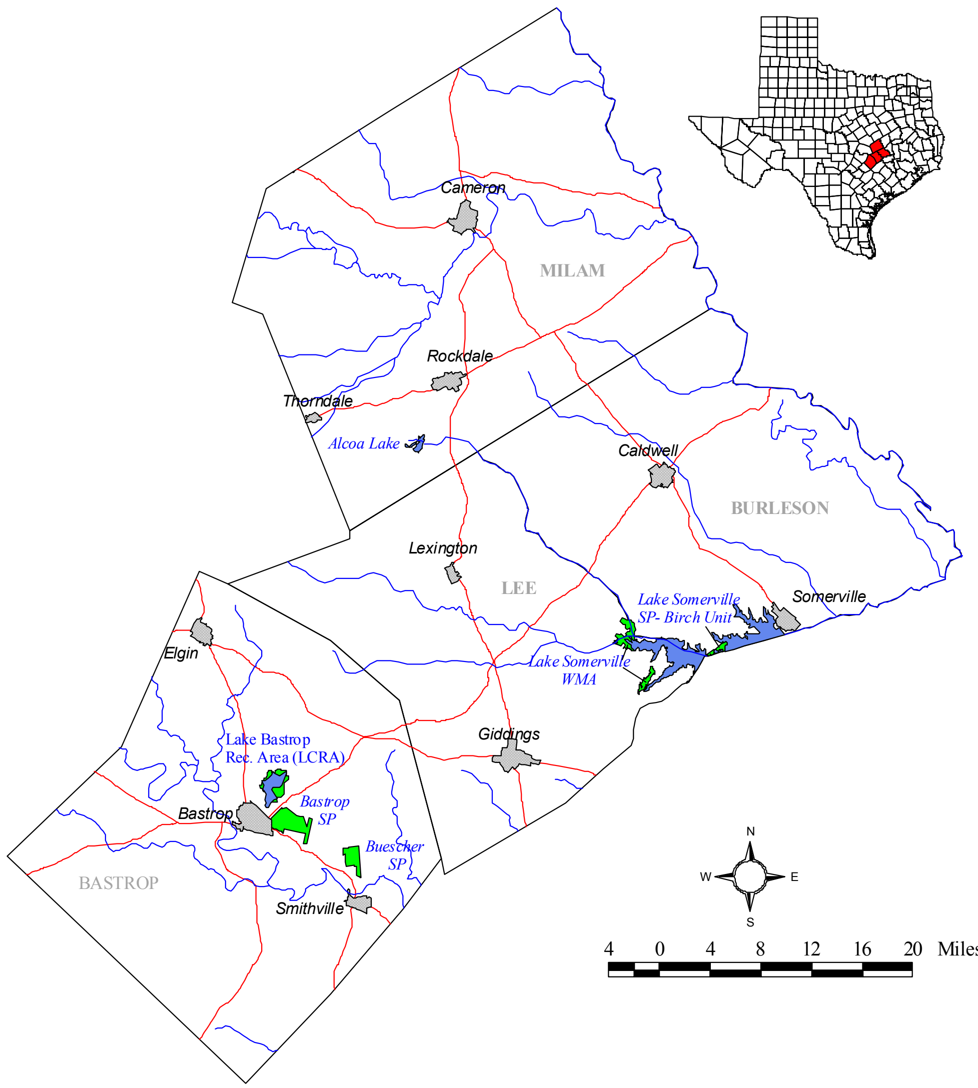
POPULATION

Population projections for counties within the study area are given in Table 1. The population of Bastrop County is projected to increase by more than 250% by year 2050 with more moderate increases in population for Burleson, Lee, and Milam Counties. The populations of other regions in the state are expected to grow at similar rates.

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

County ⇓	**Year ⇒ City ⇓**	**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Bastrop		38,263	51,627	63,901	77,030	89,779	97,624	106,153
	Bastrop	4,044	6,308	7,843	9,470	11,049	12,022	14,762
	Elgin	4,846	6,287	7,358	8,619	9,889	10,637	12,913
	Garfield	103	150	187	227	265	288	354
	Smithville	3,196	4,296	4,748	5,597	6,354	6,787	8,180
	County-Other	26,074	34,586	43,765	53,117	62,222	67,890	69,944
Burleson		13,625	14,914	16,089	17,210	18,107	18,754	20,056
	Caldwell	3,181	3,609	3,901	4,180	4,402	4,562	4,728
	Somerville	1,542	1,596	1,835	1,991	2,316	2,311	2,306
	County-Other	8,902	9,709	10,353	11,039	11,389	11,881	13,022
Lee		12,854	14,133	15,894	17,176	18,144	19,408	20,812
	Giddings	4,093	4,476	4,936	5,379	5,746	6,146	6,591
	Lexington	953	1,052	1,160	1,264	1,351	1,445	1,549
	County-Other	7,808	8,605	9,798	10,533	11,047	11,817	12,672
Milam		22,946	25,413	27,156	28,409	29,445	30,307	31,126
	Cameron	5,580	5,963	6,117	6,260	6,416	6,569	6,726
	Rockdale	5,235	6,382	6,967	7,474	7,992	8,488	9,015
	Thorndale	1,092	1,291	1,357	1,415	1,447	1,535	1,592
	County-Other	11,039	11,777	12,715	13,260	13,560	13,715	13,793

Figure 1. Map of the Study Area



Produced by the TPWD Water Resources Team, June 1999. 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 1998.
Texas Water Development Board
Texas Natural Resources Information System
Projection:
Texas Statewide Projection

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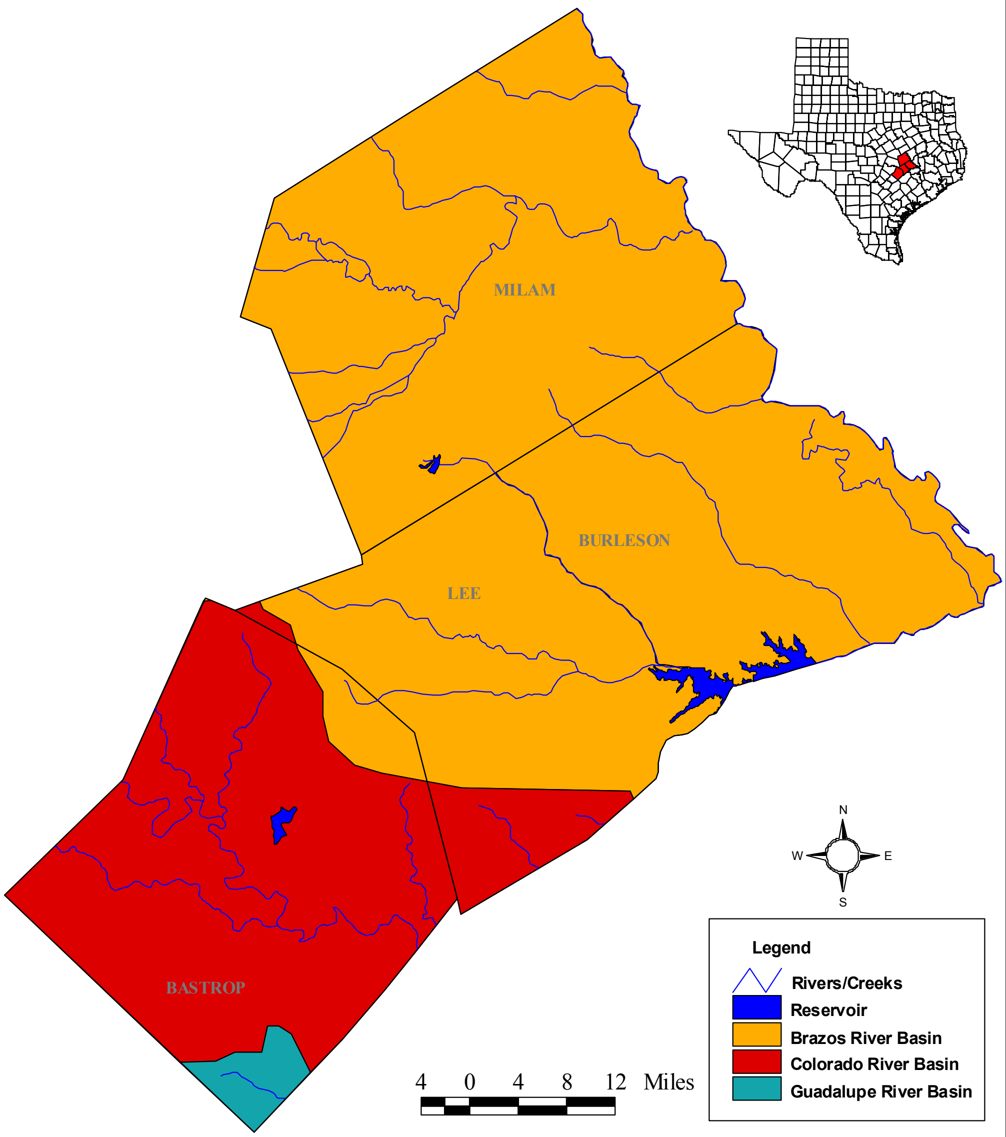
Figure 2. River Basins Crossing the Study Area



TEXAS PARKS & WILDLIFE

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Sources:
TPWD GIS Lab archives data 1998.
Texas Water Development Board
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ECONOMY AND LAND USE

The economy of the area consists primarily of agribusiness and tourism. Agricultural production is varied. It consists of cattle, poultry, goats, peanuts, hay, corn, sorghum, wheat, and oats. Hay is the principal crop. The market value for agriculture in the study area is around $125.3 million (Dallas Morning News 1997). Irrigation demands in the area are predicted to decline in the next 50 years (TWDB 1998).

TPWD REGIONAL FACILITIES

Outdoor recreational facilities contribute to the area's economy. Within the study area, TPWD operates three state parks (Figure 1): Bastrop State Park (SP), Buescher SP, and Lake Somerville SP. TPWD also maintains the Lake Somerville Wildlife Management Area (WMA). Another recreation area in the region is LCRA's Lake Bastrop Recreation Area. These facilities provide water and nature-based recreational opportunities to the public. Estimates of the economic contribution of the state parks to the counties of the study area are shown in Table 2. The economic impact parameter estimates the infusion of new money into the local economy by out-of-county visitors to the parks. The economic surge parameter includes expenditures by local visitors. The economic income parameter gives a more realistic estimate of the economic value of the parks (Crompton et. al. 1998). No economic data is available for the Wildlife Management Areas.

Bastrop SP is located near the town of Bastrop in Bastrop County. The park is a wooded 3,504 acre tract that contains portions of the Lost Pines; a unique 70 square-mile forest of loblolly pines. These pines are separated from the main body of East Texas pines by 100 miles of rolling post oak woodlands. The park also contains populations of the endangered Houston toad (*Bufo houstonensis*). The Lost Pines and the Houston toad are probably the most unique, and perhaps threatened, natural resources of the study area. The park was opened in 1937 and offers opportunities for backpacking, camping, picnicking, fishing, canoeing, swimming, golfing, wildlife viewing, hiking, and special tours. The park contains a 10-acre pond (TPWD 1998b). Total visitation to the park in 1997 was 566,215. The number of visitors that stayed overnight was 50,788. The direct economic impact of the Bastrop SP visitors in 1997 was $1,553,900 (Crompton et. al. 1998).

Buescher SP is located just north of Smithville in Bastrop County. The park contains approximately 1017 acres. The park provides opportunities for fishing, swimming, boating, camping, and hiking. The park has a seasonal distribution of over 250 species of birds, which makes it a prime location for bird watching. A scenic 13-mile long winding and hilly paved road between Buescher and Bastrop SP is ideal for biking (TPWD 1998b). The number of visitors to Buescher SP in 1997 was 276,591. The number of visitors staying overnight was 21,359 (Crompton et. al. 1998). The direct economic impact of the visitors was $255,658 (Crompton et. al. 1998).

Lake Somerville SP consists of three units: the Birch Creek Unit, the Nails Creek Unit, and the Somerville WMA/Trailway. The park is located northwest of Brenham in Lee and Burleson Counties and is adjacent to Somerville Lake. The lake covers 11,640 acres with 985 miles of shoreline. Birch Creek Unit, on the north shore of the lake, consists of 2,365 acres in Burleson

County. The Nails Creek Unit is in Lee County and consists of 3,155 acres on the south shore of the reservoir near the western end. The 14-mile Lake Somerville Trailway System connects the two units. The Birch and Nails Creek units offer hiking, boating, fishing, swimming, skiing, mountain biking, horseback riding, camping, picnicking, and volleyball. The Somerville WMA consists of 3,180 acres with the Yegua Creek Unit (2,030 acres) in southwest Burleson County and the Nails Creek Unit (1,150 acres) in northeast Lee County. The primary purpose of the WMA is to serve as a public hunting area (TPWD 1998b). Total visitation in 1997 to Somerville SP was 344,460. The direct economic impact of the visitors was $463,094 (Crompton et. al. 1998).

Table 2. 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)
Bastrop SP					
Impact	566,215	748,966	1,553,900	426,328	37.31
Surge	566,215	1,433,708	2,987,597	843,724	72.36
Buescher SP					
Impact	276,591	129,463	255,658	74,435	5.80
Surge	276,591	381,671	759,138	219,617	17.39
Lake Somerville SP (Birch Unit)					
Impact	258,419	219,989	372,605	110,060	10.29
Surge	258,419	300,340	509,401	150,631	14.12
Lake Somerville SP (Nails Unit)					
Impact	86,041	243,105	375,432	118,985	8.79
Surge	86,041	291,351	449,710	412,625	10.51

CARRIZO-WILCOX AQUIFER

The Carrizo-Wilcox aquifer is one of Texas' major aquifer systems (Figures 3&4). It extends from the Rio Grande in South Texas northeastward into Arkansas and Louisiana, providing water to all or parts of 60 counties. The Carrizo Formation overlies the Wilcox Group along a narrow band that parallels the Gulf Coast and dips beneath the land surface toward the coast, except in the East Texas structural basin adjacent to the Sabine Uplift, where the formations form a trough (TWDB 1997). The aquifer is one of several that are at least partially located in Bastrop, Burleson, Lee, and Milam counties.

According to Kier and Larkin (1998), there is little or no connection between the Carrizo Sand and the Simsboro (Wilcox) Sand. The Wilcox Group is an ancient delta complex. The Wilcox sediments exposed at the surface and in the shallow subsurface are fine to coarse sand, sandy clay, and shale with lenses of lignite and limestone (Kier and Larkin 1998). Between the

Trinity River to just south of the Colorado River, which encompasses the study area, the Wilcox consists of three formations: the Hooper Formation, the Simsboro Formation, and the Calvert Bluff Formation.

For the study area, the Simsboro Formation is of the greatest interest. The Simsboro is the major water producing formation of the Wilcox and most high capacity users pump from it (Kier and Larkin 1998). The Simsboro Formation is mostly sand and is commonly 100 to 700 feet thick. From Kier and Larkin (1998), Kaiser (1978) states that the maximum thickness of the Simsboro in East Central Texas is in Milam County where it can exceed 700 feet. The total amount of sand decreases in a southwesterly direction, and the thickness can be as little as 100 feet in Bastrop County, but is typically 175 to 300 feet (Kier and Larkin 1998).

In contrast to the Wilcox, the Carrizo Formation is fluvial in origin. The Carrizo Sand is light to dark gray, fine to coarse grained, loose, poorly sorted, and thickly bedded (Kier and Larkin 1998). The Carrizo forms a massive continuous sheet of sand over the study area (Thorkildsen and Price 1991). Kier and Larkin (1998) cites Barnes (1974) as saying that the formation is about 100 feet thick in Bastrop County, and Follet (1970) as reporting a maximum thickness of 375 feet.

According to Dutton (1999) groundwater pumpage from the Carrizo-Wilcox aquifer in the study area increased from about 10,000 to 37,200 acre-feet per year between 1988 and 1996. Projections of additional pumping increases by the year 2050 range from 56,000 to 200,000 acre-feet per year (Dutton 1999). Estimates as to the amount of water available in the portion of the Carrizo-Wilcox aquifer in the study area vary. Concomitantly, the availability of water differs with management goals. At some point, however, pumpage exceeds recharge and results in mining of the aquifer. Estimates of total aquifer storage approximate 86 million acre-feet (LCRA 1998, Follett 1970, Kier and Larson 1998). Estimates of daily groundwater available range from 61 acre-feet (LCRA 1998) to 137 acre-feet (TDWR 1979). Effective recharge rates have been estimated to be 50,100 acre-feet per year, although Kier and Larson (1998) believe that this number may be too high.

Aquifers in Central Texas

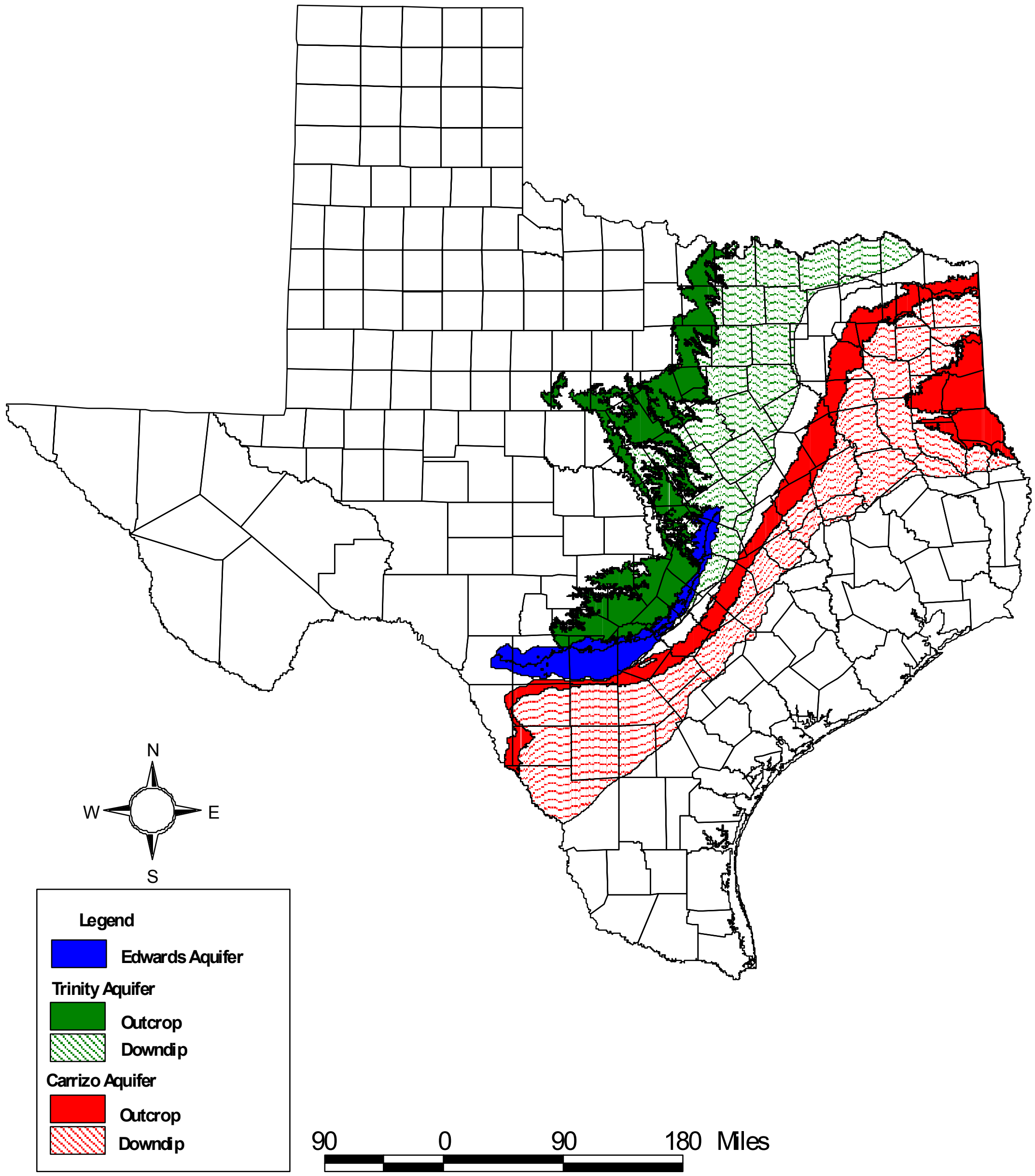
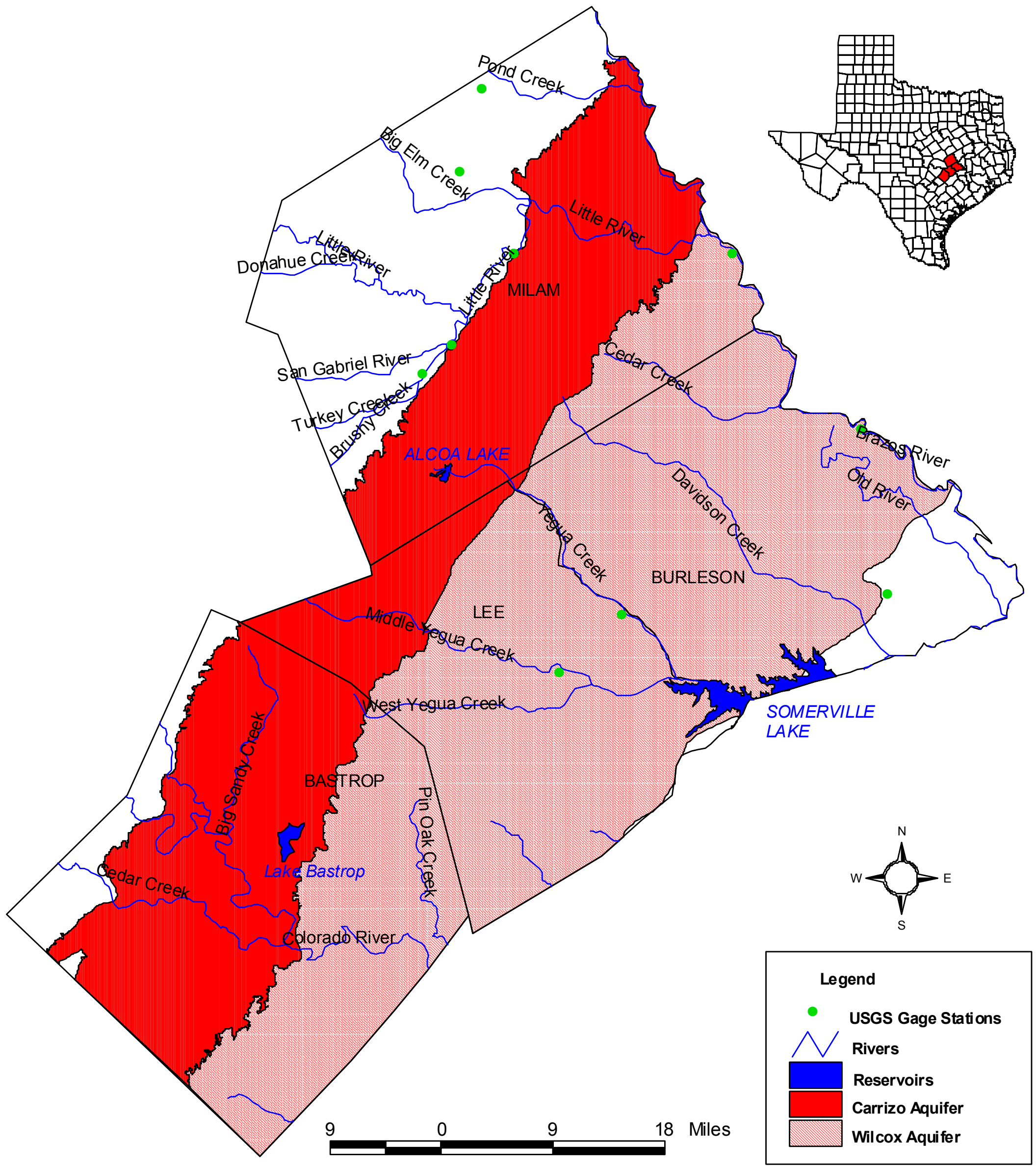


Figure 6. Water Resources



Produced by the TPWD Water Resources Team, June 1999. 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.
Texas Water Development Board
Texas Natural Resources Information System
EPA-823-C-98-008
Projection:
Texas Statewide Projection

Currently, the Carrizo-Wilcox aquifer system within the study area is nearly full and takes a limited amount of recharge. The Carrizo-Wilcox aquifer underlies most of the major streams in the study area (Figure 4). Most of the flowlines associated with the various formations show that groundwater flow paths are directed towards rivers and creeks. Thus, the natural discharge from the aquifer in the area is ultimately to the rivers of the study area (Kier and Larson 1998). Only a small portion of recharge is not discharged through creeks, springs, seeps, or evapotranspiration (Kier and Larson 1998). River bottomlands act as groundwater discharge areas, and groundwater provides varying amounts of base flow to streams of the Brazos, Colorado, and Guadalupe river basins. Smaller streams have a seasonal variability with regard to surface water-groundwater interactions (Dutton 1999). Under the modeling scenarios used by Dutton (1999), streams in the study area go from gaining to losing with regard to groundwater. The calculations show a net gain by the streams of approximately 26,000 acre-feet in 1996 to a loss in year 2050 of approximately 30,000 acre-feet. Dutton states that additional work is needed to more accurately determine the effects of future pumping on surface waters of the study area.

SPRINGS

Brune identified major springs of Texas in his reports of 1976 and 1981. From his work, the distribution and size of springs and seeps in the study area are given in Table 3 (Brune 1981). No contemporary reports of springs in the study area were available. According to Brune (1981), the majority of springs in the area are small or very small, with discharges of less than 2.8 cubic feet per second (cfs). Brune (1981) identified larger springs in Bastrop County than in the other counties in the study area, with six springs with flows between 2.8 cfs and 28 cfs. Bastrop County springs issue chiefly from Quaternary terrace sand and gravel along the Colorado River and from Tertiary or Eocene sands such as the Wilcox, Carrizo, Reklaw, and Cook Mountain. Spring water in the county is generally fresh and hard with high calcium and bicarbonate concentrations. Fluoride content is usually elevated, and the iron content may be very high (Brune 1981).

Burleson County has one reported spring (Brune 1975, 1981), Sour or Spring Lake Springs. This spring, located about 5 miles northwest of Caldwell, discharges from the Sparta aquifer and has numerous openings. Flow from the spring is generally low, but varies considerably with precipitation. Springs in Lee County issue chiefly from Quaternary terrace sand and gravel along major rivers and from Tertiary Eocene sands such as the Wilcox, Carrizo, and Sparta in the northwest part of the county. Not many springs are found in the southeast part of the county, as the formations here are largely composed of clay (Brune 1981). Most of Milam County springs issue from Tertiary Eocene sands, especially the Carrizo and Wilcox. Others originate from Quaternary Terrace gravel and sand along major rivers (Brune 1981).

Table 3. Distribution and estimated size (in 1980) of springs and seeps in the study area (Brune 1975, Brune 1981)

County	Large	Moderately large	Medium	Small	Very small	Seep	Former
Bastrop	0	0	6	2	4	0	0
Burleson	0	0	0	0	1	0	0
Lee	0	0	0	5	6	0	0
Milam	0	0	0	6	5	0	2

The numbers above are a reflection of either a spring or a group of springs.
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

Most springs emanate from the top of the groundwater table, so changes in water table elevation generally have an immediate impact upon spring discharge rates. In portions of the Carrizo-Wilcox aquifer outside of the study area, significant water-level declines have developed due to pumping. Since 1920 in the semiarid Winter Garden portion of the Carrizo aquifer, water levels have declined as much as 100 feet, and more than 250 feet near Crystal City in Zavala County. Significant water-level declines also have occurred in northeast Texas due to extensive municipal and industrial pumping. Tyler and the Lufkin-Nacogdoches area have experienced declines in excess of 400 feet and, in a few wells, as much as 500 feet since the 1940s (TWDB 1997).

In the study area, flowing wells and heavy well pumping have caused a decline in the water table in Milam County. As a consequence the springs in the county flow at greatly decreased rates, and a large number have ceased flowing (Brune 1981). Future increases in pumping will produce similar results throughout the study area. Decreases in spring flow can affect fish and wildlife habitats that are associated with the springs. In the study area, the species of most concern with regard to decreasing spring flows is the Houston toad. Additional work needs to be conducted in the study area to ascertain the connection of biological resources, existing springs, and groundwater seeps.

SURFACE WATERS

The study area includes parts of three river basins: the Brazos, Colorado, and Guadalupe (Figure 2). Major streams in the study area (Figure 4) are the Brazos River, Little River, San Gabriel River, Brushy Creek, and Yegua Creek within the Brazos River Basin; and the Colorado River. Numerous smaller streams are also found in the area’s four counties. Lake Bastrop, Somerville Reservoir, and Alcoa Lake are the largest reservoirs in the area.

Brazos River Basin

All of Milam and Burleson counties and most of Lee County are in the Brazos River Basin. The Brazos River forms the eastern boundary of the study area. This portion of the river is a part of Water Quality Classified Stream Segment 1242 as identified by the Texas Natural Resources Conservation Commission (TNRCC) (1996). The segment is classified as water quality limited due to water quality standards violations. Designated uses for the segment are for contact recreation, high quality aquatic life, and as a public water supply. For the segment as a whole, which runs from Whitney Dam to the confluence with the Navasota River, as of August 31, 1994 there were a total of 67 wastewater outfalls with an authorized discharge amount of 1490.47 million gallons pre day (MGD). Elevated fecal coliform bacteria densities from near Marlin to Cameron cause nonsupport of the contact recreation use (TNRCC 1996). This segment is used by striped bass for migratory spawning runs (Bauer et. al. 1991).

Yegua Creek is located downstream of Somerville Dam and forms the southern boundary of the study area in Burleson County. Yegua Creek is Water Quality Classified Stream Segment 1211 (TNRCC 1996). The segment is classified as effluent limited meaning that it is currently meeting water quality standards. Designated uses for the segment are for contact recreation, high aquatic life, and as a public water supply. As of August 31, 1994 there were three wastewater outfalls on Yegua Creek with a combined permitted discharge of 1.09 MGD (TNRCC 1996). Orthophosphorus concentrations that are higher than the TNRCC screening criteria sometimes occur in the lower portions of the segment (TNRCC 1996).

East Yegua Creek currently receives groundwater discharge from Alcoa's mine of approximately 30,000 acre-feet per year. No detailed studies are available to evaluate the extent of the aquatic community that has developed in response to the increased flows in East Yegua Creek. If the mine is closed or water is exported to San Antonio, the amount of water in the stream will diminish. This will result in a more natural hydrologic regime for the creek and the subsequent loss of habitat in the stream.

Somerville Lake is Water Quality Classified Stream Segment 1212 (TNRCC 1996). The reservoir impounds Yegua Creek and has a drainage area of 1007 square miles (USGS 1999). The reservoir was completed in 1967. Somerville Lake is classified as water quality limited due to its use as a public water supply. Other designated uses include for contact recreation and for high aquatic life. The lake is also used for flood control. The lake covers 11,460 acres and has a capacity of 160,100 acre-feet of water (TWDB 1997). At the top of the flood pool, the lake covers 24,400 acres. As of August 31, 1994 there were nine permitted facilities with a combined authorized discharge of 1.37 MGD into the lake. The TNRCC has detected elevated levels of chlorophyll a in the upper portions of the reservoir (TNRCC 1996).

The Little River is Water Quality Classified Stream Segment 1213 and crosses the study area in Milam County where it flows into the Brazos River. The segment is classified as water quality limited due to water quality standards violations (TNRCC 1996). Designated uses for the segment are for contact recreation, high aquatic life, and as a public water supply. As of August 31, 1994 there were 14 permitted wastewater outfalls in this portion of the Little River with an authorized discharge of 9.73 MGD (TNRCC 1996). Elevated levels of fecal coliform bacteria and nitrogen and phosphorus concentrations higher than TNRCC screening criteria occur downstream of the City of Cameron (TNRCC 1996). The TPWD has identified the Little River in the study area as an ecologically significant stream due to its thriving mussel population (TPWD 1999a)

The San Gabriel River, Water Quality Classified Stream Segment 1214, flows through Milam County into the Little River. Segment 1214 extends from the confluence with the Little River to Granger Lake Dam in Williamson County. The segment is classified as water quality limited because advanced waste treatment is required in order to meet water quality standards. Designated uses are for contact recreation, high aquatic life, and as a public water supply. As of August 31, 1994 there were no permitted facilities discharging into this portion of the San Gabriel River. Elevated levels of nitrate nitrogen and ortho and total phosphorus occur in the segment (TNRCC 1996).

The elevated nutrient concentrations in the San Gabriel River enter the stream via Brushy Creek. Brushy Creek is Water Quality Classified Stream Segment 1244 and extends from the confluence with the San Gabriel River in Milam County to the confluence with South Brushy Creek in Williamson County. The segment is classified as water quality limited due to water quality standards violations and the need for advanced waste treatment to meet water quality standards. Designated uses are for contact recreation, high aquatic life, and as a public water supply. As of August 31, 1994 there were 15 permitted outfalls on Brushy Creek with an authorized discharge amount of 30.90 MGD. Elevated phosphorus and nitrogen levels occur downstream of Round Rock to the San Gabriel River confluence. These high nutrient levels contribute to excessive growths of attached algae in the segment (TNRCC 1996).

Colorado River Basin

Most of Bastrop County and the southern portion of Lee County are in the Colorado River Basin. The Colorado River originates in New Mexico and flows approximately 900 miles to the Gulf of Mexico near Bay City, Texas. The lower 300 miles of the river, which includes the study area, are unimpounded. However, flows through this portion of the river are effected by the Highland Lakes, and specifically regulated by Buchanan and Mansfield Dams. Buchanan Dam was completed in 1937 and Mansfield Dam was completed in 1940 (Mosier and Ray 1992).

Within the study area, the Colorado River is divided into two classified stream segments. The Colorado River downstream of Town Lake in Austin is Water Quality Classified Stream Segment 1428. The segment extends from Longhorn Dam to just upstream of FM 969 near Utley in Bastrop County. The segment is classified as water quality limited due to water quality standards violations and the need for advanced waste treatment to meet water quality standards. Designated uses for this part of the Colorado River are for contact recreation, exceptional aquatic life, and as a public water supply. As of August 31, 1994 there were 34 permitted outfalls in this segment with a combined discharge rate of 1481.93 MGD. The segment only partially supports the exceptional aquatic life use due to silver concentrations downstream of Webberville that exceed the segment criteria. In addition, nitrate plus nitrite and phosphorus concentrations from the confluence with Walnut Creek to the end of the segment are elevated, and DDE in sediments downstream of Webberville exceed the TNRCC's screening level (TNRCC 1996).

The Colorado River downstream of Segment 1428 to La Grange is Water Quality Classified Stream Segment 1434. The segment is classified as water quality limited due to the need for advanced waste treatment to meet water quality standards. Designated uses are for contact recreation, exceptional aquatic life, and as a public water supply. As of August 31, 1994 there were no permitted discharges on this portion of the river. The contact recreation use immediately downstream of Bastrop and Smithville is only partially supported due to high levels of fecal coliforms; and nitrate plus nitrite and phosphorus concentrations exceed the TNRCC's screening criteria throughout the segment (TNRCC 1996). The Colorado River throughout the study area has been identified by the TPWD as an ecologically significant stream segment due to the presence of the state threatened blue sucker and the stream segment's overall use (TPWD 1999a)

The LCRA in conjunction with the TPWD and the TNRCC conducted a study of the Colorado River downstream of the City of Austin to determine minimum streamflow needs to maintain water quality and fish habitat in the river. The study results were incorporated into the LCRA's Water Management Plan, as were the results of a study by the LCRA on the freshwater inflow requirements of Matagorda Bay (LCRA 1998). For instream purposes, the Water Management Plan identified two schedules of flow: target flows and critical (subsistence) flows (Table 4). Target flows create an optimal range of habitat complexity to support a balanced, native aquatic community. Target flows are met when Lake Buchanan and Lake Travis are greater than 80% full. At lower reservoir capacities, subsistence or critical flows are provided. These flows are more or less for water quality maintenance purposes, without consideration for the biota of the river or habitat requirements. Critical flows are significantly less than target flows.

Table 4. Recommended flows for the Colorado River at Bastrop (Mosier and Ray 1992).

MONTH	Subsistence/Critical Flow (cfs)	Target Flow (cfs)
January	120	370
February	120	430
March	500a	560
April	500a	600
May	500a	1030
June	120	830
July	120	370
August	120	240
September	120	400
October	120	470
November	120	370
December	120	340

a. This flow should be maintained for a continuous period of no less than six weeks during these months. A flow of 120 cfs will be maintained on all days not within the six-week period.

Most of the natural discharge from the Carrizo-Wilcox aquifer in the study area ultimately flows to the region's rivers and streams (Kier and Larson 1998). River bottomlands act as groundwater discharge areas, and groundwater provides varying amounts of base flow to the Brazos, Colorado, and Guadalupe rivers. Under the modeling scenarios used by Dutton (1999), streams in the study area go from gaining to losing with regard to groundwater. The calculations show a net gain by the streams of approximately 26,000 acre-feet in 1996 to a loss in year 2050 of approximately 30,000 acre-feet. This represents a net change of approximately 56,000 acre-feet per year of surface water from current conditions. The loss of this contributing flow would affect the hydrology and biology of large and small streams in the study area.

WETLANDS

Several wetland types occur in the four county study area. These include bottomland hardwood forests, swamps, marshes, bogs, springs, and riparian areas. Wetlands are found along rivers, streams, lakes, and ponds; in upland depressions where surface water accumulates; and at points of groundwater discharge. Wetlands in the area may be permanent or ephemeral and support both aquatic and upland plant and animal species (TPWD 1999d).

Within the state, and the study area, the most common wetland type is bottomland hardwood forest, which are dominated by bottomland hardwood trees that grow in floodplain areas (TPWD 1999d). The typical overstory in these wetlands is composed of such species as pecan, water oak, post oak, live oak, willow oak, American elm, green ash, cedar elm, black willow, deciduous holly, hawthorns, and sugar hackberry. The understory and shrub strata are composed of saplings of the overstory, sugar hackberry, yaupon, green ash, and box elder. Vine species common in this habitat type include greenbriars, poison-ivy, mustang grape and Alabama supplejack. The herbaceous stratum of the bottomland hardwood areas is generally sparse, depending on canopy cover and abundance of leaf litter. Sedges, Missouri violet, common chickweed, and white crownbeard are the most common herbaceous species (Aluminum Company of America 1998; D.W. Moulton personal observation).

Bogs are sometimes associated with bottomland hardwood forests. These systems are usually wet throughout the year due to groundwater seepage (TPWD 1999d). Plant species found in bogs include red maple, wax myrtle, alder, bladderworts, orchids, ferns, and irises (TPWD 1999d). Two well-known peat bogs, Patschke and Boriak Bogs, occur in Milam County in the Middle Yegua Creek drainage, just west of the town of Lexington.

Freshwater marshes are also found in the study area. Freshwater marshes often contain cutgrass in deeper portions of the marsh along with smartweed, arrow arum, soft rush, spikerushes, arrowhead, and plumegrass in the shallower reaches (TPWD 1999d). At Somerville Lake SP and WMA, 14 wetland compartments have been constructed in the Yegua and Nails Creek drainages. In addition, Flag Pond on the Nails Creek Unit, is a valuable aquatic and wetland resource, which is scheduled for further development by TPWD, the Corp of Engineer (COE), and Ducks Unlimited. The intent is to manage Flag Pond, using long water control structures, to provide habitat for waterfowl, wading birds, reptiles, amphibians, and other fauna typical of the region.

Wetlands in the study area perform numerous functions for fish and wildlife resources, water quality enhancement, and flood attenuation. In the study area, wetlands are also important as breeding habitat for the endangered Houston toad. Bottomland hardwood forests buffer water from human activities and generally exhibit a high degree of productivity and biodiversity. Development and maintenance of wetlands is often dependent upon shallow groundwater tables, springs and seeps, and surface flows. In general, threats to wetlands come from a variety of anthropomorphic sources that include changing land use patterns, alterations in surface water hydrology, and the lowering of groundwater tables. Dutton (1999) identified river bottoms as groundwater discharge areas, and the connection between springs and groundwater level has previously been noted. Without knowing the degree of connection between groundwater and surface water in the study area, the extent of impact to wetlands in

Bastrop, Burleson, Lee, and Milam counties from future groundwater pumping is difficult to quantify. Additional study is required to further understand the connection between groundwater and surface water.

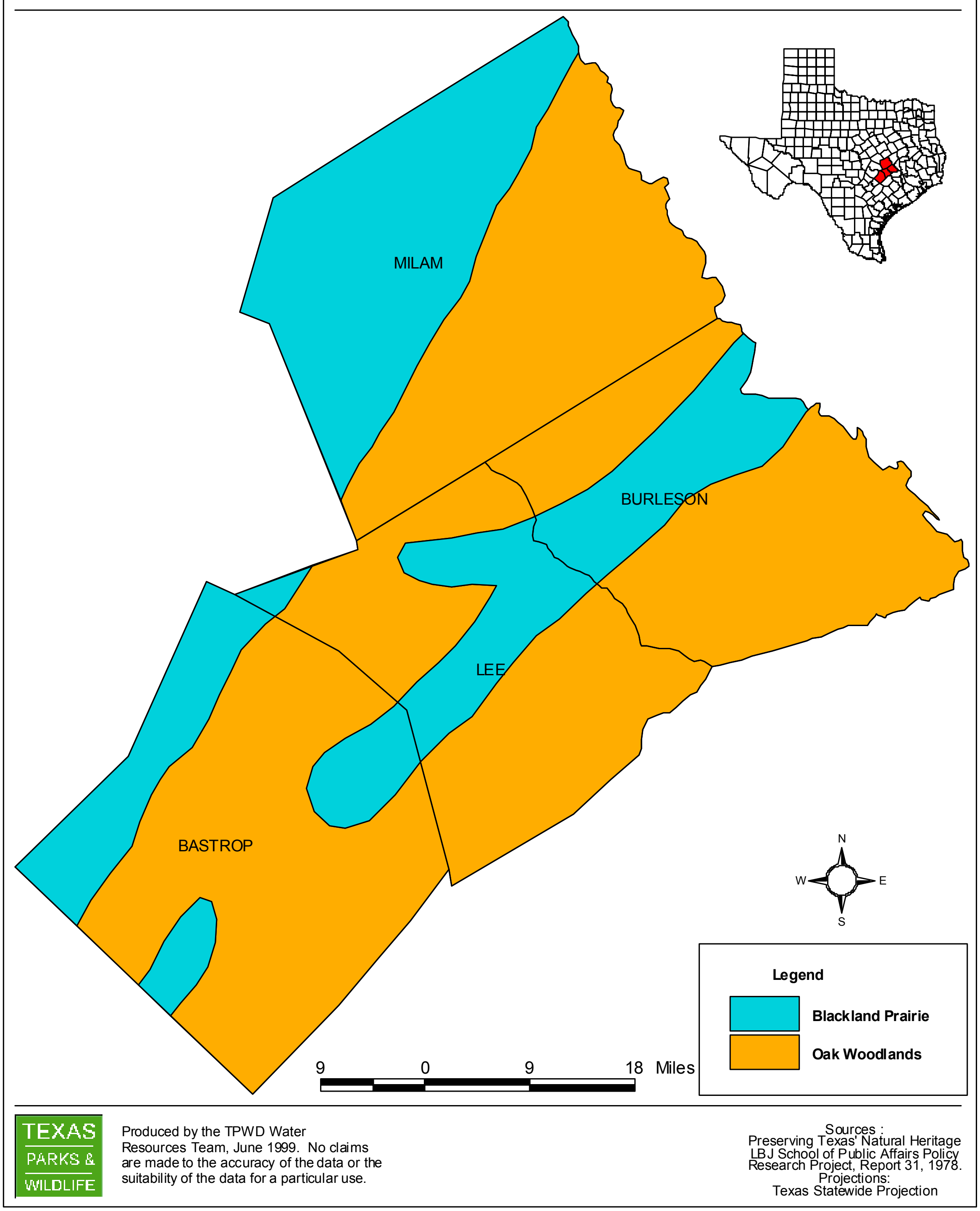
NATURAL REGIONS

In 1978 a group of scientists and laymen developed a system of classifying Texas into natural regions. The system identifies natural areas typical of Texas' original landscape, and special landscapes that are critical for the protection of diversity in scenery, geology, plants, animals, and ecosystems (TPWD 1999c). Based on the group's efforts, the state was divided into eleven natural regions with most containing identifiable subregions. The natural regions were delineated largely on the basis of soil types and major vegetation types (TPWD 1999d).

The study area includes parts of two natural regions: the Blackland Prairie, and the Oakwoods and Prairies (Figure 5). These regions roughly coincide with the Texan Biotic Province identified by Blair (1950). The Blackland Prairie covers 25,500 square miles from south-central Texas to the Red River. Topography of the Blackland Prairies region is gently rolling to nearly level and well dissected which provides rapid surface drainage. Fairly uniform dark-colored alkaline clays, often referred to as "black gumbo," interspersed with some gray acid sandy loams, characterize the area. Blackland Prairie soils once supported a tall-grass prairie dominated by bluestems, sideoats, and switchgrass. Mesquite, blackjack and post oak have invaded some areas severely. The fertility of this region makes it ideal for crop agriculture. Isolates of the Blackland Prairies occur in the Oak Woods and Prairies region. These areas may be identified by their characteristically dark clay soils. The Blackland Prairies subregion lies on fairly deep, dark, alkaline clay soils. Tall-grass types dominate (TPWD 1999d).

The Oakwoods and Prairies natural region encompasses 19,500 square miles in three longitudinal bands starting in central Texas and running north. The landscape of the Oak Woods and Prairies is gently rolling to hilly. Upland sods are light colored, acid sandy loam or sands. Bottomland soils may be light brown to dark gray and acid with textures ranging from sandy loams to clays. Ranches are more common in the Oak Woods and Prairies than in the Blackland Prairies Region to the west (TPWD 1999e). Oak-hickory forest interdigitates with tall-grass prairies in this region. The Western and Eastern Cross Timbers are major areas of oak-hickory. Peat bogs and marshes are distributed along a line corresponding to surface exposures of the Carrizo Sands formations and runs roughly southwest from northern Leon County to Palmetto State Park in Gonzales County. River valleys crossing the region support a forest of hackberries and pecans mixed with oaks on the alluvial soils (TPWD 1999e). The study area lies in the Oak Woodlands subregion. The Oak Woodlands contain the best developed oak-hickory forest in Texas.

Figure 4. Natural Subregions



VEGETATION TYPES

The soils and vegetation types of the area are correlated. Soils in the four county study area vary from alluvial, sandy soils with loamy surface in Bastrop County, to red and black soils with loamy or sandy surface layers in Lee and Milam Counties, to loam and heavy bottom soils in Burleson County (Godfrey et. al. 1973).

Based on the classification system of McMahan et. al. (1984) there are five major vegetation types in the study area (Figure 6). The main vegetation type is Post Oak Woods, Forest and Grassland. The remaining types in decreasing order of occurrence are the Post Oak Woods/Forest; Crops; Other Native or Introduced Grasses; and Pine-Hardwood Forest (Loblolly Pine-Post Oak). The vegetation types are given as associations of two or three plant dominants listed according to a physiognomic designation (McMahan et. al. 1984).

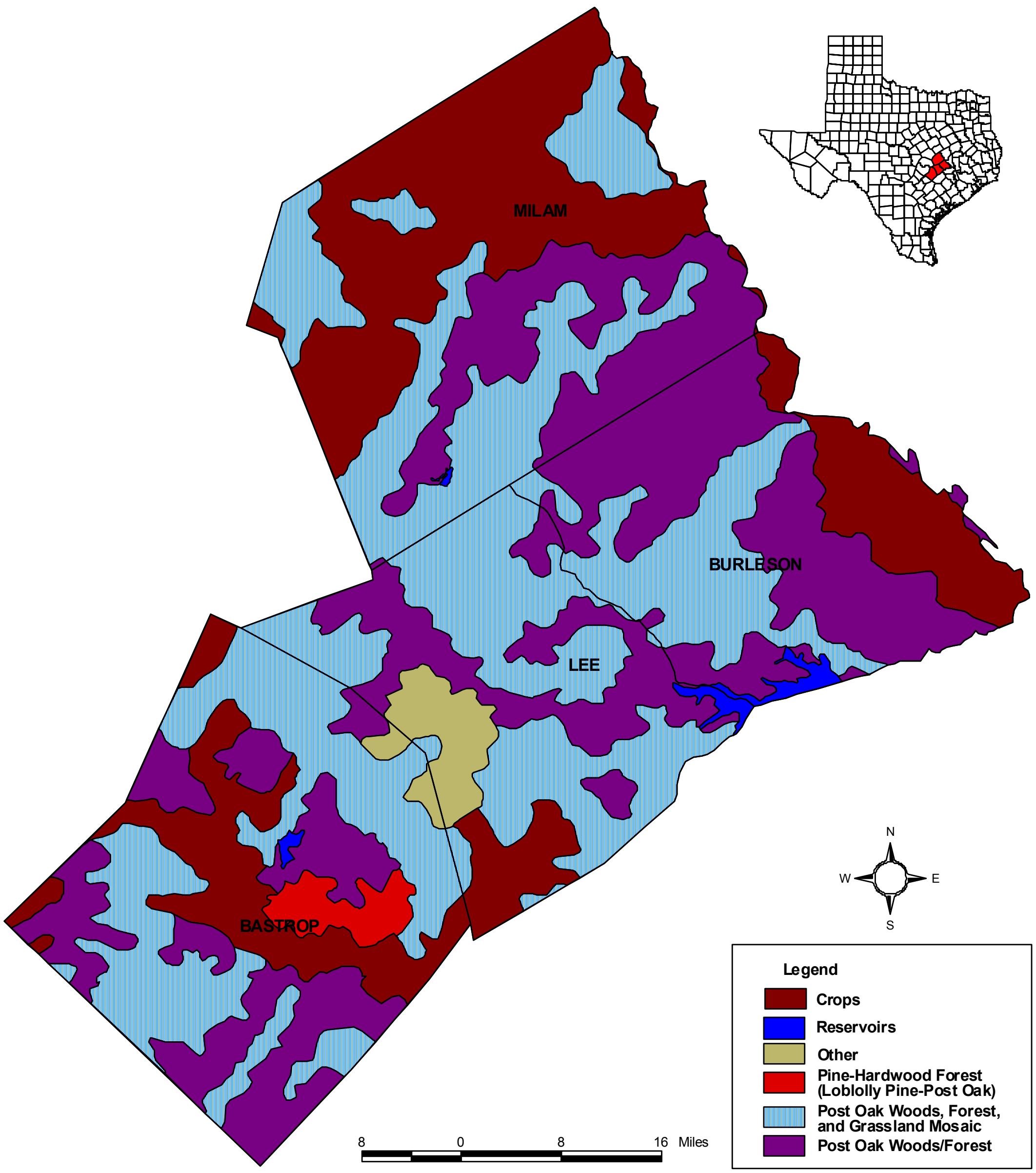
Commonly associated plants of the Post Oak Woods, Forest, and Grassland Mosaic and of the Post Oak Woods/Forest vegetation types are: blackjack oak, eastern redcedar, mesquite, black hickory, live oak, sandjack oak, cedar elm, hackberry, yaupon, poison oak, American beautyberry, hawthorn, supplejack, trumpet creeper, dewberry, coral-berry, little bluestem, silver bluestem, sand lovegrass, beaked panicum, three-awn, sprangle-grass, and tickclover. This vegetation type is most apparent on sandy soils of the Post Oak Savannah (McMahan et. al. 1984). Appendix A gives the scientific names for the plants mentioned in this section.

Commonly associated plants of the Crops vegetation type are cultivated cover crops or row crops that provide food and/or fiber for either man or domestic animals. This type also includes grassland associated with crop rotation (McMahan et. al. 1984).

The Other Native or Introduced Grasses vegetation type is composed of mixed native or introduced grasses and forbs on grassland sites or mixed herbaceous communities resulting from the clearing of woody vegetation. This vegetation type is often associated with the clearing of forests (McMahan et. al. 1984).

Of interest in the study area is the Pine-Hardwood Forest (Loblolly Pine-Post Oak) vegetation type. This vegetation type makes up the Lost Pines of Bastrop County. Commonly associated plants include: black hickory, blackjack oak, eastern redcedar, cedar elm, hackberry, greenbriar, yaupon, elbow bush, purpletop, sand lovegrass, broomsedge bluestem, little bluestem, brownseed paspalum, bushclover, tickclover, gay feather, yellow neptunia, bitter sneezeweed, and velvet bundleflower (McMahon et. al. 1984). The Lost Pines is so named because it is approximately 100 miles from the pine regions of East Texas and is the westernmost tract of southern pine in the United States. The forest is a narrow belt of loblolly pines that extend about thirteen miles across central eastern Bastrop County. They are thought to be a remnant of an Ice Age pine forest, parts of which did not survive the shift to a warm, dry climate (Texas State Historical Association 1999).

Figure 5. Vegetation



TEXAS PARKS & WILDLIFE

Produced by the TPWD Water Resources Team, June 1999. 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 actuall vegetation exhibit adequate resolution for delineation.
Projection:
Texas Statewide Projection

SPECIES OF SPECIAL CONCERN

Within the four county study area, there are currently 24 species of special concern (Table 5, Figure 7). This list includes species that are federally listed as threatened or endangered, federally proposed as threatened or endangered, federally endangered by similarity of appearance, state listed as threatened or endangered, or rare but with no regulatory listing status. Species appearing on the list do not share the same probability of occurrence, and some are migrant or wintering residents of the study area. Few of the species of special concern are directly dependent on an aquatic environment. However, several are secondarily associated with aquatic habitats.

The species with the most direct connection to freshwater aquatic ecosystems are the blue sucker (*Cycleptus elongatus*), the Guadalupe bass (*Micropterus treculi*), the smalleye shiner (*Notropis bucculi*), and the Houston toad (*Bufo houstonensis*). The blue sucker, Guadalupe bass, and smalleye shiner are fish species with differing habitat requirements and distributions. The blue sucker, state-listed as threatened, occurs in large rivers including the Colorado and the Brazos. The fish usually inhabits channels and flowing pools with a moderate current and a bedrock substrate, sometimes combined with hard clay, sand, or gravel. Streamflows to meet the spawning requirements of this species are a part of the LCRA's Water Management Plan.

The Guadalupe bass occurs in streams of the eastern Edwards Plateau, but is also found in the Colorado River upstream of Austin and in the Lampasas, Little, and Leon rivers in the Brazos River Basin. The Guadalupe bass, the official state fish of Texas, is recognized as being rare, but has no regulatory listing status. The species inhabits shallow, swift waters, and often is found in riffles or at the head of pools. The fish is moderately tolerant of high turbidity and variable temperatures (Lee et. al. 1980).

The smalleye shiner is a rare species, but has no regulatory listing status. The species is native to the upper two-thirds of the Brazos River drainage, and has been introduced to the Colorado River Basin. The fish usually occurs in turbid waters of broad, sandy channels in mainstem streams over shifting sands (Lee et. al. 1980). Loss of habitat due to the trapping of sediments behind dams has contributed to this species decline.

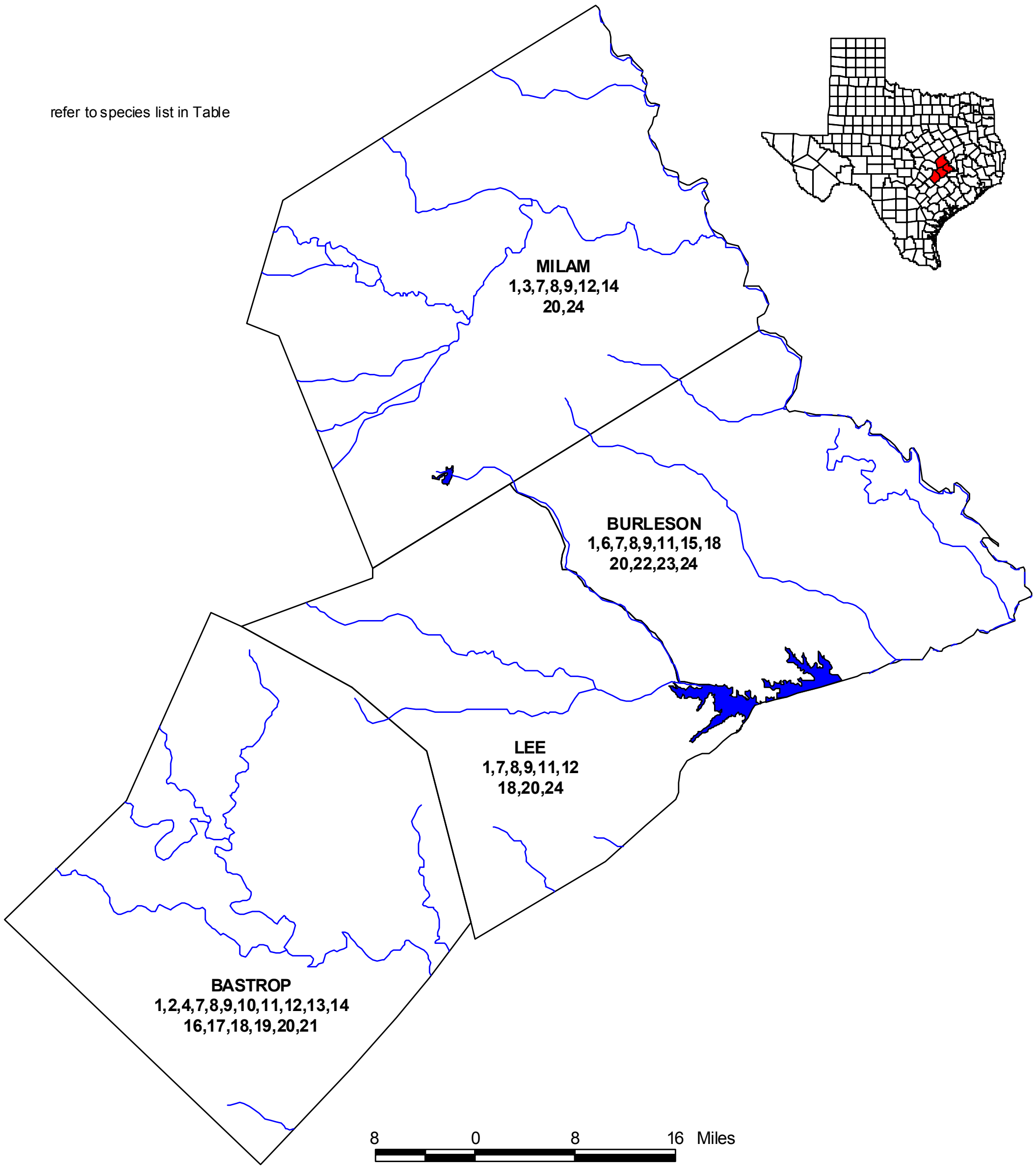
The Houston toad is a small amphibian that is endemic to southeast and central Texas. The Houston toad occurs in each of the counties of the study area, but is most abundant in Bastrop County, and is federal and state-listed as endangered. There is a strong correlation between the toad and two bands of geologic formations on which the deepest sands of the region occur, including the Carrizo formation. The Houston toad is found primarily in pine or oak woodlands underlain by pockets of deep sand. During the breeding season, January through June, the toads move to temporary pools, flooded fields, wet areas associated with seeps or springs, or permanent ponds containing shallow water. The most severe threat to the Houston toad is habitat conversion. Drought can also threaten the species (Campbell 1995). The impacts to these species from increased groundwater pumping are unknown. However, a more thorough analysis of the role of groundwater in the habitats utilized by the Houston toad is warranted. Additional information is also needed on the interaction of groundwater and surface water in the region, and the effects of increased groundwater pumping on surface water flows.

Table 5. Species of Special Concern in the study area (TPWD 1998a)

Map code*	Scientific name	Common name	Fed. Status	State Status
	AMPHIBIANS			
1	*Bufo houstonensis*	Houston toad	LE	E
	BIRDS			
2	*Ammodramus henslowii*	Henslow's sparrow		
3	*Buteo albonotatus*	Zone-tailed hawk		T
4	*Charadrius montanus*	Mountain plover	PT	
6	*Falco peregrinus*	Peregrine falcon		
7	*Falco peregrinus anatum*	American peregrine falcon		E
8	*Falco peregrinus tundrius*	Arctic peregrine falcon		T
9	*Grus americana*	Whooping crane	LE	E
10	*Haliaeetus leucocephalus*	Bald eagle	PDL	T
11	*Mycteria americana*	Wood stork		T
12	*Sterna antillarum athalassos*	Interior least tern	LE	E
	FISHES			
13	*Cycleptus elongatus*	Blue sucker		T
14	*Micropterus treculi*	Guadalupe bass		
15	*Notropis buccula*	Smalleye shiner		
	MAMMALS			
16	*Myotis velifer*	Cave myotis		
17	*Spilogale putorius interrupta*	Plains spotted skunk		
	REPTILES			
18	*Crotalus horridus*	Timber/Canebrake rattlesnake		T
19	*Holbrookia lacerata*	Spot-tailed earless lizard		
20	*Phrynosoma cornutum*	Texas horned lizard		T
21	*Thamnophis sirtalis annectens*	Texas garter snake		
	VASCULAR PLANTS			
22	*Liatris cymosa*	Branched gay-feather		
23	*Polygonella parksii*	Parks' jointweed		
24	*Spiranthes parksii*	Navasota ladies'-tresses	LE	E

* Lookup code for map of Figure 7. **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; PT – Federally Proposed Threatened; PDL – Proposed Delisted; blank – rare but with no regulatory listing status

Figure 3. Special Species



TEXAS PARKS & WILDLIFE

Produced by the TPWD Water Resources Team, June 1999. 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,
TPWS Gis lab archives data 1998.
Projections:
Texas Statewide Projection

FRESHWATER MUSSELS

Freshwater mussels are of interest due to their decreasing numbers and changing distribution patterns. They occur in rivers, creeks, lakes, ponds, canals, and reservoirs of the study area. Certain mollusk species have limited habitat requirements, while others can tolerate a wide range of conditions. Mussels occur in both perennial and intermittent streams. More stable environments may have larger and more diverse populations than smaller and less stable waters. Typically, headwater spring pools and streams, and streams in the Texas Hill Country, have few if any mussels due to limited phytoplankton and other food items for the mollusks. Mussel populations are limited by shifting sand and deep soft silt substrates. Bedrock and boulder and cobble substrates also typically have limited numbers of mussels (Howells et. al. 1996).

Freshwater mollusks have unique strengths as water quality monitors due to their long life spans, feeding habits, and persistent shells (Strayer 1999) and are often the first organisms to decline when the environmental quality of aquatic ecosystems begins to degrade (Howells et. al. 1996). Surveys of unionid mussels in Texas show that populations of many of the 51 species that occur in the state have decreased greatly in recent years. Over-grazing, the clearing of native vegetation, construction of highways and bridges, and general land clearing and development have contributed to increases in runoff and scouring floods. Scouring in upstream reaches can result in downstream deposits of soft silt or deep shifting sand and eliminate mussel habitat. Population declines may be due in part to siltation as a result of poor land and water management practices, land use modifications, over-harvesting, pollution, dams and reservoirs, habitat alteration, and competition with exotic species (Box and Mossa 1999, Howells et. al. 1997). Hydrologic changes can also affect the distribution of mussels. Table 6 is a list of the unionid mussels of potential occurrence in the study area.

Table 6. Freshwater Unionid mussels of potential occurrence in the study area (Howells et. al. 1996)

Scientific Name	Common Name
Amblema plicata	Threeridge
Anodonta grandis	Giant floater
Anodonta imbecillis	Paper pondshell
Arcidens confragosus	Rock-pocketbook
Cyrtonaias tampicoensis	Tampico pearlymussel
Lampsilis bracteata	Texas fatmucket
Lampsilis hydiana	Louisiana fatmucket
Lampsilis teres	Yellow sandshell
Leptodea fragilis	Fragile papershell
Ligumia subrostrata	Pond mussel
Megalonaias nervosa	Washboard
Potamilus ohiensis	Pink papershell
Potamilus purpuratus	Bleufer
Quadrula apiculata	Southern mapleleaf

Table 6 Cont'd.

Scientific Name	Scientific Name
Quadrula aurea	Golden orb
Quadrula houstonensis	Smooth pimpleback
Quadrula petrina	Texas pimpleback
Quincuncina mitchelli	False spike
Strophitus undulatus	Squawfoot
Toxolasma parvus	Lilliput
Toxolasma texasensis	Texas lilliput
Tritogonia verrucosa	Pistolgrip
Truncilla macrodon	Texas fawnsfoot
Uniomerus declivis	Tapered pondhorn

FISHES

Texas has a diverse freshwater fish fauna, with 169 species limited to a strictly freshwater environment (Hubbs et. al. 1991). Hubbs (1957) indicated that the distributional patterns of most freshwater fishes in Texas generally correlate to biotic provinces. In the Texan Biotic Province (Blair 1950), in which the study area is located, 110 species of fish potentially occur. However, this number is reduced when considering only the four counties of the study area. In addition, different fish species may be limited to a particular river basin or drainage. The area contains many different types of aquatic habitats that may be utilized by fish species. Several major streams and numerous smaller streams provide a wide range of run, riffle, and pool habitats. Reservoirs, small ponds, and wetlands provide additional environments that are exploited by an assortment of fish species.

Mosier and Ray (1992) prepared an annotated list of fish species from the Colorado River system (Table 7). Many of these species are found throughout the study area, and have been collected in other studies in the Colorado and Brazos river basins (Twidwell and Davis 1989, Bayer et. al.1992, Linam et. al. 1996). Others are limited in their distribution, and still others such as the Clear Creek gambusia occur outside of the study area. The status and distribution of several native species has been affected by impoundments and associated changes in hydrology and water quality (Mosier and Ray 1992). Three species are of special concern due to their limited distribution and environmental threats: the Blue sucker, Guadalupe bass, and Smalleye shiner (Figure 5). In addition, a number of non-native species have been introduced into the study area including the Mexican tetra, Rio Grande cichlid, carp, and sailfin molly. Decreases in stream flow, and the loss of aquatic habitat, could negatively affect the native fish communities of the study area.

Table 7. Annotated list of fish species from the Colorado River system (Mosier and Ray 1992).

Species	Common Name
Lepisosteus oculatus	Spotted gar
L. osseus	Longnose gar
L. spatula	Alligator gar
Amia calva	Bowfin
Anguilla rostrata	American eel
Dorosoma cepedianum	Gizzard shad
D. petenense	Threadfin shad
Astyanax mexicanus	Mexican tetra
Campostoma anomalum	Stoneroller
Cyprinus carpio	Carp
Cyprinella lutrensis	Red shiner
C. venusta	Blacktail shiner
Dionda episcopa	Roundnose shiner
Hybognathus placitus	Plains minnow
Lythrurus fumeus	Ribbon shiner
Macrhybopsis aestivalis	Speckled chub
Notemigonus crysoleucus	Golden shiner
Notropis amabilis	Texas shiner
N. amnis	Pallid shiner
N. atrocaudalis	Blackspot shiner
N. buccula	Smalleye shiner
N. buchanani	Ghost shiner
N. oxyrhynchus	Sharpnose shiner
N. potteri	Chub shiner
N. schumardi	Silverband shiner
N. stramineus	Sand shiner
N. texanus	Weed shiner
N. volucellus	Mimic shiner
Opsopoeodus emilae	Pugnose shiner
Phenocobius mirabilis	Suckermouth minnow
Pimephales promelas	Fathead minnow
P. vigilax	Bullhead minnow
Carpoides carpio	River carpsucker
Cycleptus elongatus	Blue sucker
Ictiobus bubalus	Smallmouth buffalo
Minytrema melanops	Spotted sucker
Moxostoma congestum	Gray redhorse sucker
Ictaluras furcatus	Blue catfish
I. melas	Black bullhead
I. natalis	Yellow bullhead

Table 7 Cont'd.

Species	Common Name
I. punctatus	Channel catfish
Noturus gyrinus	Tadpole madtom
Pylodictus olivaris	Flathead, Yellow catfish
Aphredoderus sayanus	Pirate perch
Fundulus notatus	Blackstripe topminnow
F. chrysotus	Golden topminnow
F. zebrinus	Plains killifish
Gambusia affinis	Mosquitofish
G. heterochir	Clear Creek gambusia
Poecilia latipinna	Sailfin molly
Menidia beryllina	Inland silversides
Morone crysops	White bass
M. saxatilis	Striped bass
Lepomis auritus	Redbreast sunfish
L. cyanellus	Green sunfish
L. gulosus	Warmouth
L. humilis	Orangespotted sunfish
L. macrochirus	Bluegill
L. megalotis	Longear sunfish
L. microlophus	Redear sunfish
L. punctatus	Spotted sunfish
L. symmetricus	Bantam sunfish
Micropterus dolmieui	Smallmouth bass
M. punctulatus	Spotted bass
M. salmoides	Largemouth bass
M. treculi	Guadalupe bass
Pomoxis annularis	White crappie
Etheostoma chlorosomum	Bluntnose darter
E. gracile	Slough darter
E. lepidum	Greenthroat darter
E. proeliare	Cypress darter
E. spectabile	Orangethroat darter
Percina carbonaria	Logperch
P. macrolepidum	Roughscale logperch
P. sciera	Dusky darter
Aplidinotus grunniens	Freshwater drum
Cichlosoma cyanoguttatum	Rio Grande cichlid
Sarotherodon aurea	Blue tilapia

AMPHIBIANS

In Texas, there are 42 species of anurans (toads and frogs) and at least 21 species of caudatans (salamanders, newts, and sirens) (Garrett and Barker 1987). Amphibians are, by their nature, dependent upon a freshwater environment. Most of the amphibians in Texas lay their eggs in water. The endangered Houston toad, as previously mentioned, occurs in the study area and requires water for reproduction. Amphibians of potential occurrence in Bastrop, Burleson, Lee, or Milam county are listed in Table 8. If increased pumping of the Carrizo-Wilcox aquifer is accompanied by decreased spring flow, diminished water to wetland and bottomland areas, and reduced stream flow, then less habitat will be available for these amphibian species.

Table 8. Amphibians of potential occurrence in the study area (Garrett and Barker 1987, TPWD 1998a).

Species	Common Name
Acris crepitans	Blanchard's cricket frog
Ambystoma texanum	Smallmouth salamander
Bufo houstonensis	Houston toad
Bufo speciosus	Texas toad
Bufo valliceps	Gulf coast toad
Bufo woodhousii	Woodhouse's toad
Gastrophyrne carolinensis	Eastern narrowmouth toad
Gastrophyrne olivacea	Great plains narrowmouth toad
Hyla chrysoscelis	Cope's gray treefrog
Hyla cinerea	Green treefrog
Hyla versicolor	Northern gray treefrog
Notophthalmus viridescens	Eastern newt
Pseudacris clarkii	Spotted chorus frog
Pseudacris streckeri	Strecker's chorus frog
Pseudacris triseriata	Striped chorus frog
Rana areolata	Crawfish frog
Rana catesbeiana	Bullfrog
Rana clamitans	Green frog
Scaphiopus holbrookii	Eastern spadefoot
Siren intermedia	Lesser siren

REPTILES

Reptiles are represented by three orders: Chelonia (turtles), Crocodilia (Crocodilians), and Squamata (lizards and snakes). Members of each of these orders are found in the study area (Table 9). Ecological requirements for reptiles are diverse and numerous ranging from aquatic to xeric conditions, and arboreal to subterranean. While some members of the group are tied to a wetland or aquatic environment, others prefer upland habitats. Four of the reptile species in the study area are of special concern due to their limited numbers or range: the timber rattlesnake (*Crotalus horridus*), the spot-tailed earless lizard (*Holbrookia lacerata)*, the Texas horned lizard (*Phrynosoma cornutum)*, and the Texas garter snake (*Thamnophis sirtalis)* (Figure 7). If increased pumping of the Carrizo-Wilcox aquifer is accompanied by decreased spring flow, diminished water to wetland and bottomland areas, and reduced stream flow, then less habitat will be available for reptiles in the study area.

Table 9. Reptiles of potential occurrence in the study area (Garett and Barker 1987)

Species	Common Name
Alligator mississippiensis	American alligator
Chelydra serpentina	Snapping turtle
Sternotherus odoratus	Common musk turtle
Terrapene carolina	Eastern box turtle
Terrapene ornata	Western box turtle
Trionyx spiniferus	Spiny softshell
Anolis carolinensis	Green anole
Crotaphytus collaris	Collared lizard
Eumeces fasciatus	Five-lined skink
Eumeces obsoletus	Great plains skink
Eumeces septentrionalis	Prairie skink
Hemidactylus turcicus	Mediterranean gecko
Holbrookia lacerata	Spot-tailed earless lizard
Ophisaurus attenuatus	Slender glass lizard
Phrynosoma cornutum	Texas horned lizard
Sceloporus olivaceus	Texas spiny lizard
Sceloporus undulatus	Eastern fence lizard
Scincella lateralis	Round skink
Agkistrodon contortrix	Copperhead
Agkistrodon piscivorus	Cottonmouth
Arizona elegans	Glossy snake
Cnemidophorus gularis	Texas spotted whiptail
Cnemidophorus sexlineatus	Six-lined racerunner
Coluber constrictor	Racer
Crotalus horridus	Timber (Canesnake) rattlesnake
Deirochelys reticularia	Chicken turtle
Elaphe guttata	Corn snake
Elaphe obsoleta	Black rat snake
Farancia abacura	Mud snake
Lampropeltis calligaster	Prairie kingsnake
Lampropeltis getula	Common kingsnake

Table 9 Cont'd.

Species	Common Name
Lampropeltis triangulum	Milk snake
Leptotyphlops dulcis	Texas blind snake
Liochlorophis aestivus	Rough green snake
Masticophis flagellum	Coachwhip
Micrurus fulvius	Eastern coral snake
Nerodia erythrogaster	Plainbelly water snake
Nerodia fasciata	Southern water snake
Nerodia rhombifer	Diamondback water snake
Regina grahamii	Graham's crayfish snake
Rhinocheilus lecontei	Longnose snake
Salvadora grahamiae	Mountain patchnose snake
Storeria dekayi	Brown snake
Tantilla gracilis	Flathead snake
Thamnophis proximus	Western ribbon snake
Thamnophis sirtalis	Texas garter snake
Tropidoclonion lineatum	Lined snake
Virginia striatula	Rough earth snake

BIRDS

There are many resident bird species that occur in the study area. A number of these species are found in the state parks of the region (Appendix B). Birds are generally distributed throughout the area, occupying a variety of habitats and niches. While some species are generalist or are adapted to a wide range of environmental conditions, others are specific in their habitat preferences. Many of the resident bird species live along water bodies of the area and utilize the riparian corridors for food and shelter. In addition, a number of migratory neotropical songbirds, wintering shorebirds, and waterfowl stopover to feed and rest along reservoirs, river banks, and creek bottoms of the study area. Table 10 lists the waterfowl of the study area. Of the birds that are found in the region, the TPWD identifies 10 rare species (TPWD 1998a). Seven of these species are wetland or riparian dependent including the *Falco* spp., the American bald eagle, the whooping crane, and the wood stork. If increased pumping of the Carrizo-Wilcox aquifer is accompanied by decreased spring flow, diminished water to wetland and bottomland areas, and reduced stream flow, than less habitat will be available for these avian species.

Table 10. Waterfowl and water associated birds of the study area (Texas Parks and Wildlife Department 1998a).

Species	Common Name
Aix sponsa	Wood duck
Anas acuta	Northern pintail
Anas americana	American wigeon
Anas clypeata	Northern shoveler
Anas crecca	Green-winged teal

Table 10 Cont'd.

Species	Common Name
Anas platyrhynchos	Mallard
Anas strepera	Gadwall
Anser albifrons	Greater white-fronted goose
Aythya affinis	Lesser scaup
Aythya americana	Redhead
Branta canadensis	Canada goose
Bucephala albeola	Bufflehead
Bucephala clangula	Common goldeneye
Chen caerulescens	Snow goose
Dendrocygna autumnalis	Black-bellied whistling-duck
Dendrocygna bicolor	Fulvous whistling-duck
Falco peregrinus	Peregrine falcon
Falco peregrinus anatum	American peregrine falcon
Falco peregrinus tundrius	Arctic peregrine falcon
Grus americana	Whooping crane
Mergus serrator	Red-breasted merganser
Mycteria americana	Wood stork
Oxyura jamaicensis	Ruddy duck
Parula americana	Northern parula
Pelecanus occidentalis	Brown pelican
Plegadis chihi	White-faced ibis
Sterna antillarum athalassos	Interior least tern

MAMMALS

Within Texas there are 141 species of native terrestrial mammals. In addition to the native species that occur in the area naturally, there are also 12 exotics or nonnative species that have been introduced by man and have become established as a part of the freeliving fauna. The diversity of mammals in Texas varies with geographical region. The lowest mammalian diversity is in the Blackland Prairies region that includes the study area (Davis and Schmidly 1994).

Davis and Schmidly (1994) divided Texas into four regions based on the ecological distribution of mammals: the Trans-Pecos, Plains Country, East Texas, and the Rio Grande Plains. Included within the East Texas region are the Pineywoods, central Texas Woodlands, Blackland Prairies, and Coastal Prairies and Marshes. According to this scheme, Bastrop, Burleson, Lee, and Milam counties are located in the East Texas region. Mammals that are generally distributed throughout the state are listed in Table 11. Mammals that are unique to the East Texas region are listed in Table 12. While the species listed in Table 12 are known to occur in the East Texas region, they may or may not be found in the four counties of the study area. The mammals that are unique to East Texas are species characteristic of the deciduous forests and coastal prairies of the southeastern United States, which reach their western distributional limits in Texas (Davis and Schmidly 1994).

Within the past 100 years, 9 species of land mammals and one marine mammal have become extirpated in Texas. A variety of factors can cause extinction, but in the case of these species, persecution and habitat alteration by man probably had more to do with their disappearance than any other single factor. About 16% of the land mammals remaining in Texas today can be viewed as having some sort of biological problem that threatens or potentially threatens their existence. These are species that currently face or likely will face serious conservation problems in the future. Habitat loss and degradation are the most important causes of wildlife decline, but overharvesting and poaching, trade in wild animal products, introduction of exotic species, pollution from pesticides and herbicides, and other causes also take a significant toll (Davis and Schmidly 1994).

Table 11. Mammals generally distributed throughout Texas, including the study area (Davis and Schmidly 1994).

Species	Common Name	Comments
Didelphis virginiana	Virginia Opossum	(absent from portions of the Trans-Pecos)
Lasionycteris noctivagans	Silver-haired Bat	
Eptesicus fuscus	Big Brown Bat	(not in Rio Grande Plains)
Lasiurus borealis	Eastern Red Bat	
Lasiurus cinereus	Hoary Bat	
Tadarida brasiliensis	Brazilian Free-tailed Bat	
Sylvilagus floridanus	Eastern Cottontail	
Lepus californicus	Black-tailed Jackrabbit	(not in the Big Thicket of East Texas)
Chaetodipus hispidus	Hispid Pocket Mouse	(not in the Big Thicket of East Texas)
Castor canadensis	American Beaver	
Reithrodontomys fulvescens	Fulvous Harvest Mouse	(not on the High Plains)
Peromyscus leucopus	White-footed Mouse	
Peromyscus maniculatus	Deer Mouse	
Sigmodon hispidus	Hispid Cotton Rat	
Canis latrans	Coyote	
Urocyon cinereoargenteus	Common Gray Fox	
Ursus americanus	Black Bear	(extinct except for remnant populations in the Trans-Pecos)
Bassariscus astutus	Ringtail	
Procyon lotor	Common Raccoon	
Mustela frenata	Long-tailed Weasel	
Mephitis mephitis	Striped Skunk	
Felis concolor	Mountain Lion	(gone from much of range except South Texas and the Trans-Pecos)
Lynx rufus	Bobcat	
Odocoileus virginianus	White-tailed Deer	
Bos bison	Bison	(extinct in the wild in Texas)

Table 12. Mammals occurring principally in East Texas, including the study area (Davis and Schmidly 1994).

Species	Common Name	Comments
Blarina carolinensis	Southern Short-tailed Shrew	
Myotis austroriparius	Southeastern Myotis	
Lasiurus seminolus	Seminole Bat	
Plecotus rafinesquii	Rafinesque's Big-eared Bat	
Sylvilagus aquaticus	Swamp Rabbit	
Sciurus carolinensis	Eastern Gray Squirrel	
Glaucomys volans	Eastern Flying Squirrel	(barely enters the Cross Timbers area of the Plains Country)
Geomys attwateri	Attwater's Pocket Gopher	
Geomys breviceps	Baird's Pocket Gopher	
Oryzomys palustris	Marsh Rice Rat	(also in coastal region of Rio Grande Plain)
Reithrodontomys humulis	Eastern Harvest Mouse	
Peromyscus gossypinus	Cotton Mouse	
Ochrotomys nuttalli	Golden Mouse	
Microtus ochrogaster	Prairie Vole	(subspecies ludovicianus)
Lutra canadensis	River Otter	

CONCLUSIONS

Increasing population growth in Texas has escalated demand on the limited water resources of the state. Planning for these demands for water often occurs with limited consideration of the potential environmental consequences of specific actions. This is especially true with regard to groundwater. Recently, the San Antonio Water System contracted with Alcoa Inc. for up to 90,000 acre-feet per year of Carrizo-Wilcox groundwater. Additional exports of water from the Carrizo-Wilcox aquifer in areas of Bastrop, Burleson, Lee, and Milam counties are anticipated due to population growth in the study area and throughout the state. Accompanying the growth in population will be changing land use patterns, urbanization, and increased demands for water.

Demands for water will be met from both groundwater and surface water sources. Increased groundwater use will result in a lowering of aquifer levels and, more than likely, a reduction in flow for springs in the study area. In addition, surface flows that are presently enhanced by groundwater interactions will be reduced. Modeling scenarios show that surface flows will go from a net gain by the streams of approximately 26,000 acre-feet in 1996 to a loss in year 2050 of approximately 30,000 acre-feet. This represents an overall reduction in surface water of 56,000 acre-feet per year under the highest demand scenario. Dutton states that additional study is needed to more accurately determine the affects of future pumping on surface waters of the area.

As groundwater pumping exceeds recharge; springs, bottomland, wetland, and riparian habitats are at greatest risk of impact. Wetland, bottomland, and riparian areas provide important biological and hydrological functions. They not only provide habitat for a diverse range of organisms, but they can function in water quality protection, soil stabilization, and flood attenuation. Another vegetation-type of concern is the Lost Pines. The Lost Pines are a unique and disjunct loblolly pine forest found in sandy soils of Bastrop County. A thorough analysis of the relationship between groundwater levels is needed to determine whether and to what extent they will be affected by a lowering of the groundwater table.

The flora and fauna of the four counties is typical of the biotic regions and provinces of the area. Aquatic species are generally consistent with their associated drainages. Of the endangered species of potential occurrence in the area, two are dependent upon an aquatic environment: the Blue sucker (*Cycleptus elongatus*) and the Houston toad (*Bufo houstonensis*). The Blue sucker is a fish found in the Colorado River that is state-listed as threatened. Minimum flows to protect this species are addressed in the Lower Colorado River Authority's (LCRA) water management plan. The Houston toad occurs in each of the counties of the study area, but predominantly Bastrop County, and is federal and state-listed as endangered. While the Blue sucker is dependent upon flows of the Colorado River, the Houston toad needs ephemeral or permanent pools of water to survive. The impacts to these species from increased groundwater pumping are unkown. However, a more thorough analysis of the role of groundwater in the habitats utilized by the Houston toad is warranted.

In general, the influence of groundwater in shaping and maintaining the biotic communities of the study area is unknown. Lowering of the water table will probably have localized rather than regional effects. However, these effects could be pronounced, especially if they involve unique or threatened biotic resources of the area. Global warming, in concert with the mining of groundwater in the study area, could exacerbate the loss and degradation of species habitat and biodiversity by increasing the rate of species extinction, changing population sizes and species distributions, modifying the composition of habitats and ecosystems, and altering their geographic extent. Before groundwater is exported out of the study area, the potential effects of de-watering in conjunction with changing land use patterns, habitat loss and degradation, and urbanization needs to be evaluated and documented.

LITERATURE CITED

Aluminum Company of America. 1998. Sandow Mine: Permit 1D, Renewal/revision. Volume 5, section 133.

Arnold, K.A. 1989. Birds of Lake Somerville State Recreation Area: a field checklist. Resource management section, Teas Parks and Wildlife Department, 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.

Barnes, V.E. 1974. Geologic atlas of Texas - Austin sheet: University of Texas at Austin, Bureau of Economic Geology, Austin, Texas.

Blair, W.F. 1950. The biotic provinces of Texas. Tex. J. Sci. 2:93-117.

Box, J.B. and J. Mossa. 1999. Sediment, land use, and freshwater mussels: prospects and problems. Journal of the North American Benthological Society. 18 (1): 99-117.

Brune, G, 1975. Major and historical springs of Texas. Texas Water Development Board, Report 189, Austin, Texas.

Brune, G. 1981. Springs of Texas: Vol. I. Branch-Smith, Inc. Fort Worth, Texas.

Campbell, L. 1995. Endangered and threatened animals of Texas - the life history and management. Texas parks and Wildlife Press. Austin, 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.

Davis, W.B. and D.J. Schmidly. 1994. The mammals of Texas. Texas Parks and Wildlife Press. Austin, Texas.

Dutton, A.R. 1999. Assessment of groundwater availability in the Carrizo-Wilcox Aquifer in Central Texas-results of numerical simulations of six groundwater-withdrawal projections (2000-2050). Draft Final Contract Report. Submitted to Texas Water Development Board, Contract No. 99-483-279, Austin, Texas.

Follett, C.R. 1970. Groundwater resources of Bastrop County, Texas. Texas Water Development Board, Report 109, Austin, Texas.

Garrett J.M. and D.G. Barker. 1987. A field guide to reptiles and amphibians of Texas. Texas Monthly Field Guide 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., R.W. Neck, and H.D. Murray. 1996 . Freshwater Mussels of Texas. Texas Parks and Wildlife Department, Inland Fisheries Division. Texas Parks and Wildlife Press.

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. 1957. Distributional patterns of Texas freshwater fishes. Southern Naturalist 2:89-104.

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. Texas Journal of Science. 43(4): Supplement.

Kaiser, W.R. 1978. Depositional systems of the Wilcox Group (Eocene) of East-Central Texas and the occurrence of lignite. In Kaider, W.R. (ed) 1978. Gulf Coast Lignite Conference: Geology, utilization, and environmental aspects. University of Texas, Bureau of Economics Geology, Austin, Texas.

Kier, R.S and R.G. Larkin. 1998. Hydrology of the Carrizo-Wilcox Aquifer system Bastrop, Caldwell, Fayette, Lee, Travis, and Williamson Counties (Preliminary). Robert Kier Consulting, Austin, Texas.

Lee, D.S., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister and J.R. Stauffer, Jr. 1980. Atlas of North American freshwater fishes. North Carolina State Museum of Natural History.

Linam, G.W., J.R. Seaman, R. Cantu, and K.L. Portis. 1996. Aquatic Survey Results from Camp Swift, Bastrop County, Texas. River Studies Report No.15f. Texas Parks and Wildlife Department, Austin, Texas.

Lower Colorado River Authority. 1998. Fact sheat: lake Bastrop test wells. Austin, Texas.

Mitchell, D., C. Alexander, and E. Kutac. 1985. Birds of Buescher and Bastrop State Parks: a field checklist. Resource Management Section, Texas Parks and Wildlife Department, Austin, Texas.

McMahan, C.A., R. Frye, and K.L. Brown. 1984. The vegetation types of Texas including cropland: an illustrated synopsis to accompany the map. Texas Parks and Wildlife Department, Austin, Texas.

Mosier, D.T. and R.T. Ray. 1992. Instream flows for the lower Colorado River: reconciling traditional beneficial uses with the ecological requirements of the native aquatic community. Lower Colorado River Authority, Austin, Texas.

Strayer, D. L. 1999. Effects of alien species on freshwater mollusks in North America. Journal of the North American Benthological Society. 18 (1): 74-98.

Texas Department of Water Resources. 1979. Groundwater availability in Texas: estuarines and projections through 2030. Texas Department of Water Resources Report 238. Austin, Texas.

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 Parks and Wildlife Department. 1999a. Ecologically Significant Stream Segments. Online. Available at http://www.tpwd.state.tx.us/conserve/sb1/rivers/rivers.htm.

Texas Parks and Wildlife Department. 1999b. Texas wetlands conservation plan. Texas Parks and Wildlife Department, Austin, Texas.

Texas Parks and Wildlife Department. 1999c. The natural regions of Texas. Online. Available at http://www.tpwd.state.tx.us/nature/ecoreg/pages/intro.htm

Texas Parks and Wildlife Department. 1999d. Region 3: the Blackland Prairies. Online. Available at http://www.tpwd.state.tx.us/nature/ecoreg/pages/blkp.htm#blackland

Texas Parks and Wildlife Department. 1999e. Region 2: the Oak Woods and Prairies. Online. Available at http://www.tpwd.state.tx.us/nature/ecoreg/pages/oakwod.htm#oakwod

Texas State Historical Association. 1999. Lost pine forest. The Handbook of Texas Online. http://www.tsha.utexas.edu/handbook/online/articles/view/LL/ryl4.html

Texas Water Development Board. 1997. Water for Texas: today and tomorrow. Texas Water Development Board, Document No. GP-6-2, Austin, Texas.

Texas Water Development Board. 1998. Counties population projections in Texas. Online, Available at http://www.twdb.state.tx.us.

Thorkildsen, D., and Price, R.D., 1991. Ground-water resources of the Carrizo-Wilcox aquifer in the Central Texas region. Report No. 332. Texas Water Development Board, Austin, Texas.

Twidwell, S.R., and J.R. Davis. 1989. An assessment of six least disturbed unclassified Texas streams. LP-89-04. Texas Water Commission, Austin, Texas.

APPENDIX A

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

APPENDIX A

Scientific Names of Plants Mentioned

American beautyberry	*Callicarpa americana*
Bluestem, broomsedge	*Andropogen virginicus*
_______, little	*Schizachyrium scoparium var. frequens*
_______, silver	*Bothriochloa saccharoides*
Bundleflower, velvet	*Desmanthus illinoensis*
Bushclover	*Lespedeza spp.*
Coral-berry	*Symphoricarpos orbiculatus*
Dewberry	*Rubus spp.*
Elbowbush	*Forestiera pubescens*
Elm, cedar	*Ulmus crassifolia*
Gay feather	*Liatris spp.*
Greenbriar	*Smilax spp.*
Hackberry	*Celtis spp.*
Hawthorn	*Crataegus spp.*
Hickory, black	*Carya texana*
Lovegrass, sand	*Eragrostis trichodes*
Mesquite	*Prosopis glandulosa*
Neptunia, yellow	*Neptunia lutea*
Oak, blackjack	*Quercus marilandica*
___, live	*Q. virginiana*
___, sandjack	*Q. incana*
Panicum, beaked	*Panicum anceps*
Paspalum , brownseed	*Paspalum plicatulum*
Poison oak	*Rhus toxicodendron*
Purpletop	*Tridens flavus*
Redcedar, eastern	*Juniperus virginiana*
Sneezeweed, bitter	*Helenium amarum*

Sprangle-grass	*Chasmanthium sessiliflorum*
Supplejack	*Berchemia scandens*
Three-awn	*Aristida spp*.
Tickclover	*Desmondium spp*.
Trumpet creeper	*Campsis radicans*
Yaupon	*Ilex vomitoria*

APPENDIX B :

Birds Observed in Bastrop/Buescher (Mitchell et. al 1985) and Somerville State Parks (Arnold 1989)

Family Species ⇓	State Park ⇒	Bastrop/Buescher					*Lake Somerville*			
		SP	S	F	W		*SP*	*S*	*F*	*W*
Gaviidae										
Common loon		O		ACC	O		*H*		*H*	*R*
Podicipedidae										
Eared grebe		U	O	U	U		*U*		*O*	*U*
Pied-billed grebe**		C	F	C	C		*U*		*U-C*	*C*
Honed grebe		O		ACC	O					
Pelecanidae										
American white pelican		U		U	R		*C*	*I*	*C*	*C*
Phalacrocoracidae										
Double-crested cormorant		C		C	C		*C*	*C*	*C*	*C*
Olivaceous cormorant							*U*	*U*	*U*	*U*
Neotropic cormorant		U	U	U	R					
Anhingidae										
Anhinga		R	I	R			*O*	*O*	*O*	
Ardeidae										
Least bittern		R	R	O						
Great blue heron**		C	F	C	C		*C*	*U*	*U-C*	*U-C*
Little blue heron		U	U	U	O		*U*	*C*	*U-C*	
Tricolored heron			R	R			*R*	*R*	*O*	
Green-backed heron							*U*	*U*	*U-C*	
Black-crowned night-heron				R	O		*U-C*	*U-C*	*U-C*	
Yellow-crowned night-heron		R	R	U	O		*O*	*O*	*O*	*H*
Great egret**		F	U	F	F		*C*	*C*	*C*	*U-C*
Cattle egret**		F	F	F	O		*C*	*C*	*C*	*I*
Green heron**		U	U	U	R					
Snowy egret			R	U	O					
Threskiornithidae										
White ibis				O						
White-faced ibis				R				*H*	*R*	
Roseate spoonbill			O	O			*R*	*O-U*	*O-U*	
Ciconiidae										
Wood stork			R	R				*U-C*	*U-C*	
Anatidae										
American black duck										*R*
Mottled duck				R	R		*O-U*	*U*	*U*	*H*
Fulvous whistling duck			O						*H*	
Black-bellied whistling-duck**		R	R	U	R		*H*	*R*	*R*	*I*
Greater white-fronted goose				R	R		*U-C*		*U-C*	*I*
Snow goose		O		R	O		*U-C*		*U-C*	*U-C*
Ross goose							*H*		*R*	
Canada goose		R		U	U		*U*		*U*	*U-C*

Family Species ⇓ / State Park ⇒	Bastrop/Buescher				*Lake Somerville*			
	SP	S	F	W	*SP*	*S*	*F*	*W*
Wood duck**	U	U	U	U	U	U-C	U-C	U-C
Cinnamon teal					R		H	R
Green-winged teal	U		U	F	C		C	C
Mallard**	R		R	R	C	U	C	C
Northern pintail	U		U	U	C		C	I
Blue-winged teal	F	O	U	F	C	I	C	O
Northern shoveler	U		U	F	C	I	U-C	C
Gadwall	C		U	C	C		C	C
American wigeon	C		F	C	C		U-C	C
Canvasback	R			R	C		C	C
Redhead	U		R	U	C		C	O
Ring-necked duck	F		R	U	C		U-C	U-C
Greater scaup				O	H		H	H
Lesser scaup	C		U	C	C		U-C	U-C
Oldsquaw	R,I			R				
Common goldeneye				R	R		O	H
Hooded merganser	R		R	U	R		H	H
Common merganser	O			R				
Red-breasted merganser	R			R				
Bufflehead							U	U
Ruddy duck	F	O	F	F	U		U-C	U-C
Cathartidae								
Black vulture	C	C	C	C	C	C	C	C
Turkey vulture	A	A	A	A	C	C	C	C
Accipitridae								
Osprey	U		R	U	R	R	R	R
White-tailed kite	UI	UI	UI	UI				
Black-shouldered kite					H	H	H	H
Mississippi kite	U		U		H		I	
Bald eagle**	R		O	R	R		R	R
Northern harrier	U		U	U	U		U	U
Red-shouldered hawk**	F	F	F	F	U	U	U	U
Sharp-shinned hawk	F		U	F	H		U	U
Cooper's hawk	R	O	U	U	H		U	U
Broad-winged hawk	U		U		C		U-C	
Swainson's hawk	U	R	U		O		H	
Zone-tailed hawk			R	R				
Red-tailed hawk	F	U	F	R	U	U	U	U-C
Golden eagle				ACC	H		R	R
Crested caracara	U	U	U	U	R	R	R	R
American kestrel	C		C	C	U-C		C	C
Merlin	R		R	R	H		H	H

Family Species ⇓ / State Park ⇒	Bastrop/Buescher					*Lake Somerville*			
	SP	S	F	W		*SP*	*S*	*F*	*W*
Peregrine falcon	R		R	R		*R*		*H*	*O*
Phasianidae									
Turkey	R	R	R	R					
Odontophoridae									
Northern bobwhite	R	R	R	R		*U*	*U-C*	*U-C*	*U-C*
Rallidae									
King rail						*H*	*H*	*H*	
Sora	U		R	U		*H*		*H*	
Virginia rail	R		R	R		*H*		*H*	
Common moorhen**	R	R	O			*H*	*H*	*H*	
American coot**	A	U	A	A		*C*		*C*	*C*
Gruidae									
Sandhill crane	U		U	R		*I*		*U-C*	*I*
Charadriidae									
Black-bellied plover						*H*		*U*	
Lesser golden plover								*H*	
Semipalmated plover	R		R			*R*		*R*	
Killdeer**	C	C	C	C		*C*	*U-C*	*C*	*C*
Recurvirostridae									
Black-necked stilt**	O		O						
American avocet	R		R				*O*	*U*	
Scolopacidae									
Greater yellowlegs	U		U			*C*	*O*	*U-C*	*U*
Lesser yellowlegs	U		U	R		*U-C*	*O*	*U*	*I*
Solitary sandpiper	R		U			*H*	*O*	*R*	
Spotted sandpiper	F		F	F		*U*	*O*	*U*	*U*
Upland sandpiper	C		C			*H*		*U-C*	
Western sandpiper	U		U						
Least sandpiper	U		U	R					
Pectoral sandpiper	R		R			*U*		*U*	
Upland sandpiper	C		C			*H*		*U-C*	
Dunlin						*H*	*R*	*H*	
Stilt sandpiper	R		R			*O*	*O*	*O*	
Buff-breasted sandpiper						*H*		*O*	
Whimbrel						*H*		*H*	
Hudsonian godwit						*R*			
Semipalmated sandpiper	R		R			*U-C*		*O*	
White-rumped sandpiper						*C*	*R*	*U-C*	
Baird's sandpiper	O		R					*U*	
Common snipe	U		R	U		*U-C*		*U-C*	*U-C*
American Woodcock*	U			U		*H*		*O*	*H*
Long-billed dowitcher	U		U			*H*		*H*	

Family Species ⇓ / State Park ⇒	Bastrop/Buescher					*Lake Somerville*			
	SP	S	F	W		*SP*	*S*	*F*	*W*
Wilson's phalarope	R		R			*O*		*H*	
Laridae									
Franklin's gull	U		U			*U-C*	*O*	*U-C*	*I*
Ring-billed gull	U		R	U		*U*	*O*	*U-C*	*U*
Laughing gull								*R*	
Bonaparte's gull						*O*		*U*	*U-C*
Herring gull				R		*U*		*H*	*I*
Forster's tern	U	O	R	U		*C*	*U*	*U-C*	*C*
Caspian tern						*O*		*H*	*R*
Royal tern						*R*		*H*	*H*
Common tern						*U*		*U*	*H*
Black tern	R		R			*H*		*U*	
Black skimmer							*H*		
Columbidae									
Rock dove	U	U	U	C		*U*	*H*	*U*	*U*
Mourning dove	A	C	A	A		*C*	*C*	*C*	*C*
Inca dove	U	U	U	U		*U-C*	*U-C*	*U-C*	*U-C*
Common ground-dove	U	R	R	U				*H*	
White-winged dove	R	R	R	R					
Cuculidae									
Black-billed cuckoo	R					*H*		*H*	
Yellow-billed cuckoo	C	C	R			*U*	*U*	*U*	
Greater roadrunner	U	U	U	U		*U*	*U*	*U*	*U*
Tytonidae									
Common barn-owl						*H*	*H*	*H*	*H*
Strigidae									
Eastern screech-owl	F	F	F	F		*H*	*H*	*H*	*U*
Great horned owl	U	U	U	U		*H*	*H*	*H*	*H*
Barred owl	F	F	F	F		*U*	*H*	*U*	*U*
Short-eared owl								*H*	*H*
Caprimulgidae									
Common nighthawk	F	C	F	O		*H*	*H*	*H*	
Paruaque	O								
Chuck-will's-widow	U	C				*H*	*H*	*H*	
Whip-poor-will	U		U				*H*	*H*	*H*
Apodidae									
Chimney swift	C	C	C			*C*	*U*	*U-C*	
Trochilidae									
Ruby-throated hummingbird	C	C	C			*R*	*U*	*U*	
Black-chinned hummingbird	R	R	R						
Rufous hummingbird	R		R	O					
Alcedinidae									

Family Species ⇓	State Park ⇒	Bastrop/Buescher					*Lake Somerville*			
		SP	S	F	W		*SP*	*S*	*F*	*W*
Belted kingfisher**		F	U	U	F		*U*	*U*	*U*	*O*
Green kingfisher*		R,I			R,I					
Picidae										
Red-headed woodpecker		R	R	R	R		*U*	*U*	*U*	*H*
Red-bellied woodpecker		C	C	C	C		*U*	*U*	*U*	*U*
Golden-fronted woodpecker			R,I		R,I					
Yellow-bellied sapsucker		U		U	F		*U*			*U*
Ladder-backed woodpecker		F	F	F	F					*H*
Downy woodpecker		F	U	U	F		*U*	*U*	*U*	*U*
Hairy woodpecker		R,I	R,I	R,I	U,I		*O*	*O*	*H*	*H*
Northern flicker		F		F	F		*U*		*U*	*U*
Pileated woodpecker		U	U	U	U		*O*	*H*	*O*	*O*
Tyrannidae										
Acadian flycatcher**		U	U	R			*H*	*H*		
Olive-sided flycatcher		U		UI			*H*		*H*	
Eastern wood-pewee		F	U	U			*H*	*H*	*H*	
Yellow bellied-flycatcher		R		U					*R*	
Alder flycatcher		R		U					*O*	
Least flycatcher		U		U					*R*	
Willow flycatcher		F		U						
Great crested flycatcher		F	F	F			*U-C*	*U*	*O*	
“Traill’s” flycatcher		F		F					*O*	
Western kingbird		U	F	U			*H*	*H*	*O*	
Eastern kingbird		U	R	U			*C*	*O*	*O*	
Vermilion flycatcher		R,I		R,I	R,I					
Ash-throated flycatcher		R			R					
Scissor-tailed flycatcher		C	C	F	ACC		*C*	*C*	*C*	
Eastern phoebe**		U	U	U	F					
Corvidae										
Blue jay		C	C	C	C		*C*	*C*	*C*	*C*
American crow		A	C	A	A		*C*	*C*	*C*	*C*
Alaudidae										
Horned lark										*H*
Hirundinidae										
Purple martin		C	C	U			*U-C*	*U-C*	*U-C*	*I*
Tree swallow		U		U	O		*I*		*I*	
Barn swallow		U	U	C	O		*C*	*C*	*C*	
N. rough-winged swallow**		U	O	F				*U*	*O*	*U*
Bank swallow**		U		U			*I*		*I*	
Cliff swallow**		F	F	A			*C*	*C*	*C*	
Cave swallow**			R	R						

Family Species ⇓	State Park ⇒	Bastrop/Buescher					*Lake Somerville*			
		SP	S	F	W		*SP*	*S*	*F*	*W*
Paridae										
Carolina chickadee		C	C	C	C		*C*	*C*	*C*	*C*
Tufted titmouse		C	C	C	C		*U*	*U*	*U*	*U*
Sittidae										
Red-breasted nuthatch		R,I		R,I	R,I					*I*
Certhiidae										
Brown Creeper		R		R	U		*O*			*U*
Troglodytidae										
Carolina wren		C	C	C	C		*C*	*C*	*C*	*C*
Bewick's wren		U	U	U	U		*U*		*U*	*U*
House wren		F		F	U		*U*		*U*	*U*
Winter wren		U		R	U		*H*		*H*	*H*
Sedge wren							*H*		*H*	*H*
Marsh wren		U		R	U		*H*		*H*	*H*
Regulidae										
Golden-crowned kinglet		U,I		U,I	U,I		*I*			*I*
Ruby-crowned kinglet		C		C	C		*C*		*U-C*	*C*
Sylviidae										
Blue-gray gnatcatcher		F	U	F	R		*C*		*U-C*	*O*
Turdidae										
Eastern bluebird		F	U	U	F		*U*	*O*	*O*	*C*
Veery		R		ACC			*H*		*H*	
Mountain bluebird					O					
Townsend's solitare					O					
Gray-cheeked thrush		R		R			*H*		*H*	
Swainson's thrush							*O*		*H*	
Hermit thrush		C		U	C		*U*		*H*	*U*
Wood thrush		R	R	R	O		*H*	*H*	*H*	
American robin		A	R	F	A		*C*	*H*	*H*	*C*
Mimidae										
Gray catbird		F	O	U	R		*O*	*H*	*H*	
Northern mockingbird		C	C	C	C		*C*	*C*	*C*	*C*
Brown thrasher		F	U	F	U		*U*	*H*	*H*	*U*
Motacillidae										
American pipit		U		U	U					
Water pipit							*U*		*U-C*	*U-C*
Sprague's pipit							*H*		*H*	*H*
Bombycillidae										
Cedar waxwing		U,I		U,I	U,I		*U-C*			*U-C*
Laniidae										
Loggerhead shrike		F	U	F	F		*U*	*U*	*U*	*U-C*
Sturidae										
European starling		C	F	C	C		*C*	*C*	*C*	*C*

Family Species ⇓	State Park ⇒	Bastrop/Buescher					*Lake Somerville*			
		SP	S	F	W		*SP*	*S*	*F*	*W*
Vireonidae										
White-eyed vireo		C	C	C	U		*U*	*U*	*U*	
Bell's vireo		R	R		O		*H*		*H*	
Solitary vireo		F		F	U		*H*		*H*	
Yellow-throated vireo		U	U				*H*		*H*	
Warbling vireo		U		F			*H*		*H*	
Philadelphia vireo		U					*H*		*H*	
Red-eyed vireo		F	F	R			*O*	*H*	*O*	
Parulidae										
Tennessee warbler		U		R			*H*		*H*	
Blue-winged warbler		R		R						
Golden-winged warbler		R								
Orange-crowned warbler		F		U	F		*H*		*O*	*U*
Yellow warbler		U		C			*H*	*H*	*U*	
Nashville warbler		F		F	O		*H*		*H*	
Northern parula**		C	C	F			*U-C*	*U*	*H*	
Yellow-throated warbler*		U		R	R		*H*	*H*	*H*	
Prothonotary warbler**		U		R			*U*	*O*	*O*	
Swainson's warbler**		R	R	O			*U*	*U*		
Northern waterthrush		F		F			*H*		*H*	
Louisiana waterthrush**		U	R	U	O		*H*	*H*	*H*	
Kentucky warbler**		F	F	U			*H*	*H*	*H*	
Common yellowthroat*		U	R	U	U		*H*	*H*	*H*	
Hooded warbler**		U	U	R			*H*	*H*	*H*	
Chestnut-sided warbler		U		U			*H*		*H*	
Magnolia warbler		U		R			*H*		*H*	
Yellow-rumped warbler		A		C	A		*C*		*O-U*	*C*
Black-throated green warbler		F		F	R		*H*		*O*	
Blackburnian warbler		F		U			*H*		*H*	
Pine warbler		A	C	A	A		*H*		*H*	*U-C*
Palm warbler		R			R		*H*		*H*	
Bay-breasted warbler		U		R			*H*		*H*	
Blackpoll warbler		R		O						
Cerulean warbler		O		ACC						
Black-and-white warbler		C	U	U	R		*U*	*H*	*O*	*H*
American Redstart		U		F			*H*		*H*	
Worm-eating warbler		U		R						
Ovenbird		U		O			*H*		*H*	
Mourning warbler		R		R			*H*		*O*	
Wilson's warbler		U		U	R		*H*		*U*	*U*
Canada warbler		R		U			*U-C*	*U*	*U-C*	*U-C*
Common grackle		C	R	F	C		*C*	*U-C*	*U-C*	*C*
Bronzed cowbird		R		R	R		*H*		*H*	

Family Species ⇓	State Park ⇒	Bastrop/Buescher					*Lake Somerville*			
		SP	S	F	W		*SP*	*S*	*F*	*W*
Brown-headed cowbird		C	C	F	C		*C*	*U*	*C*	*C*
Orchard oriole		U	R	U			*H*	*U*	*O*	
Northern oriole							*H*		*O*	
Baltimore oriole		U		U	O					
Bullock's oriole		R	R	R						
Fringillidae										
Purple finch		R,I			U,I		*I*			*I*
House finch		R		R	R					
Red crossbill		O		RI	RI					
Pine siskin		UI		U	F		*I*			*I*
Lesser goldfinch		R	U		R					
American goldfinch		C		U	C		*C*			*U-C*
Passeridae										
House sparrow		U	U	U	U		*C*	*C*	*C*	*C*

*Legend

SP: March-May, S: June-August, F: September-November, W: December-February
A: abundant, over 50 per day; should be recorded each visit.
C: common, 15-50 per day; should be recorded on 80% of visits.
F: fairly common, 5-15 per day or several flocks passing overhead; should be recorded on 60% of visits.
U: uncommon, less than 5 per day, or no more than 1 group per day; recorded less than 40% of visits.
R: rare, 1 to several per season, or a group per season.
I: irregular and unpredictable.
Acc: accidental, out of normal range; maybe 2 records in a decade.

**Legend

SP: March-May, S: June-August, F: September-November, W: December-February
C: common, more than 10 per day; to be expected in proper habitat.
U: uncommon, 1 to 10 per day, usually present but may be overlooked.
R: rare, few records; not expected every season or year.
I: may occurs in numbers; some years totally absent.
H: hypothetical, no verified sightings from within the park, but to be looked for in season indicated.