ECOREGIONS 33 & 35 – SOUTH CENTRAL AND SOUTHERN HUMID, MIXED LAND USE REGION

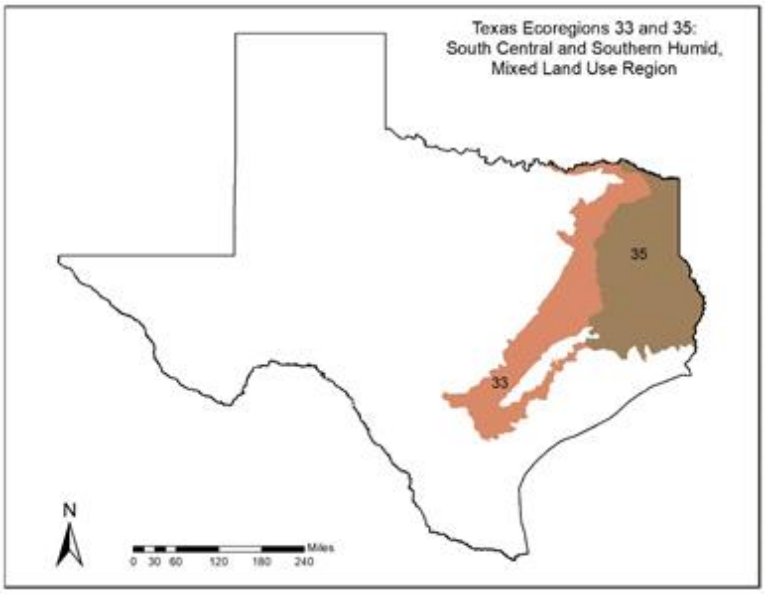

Figure 275. Map of Texas aggregate Ecoregions 33 and 35 – South Central and Southern Humid, Mixed Land Use Region.

Figure 276. Site photo from Frazier Creek.

Based on the results of the detrended correlation analysis from the 1992 report on the Texas Aquatic Ecoregion Project, fish assemblages in ecoregions 33 and 35 formed a distinct grouping as expressed by biological attributes such as species richness (Bayer et al. 1992). Subsequently, the two ecoregions were aggregated as the South Central and Southern Humid, Mixed Land Use Region for the purpose of identifying and evaluating levels of biotic integrity in fish and benthic macroinvertebrate assemblages (Linam et al. 2002).

Ecoregion 33 Characterization

Ecoregion 33, the East Central Plains, is generally characterized by gently rolling to hilly topography which is moderately dissected by drainages (TPWD Landscape Ecology Program webpage). Sandy to sandy loam soils, often with a marked clay subsurface horizon, are typical to Ecoregion 33. These soils are generally Alfisols and are typically acidic to neutral. Typical ecological sites include Claypan Savannah, Claypan Prairie, Sandy Loam, Sandy, and Deep Sand (TPWD Landscape Ecology Program webpage). Pasture and range typify land use in most of the region (Griffith et al. 2007). Mean annual precipitation varies from 71 cm in the south to 122 cm in the northern portions of the region. Griffith et al. (2007) identified six level IV ecoregions within level III Ecoregion 33 and provide more in-depth discussions of physiographic characteristics of the ecoregion. Greater detail on the physiographic characteristics of the region are also given in this report in the physical characterization for each sample site.

As noted by Griffith et al. (2007), the eastern boundary of Ecoregion 33 with the South Central Plains (Ecoregion 35) is a relatively difficult to define transition of soils and vegetation. The region essentially represents a transition from the woodlands and forests of East Texas to the prairies to the west, specifically the Blackland Prairie (Figure 275). Savannas and woodlands are typically dominated by post oak, blackjack oak *Q. marilandica*, and black hickory *Carya texana* (TPWD Landscape Ecology Program webpage).

The primary natural processes that affect this system include drought, grazing, and fire. A large portion of this system has been impacted by conversion to improved pasture for rangeland or crop production for agriculture. Overgrazing and fire suppression have led to increased woody cover and the invasion of some areas by problematic brush species such as eastern red cedar *Juniperus virgiana* to the north and mesquite *Prosopis glandulosa* to the south (TPWD Landscape Ecology Program).

Table 11. Streams in Ecoregion 33.

Blair Creek	Davidson Creek	Mill Creek
Catfish Creek	Kickapoo Creek	Ponds Creek
Cedar Creek	Little Mustang Creek	Smackover Creek
Cummins Creek	Lower Keechi Creek	Wheelock Creek
Cuthand Creek	Middle Yegua Creek	

BLAIR CREEK

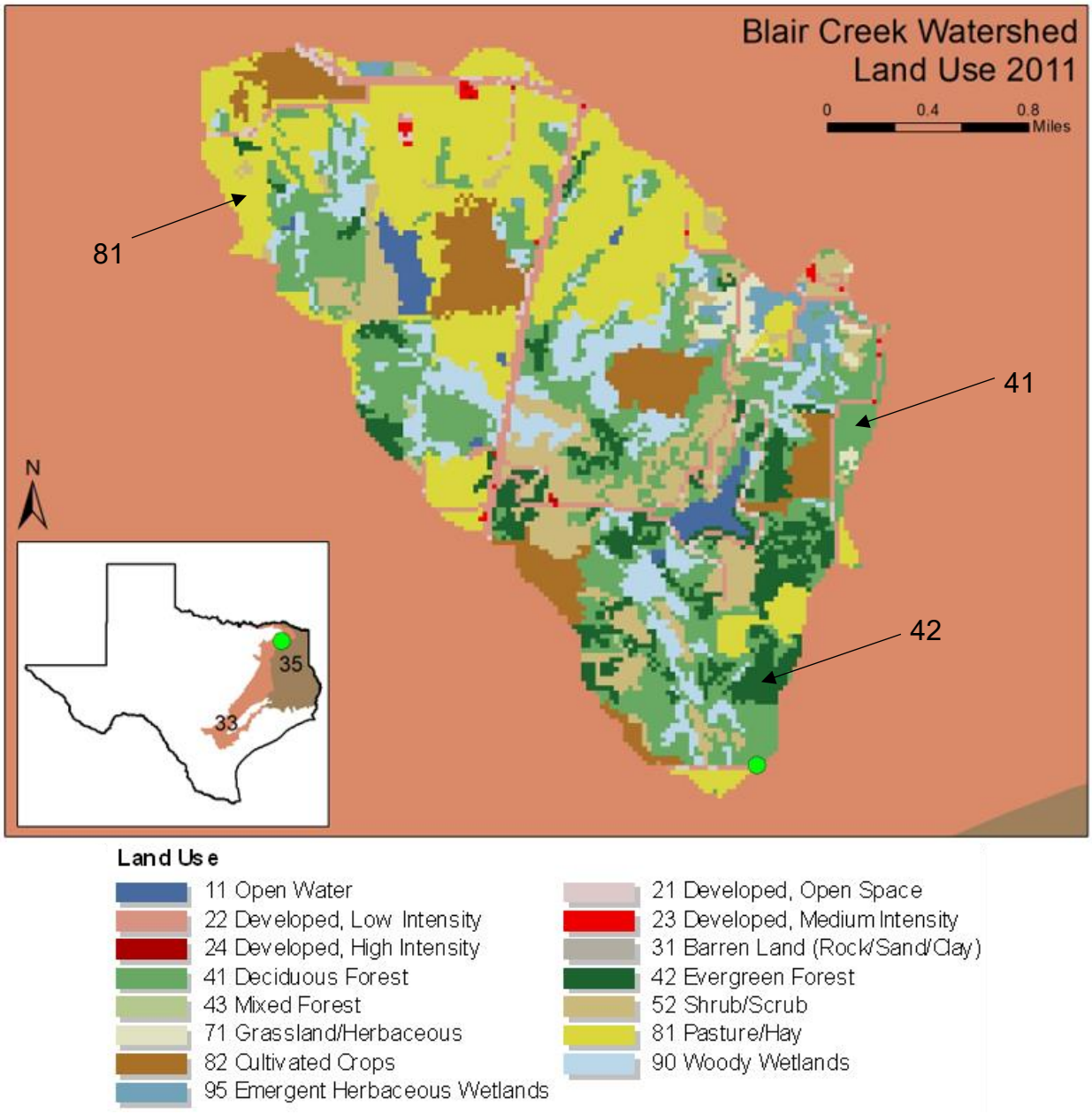

Figure 277. Map of Blair Creek watershed location and 2011 land use; forest and pasture/hay were the most common land uses.

Sampling Dates

Physical Habitat:	June 29, 2004; August 16, 2004
Water Quality:	10 sampling events
Fish:	June 29, 2004; August 16, 2004
Benthic Invertebrates:	June 29, 2004; August 16, 2004

Physical Characterization

Watershed and Land Use

Blair Creek lies within the Cypress Creek Basin. Sample site 17952 is located in Franklin County, 1.73 km west of SH 37 and 1.17 km north of Lake Cypress Springs (Figure 277).

The Blair Creek watershed at site 17952 is approximately 11.4 sq km. The watershed lies within the Level IV Ecoregion 33a, the Northern Post Oak Savanna. The dominant land cover in the watershed is forest at 32% and is most concentrated in the middle and lower part of the watershed. Pasture/hay is a secondary land cover encompassing 26% and is most concentrated in the upper portions of the watershed (Homer et al. 2015; Figure 277 and Figure 278). The combined land cover for developed land use (open space and low, medium, and high intensity) totals 6.96% and total cover for cultivated crops is 8.96%.

From 1992-2011 there was a 2 sq km decrease in pasture/hay and a 1.9 sq km decrease in forest. There was a 1.2 sq km increase in wetlands and a 1.2 sq km increase in shrub (Figure 279).

There are no permitted wastewater outfalls within the Blair Creek watershed.

In Channel and Riparian Physical Habitat

Physical habitat for Blair Creek was evaluated twice in 2004. Blair Creek is a second order perennial stream that is impounded upstream of the sampling site to form Zachry Lake. Downstream of the site, it drains into Lake Cypress Springs. Habitat Quality Index scores are available for both sample events and indicate a high aquatic life use rating (20). Riparian areas were well vegetated throughout the reach with an average riparian buffer measured at greater than 20 meters for both sampling events. The riparian zone was generally dominated by trees followed by grasses then shrubs. The average percentage of tree canopy cover was 92%. The dominant stream substrate was sand, and the average percent of substrate gravel size or larger was 16%. Average percent instream cover was 27% to 31% and instream cover types include large and small woody debris, undercut banks, overhanging vegetation, root mats, and leaf packs. Blair Creek ranged from 0.07-0.13 meters deep on average and 2.5-3.7 meters wide. Average stream bank slope ranged from 45-48 degrees. Stream flow at the site was measured at a minimum value of 0.3 cfs and a maximum of 2.5 cfs. Average stream bank erosion potential was 33%-34%. The deepest pool measured at Blair Creek was 0.8 meters. No riffles were observed at the site and there were nine total stream bends.

Water Quality

Water samples were collected at station 17952 over 10 sampling events from October 2003 through August 2004. Parameters measured included temperature, flow, transparency, specific conductivity, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total nitrogen, phosphorus, total organic carbon, chloride, sulfate, and chlorophyll-a

Biological Characterization

Fish

Twenty-three species (eight families) were collected between the two sampling events. Centrarchidae was the richest family (eight species) with Longer Sunfish being the most abundant species collected. The aquatic life use, based on the fish assemblage, rated as exceptional.

Benthic Macroinvertebrates

A total of 436 individuals representing 11 orders of macroinvertebrates were collected during the two sampling events at Blair Creek (Appendix E). Mayflies (Ephemeroptera) were the most abundant order with taxa from six genera and four families representing 36.5% of the individuals collected. Odonata and Diptera were the next most abundant orders, representing 27.3% and 15.4%, respectively, of the individuals collected. The most abundant families collected were Gomphidae, Chironomidae, and Heptageniidae, representing 16.7%, 11.7%, and 11.2%, respectively, of the total number of individuals collected.

Considered collectively across both sample dates, the functional organization of the Blair Creek macroinvertebrate assemblage was dominated by predators, collector-gatherers, and scrapers which accounted for 36.7%, 34.2%, and 17.5%, respectively, of the total number of individuals collected. The filtering collectors (9.4%) and shredders (2.2%) functional groups represented a smaller proportion of individuals. The EPT for the two collections (9 in June 2004, 8 in August 2004) fall between the 25th and 50th percentile for the aggregated ecoregion. Tolerant taxa are well represented at Blair Creek as indicated by the results for the biotic index (4.9 and 5.0).

Results for the Ecoregions 33 and 35 BIBI for RBP samples were relatively consistent and indicated high aquatic life use for both samples. Both scores fall between the 50th and 75th percentile of all benthic RBP IBIs for the South Central and Southern Humid, Mixed Land Use Region.

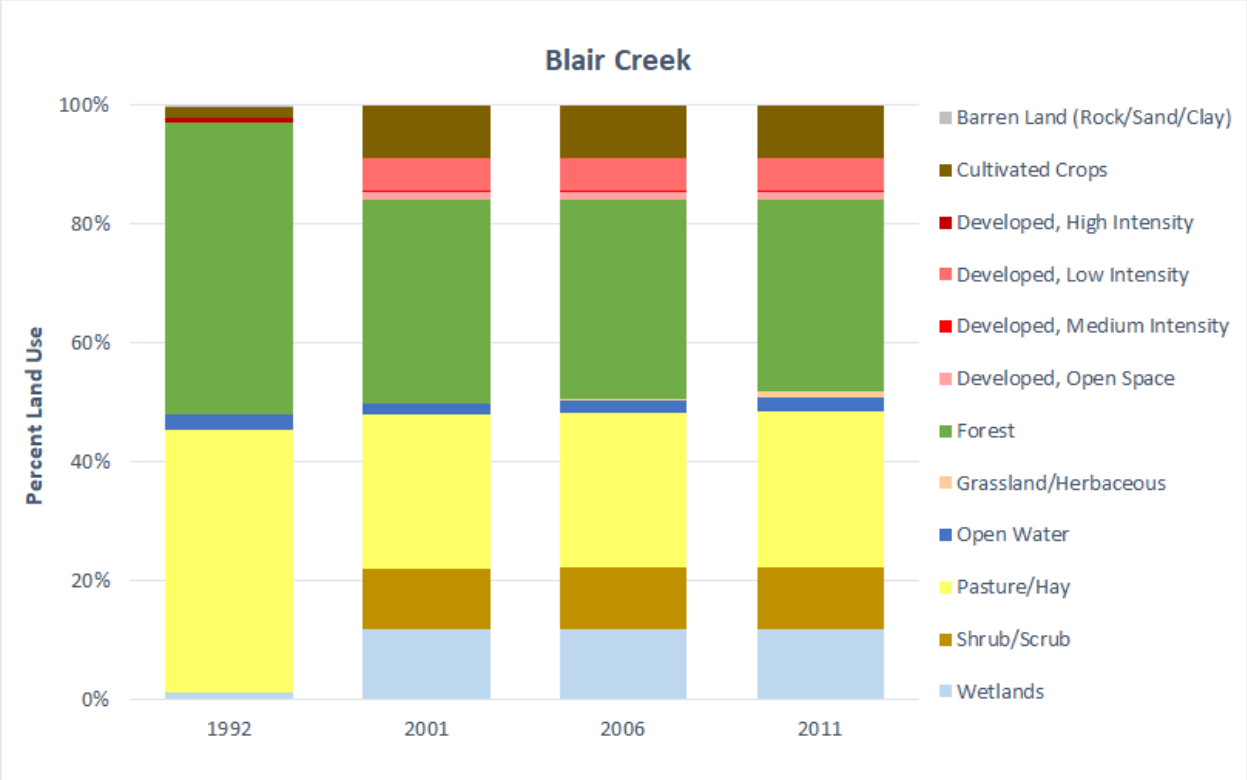

Figure 278. Percent land use in the Blair Creek watershed from 1992-2011.

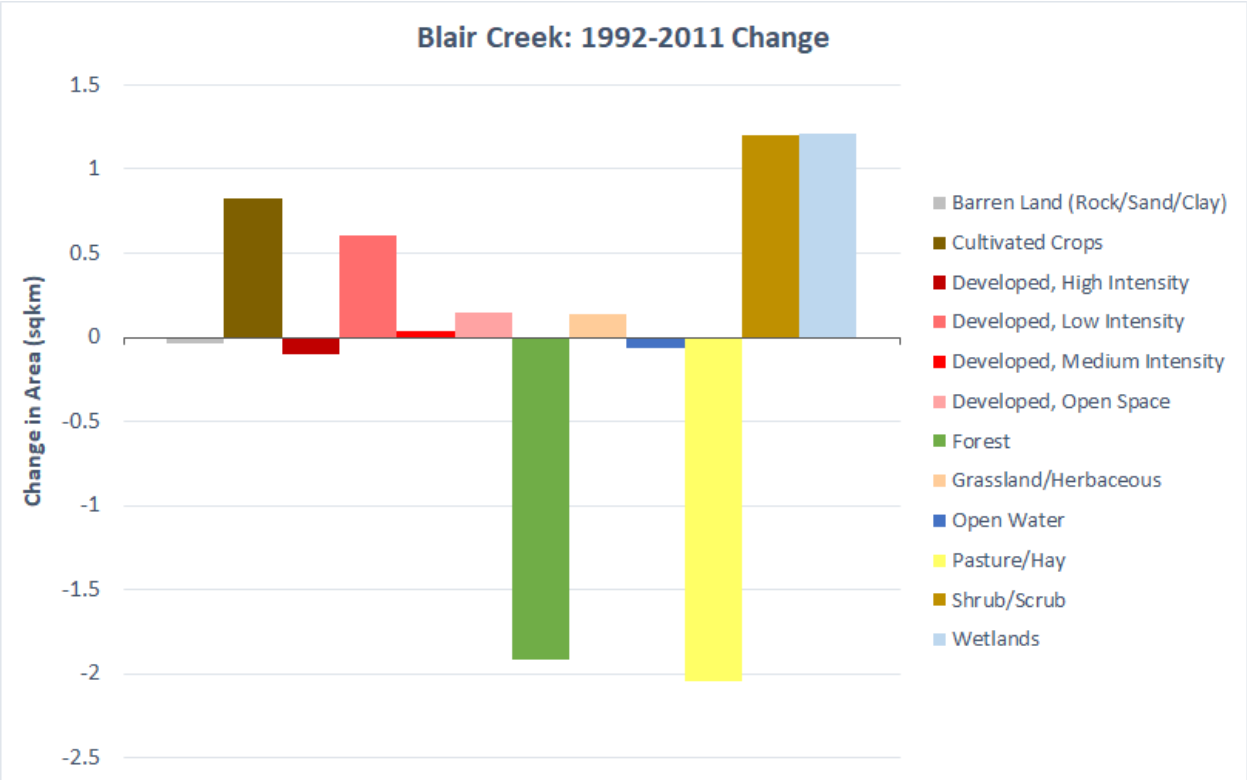

Figure 279. Land use change in area (sq km) from 1992-2011 for the Blair Creek watershed.

CATFISH CREEK

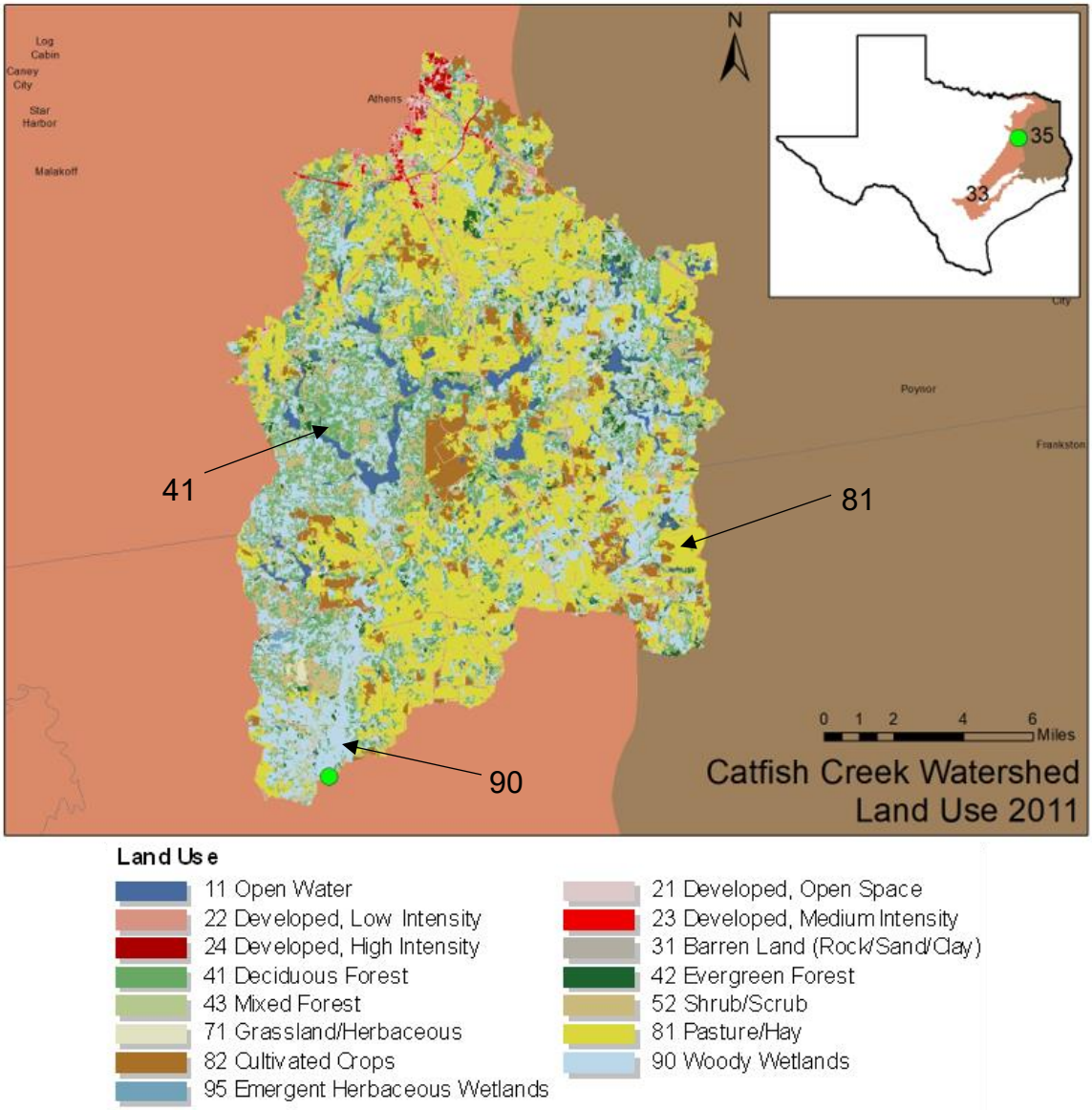

Figure 280. Map of Catfish Creek watershed location and 2011 land use; pasture/hay, forest, and wetlands were the most common land uses.

Sampling Dates

Physical Habitat:	August 16, 1988; April 11, 1989; June 10, 2003; August 25, 2003; August 13, 2004; September 16, 2014
Water Quality:	117 sampling events
Fish:	August 16, 1988; April 11, 1989; June 10, 2003; August 25, 2003; August 13, 2004; September 16, 2014
Benthic Invertebrates:	August 16, 1988; June 10, 2003; August 25, 2003; August 13, 2004; September 16, 2014

Physical Characterization

Watershed and Land Use

Catfish Creek lies within the Trinity River Basin. Sample site 10717 is located 1.70 km downstream of the confluence with Long Creek in the Gus Engeling Wildlife Management Area, 4.18 km east of Bethel in Anderson County (Figure 280).

The Catfish Creek watershed at site 10717 is approximately 505 sq km. Most of the watershed lies within the Level IV Ecoregion 33a, the Northern Post Oak Savanna. The dominant land cover in the watershed is pasture/hay at 33.65% and is present throughout the watershed (Homer et al. 2015; Table Y1, Figure 280 and Figure 281). Forest and wetlands are secondary land covers encompassing 20.70% and 20.37% of the Catfish Creek watershed, respectively. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 5.59% and total cover for cultivated crops is 6.28%.

From 1992-2011 there was a 124.58 sq km decrease in forest and a 56.62 sq km decrease in pasture/hay. There was a 93.2 sq km increase in wetlands, 46.47 sq km increase in shrub, and 13.0 sq km increase in open space development (Figure 282).

There are no permitted wastewater outfalls within the Catfish Creek watershed.

In Channel and Riparian Physical Habitat

Physical habitat for Catfish Creek was evaluated during five sampling events from 1988 to 2014. Catfish Creek is a fourth order perennial stream that drains to the Trinity River. Habitat Quality Index scores are available for four sample events and indicate an intermediate to high aquatic life use rating (17.5-21). Riparian areas were well vegetated throughout the reach with an average riparian buffer measured at greater than 20 meters for all sampling events. The riparian zone was generally dominated by trees followed by grasses then shrubs. The average percentage of tree canopy cover ranged from 95% to 100%. The dominant stream substrate was sand and silt, and the average percent of substrate gravel size or larger varied from 0% to 9%. Average percent instream cover was 22% to 42% and instream cover types include large and small woody debris, undercut banks, leaf packs, and macrophytes. Catfish Creek ranged from 0.25-0.6 meters deep on average and 5-9 meters wide. Average stream bank slope ranged from 33-50 degrees. Stream flow at the site was measured at a minimum value of 4.7 cfs and a maximum of 24 cfs. Average stream bank erosion potential was 21%-83%. The deepest pool measured at Catfish Creek was 1.5 meters. Number of riffles observed at the site varied from zero to five, and total number of stream bends ranged from one to five.

Water Quality

Water samples were collected at station 10717 over 117 sampling events from August 1988 through January 2020. Parameters measured included temperature, flow, transparency, specific conductivity, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total nitrogen, phosphorus, total organic carbon, chloride, sulfate, and chlorophyll-a.

Biological Characterization

Fish

All aquatic life use ratings (based on the fish assemblage) rated as high, except for the September 2014 collection which rated as exceptional. Anomalies were fairly prevalent in the 1980s with 1.6% of the individuals collected in 1988 and 0.7% of the individuals collected in 1989 identified with some sort of physical anomaly, resulting in metric scores of 1 and 3, respectively. No anomalies were noted in the more recent collections. Thirty-five species (11 families) were collected over the course of the six sampling events. Centrarchidae yielded the most species (11). Blacktail Shiner*,* Weed Shiner *Notropis texanus,* Longear Sunfish, and Dusky Darter *Percina sciera* were present in every collection. Ribbon Shiner *Lythrurus fumeus* was common in the 1980 collections, absent in 2003 and 2004, and the most abundant fish species in the 2014 collection. Emerald Shiner *Notropis atherinoides* was first collected in June 2003, was the most abundant fish species by the August 2003 and 2004 collections but was absent in 2014. Given that both species were never identified together it is possible that one of the species was misidentified. Several species were only collected once. Single specimens of Channel Catfish, Red Shiner, and Dollar Sunfish *Lepomis marginatus* were collected in 1988, 1989, and 2003, respectively. Flier *Centrarchus macropterus* were only collected in 1989, Redear Sunfish *Lepomis microlophus* in 2003, and Blackspot Shiner *Notropis atrocaudalis* in 2014, but were represented by several individuals in each instance.

Benthic Macroinvertebrates

During the period from August 1988 to September 2014 five benthic macroinvertebrate samples were collected at Catfish Creek. A total of 894 individuals representing 16 orders and 75 macroinvertebrate taxa were collected (Appendix E). Taxa richness for individual samples ranged from a low of 13 in the collection made in June 2003 to a high of 32 in the collection made in September 2014. Caddisflies (Trichoptera) was the most commonly collected order representing 26.1% of the total individuals collected. Coleoptera (18.1%), Ephemeroptera (15.8%), Diptera (13.1%), Pelecypoda (8.9%), and Odonata (4.2%) were also commonly collected.

The median taxa richness across all collections was 20 which falls between the 25th and 50th percentiles for taxa richness in ecoregion 33, and below the 25th percentile taxa richness for ecoregion 35. Perhaps this result is a reflection of the geographic position of the Catfish Creek watershed straddling these two ecoregions. Though variable in abundance, the EPT taxa seem dominant in the assemblage, representing a range from 2% to 79.6% with a median of 41.3% of individuals across all collections. Similar to findings for taxa richness, the number of EPT taxa was relatively low relative to that found in other streams in ecoregions 33 and 35, with a median value of 9 across all collections. This value falls below the 25th percentile for ecoregion 35 and between the 25th and 50th percentiles for ecoregion 33.

Functionally, the Catfish Creek benthic macroinvertebrate assemblages were found to be relatively diverse, with the median percent dominant functional group (44.4%) across all collections falling between the 50th and 75th percentiles for the aggregated ecoregion. The collector-gatherer and filtering-collector taxa collectively were the dominant functional component and represented a median percentage of 65% across all collections. The scraper-collectors (median 15.6%) comprise a smaller component of the functional assemblage. These findings are consistent with the heavily canopied channel with large amounts of suspended and benthic fine and coarse particulate organic matter (FPOM and CPOM) that characterize Catfish Creek. Predators (median 15.2%) comprised the next most abundant functional group.

As a result of the naturally heavy canopy, high turbidity, high organic loads, and low gradient, Catfish Creek periodically experiences relatively low dissolved oxygen values, especially during the summer when water temperatures are warm. As a result, the median value for the biotic index of 5.5 exceeds the 75th percentile value for the biotic index in other samples from reference streams in the aggregated ecoregion.

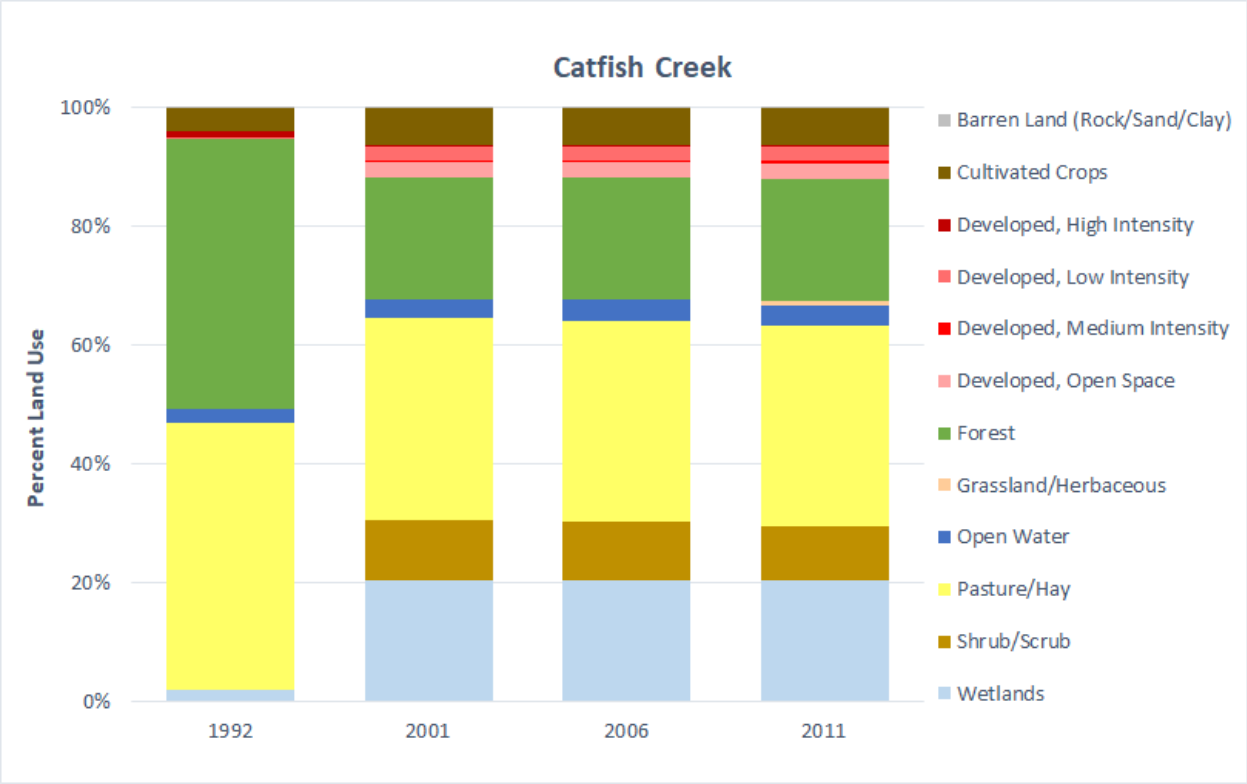

Figure 281. Percent land use in the Catfish Creek watershed from 1992-2011.

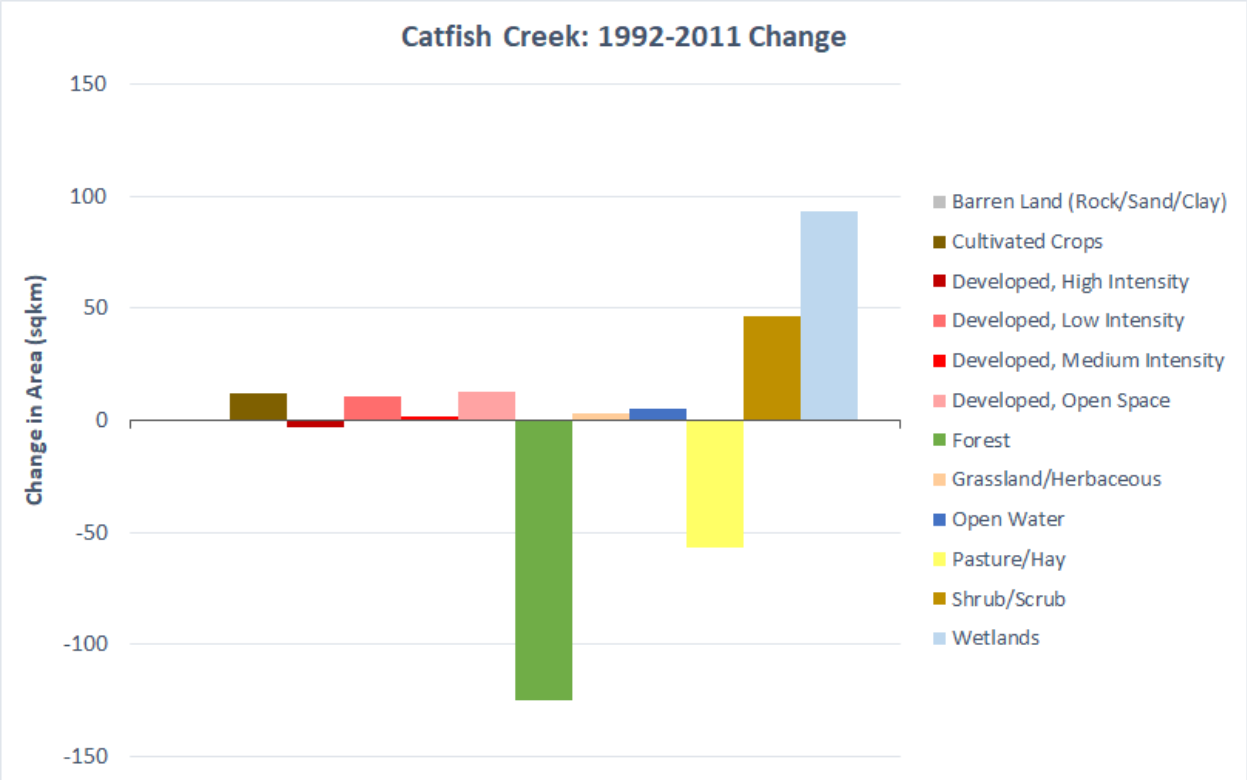

Figure 282. Land use change in area (sq km) from 1992-2011 for the Catfish Creek watershed.

CEDAR CREEK

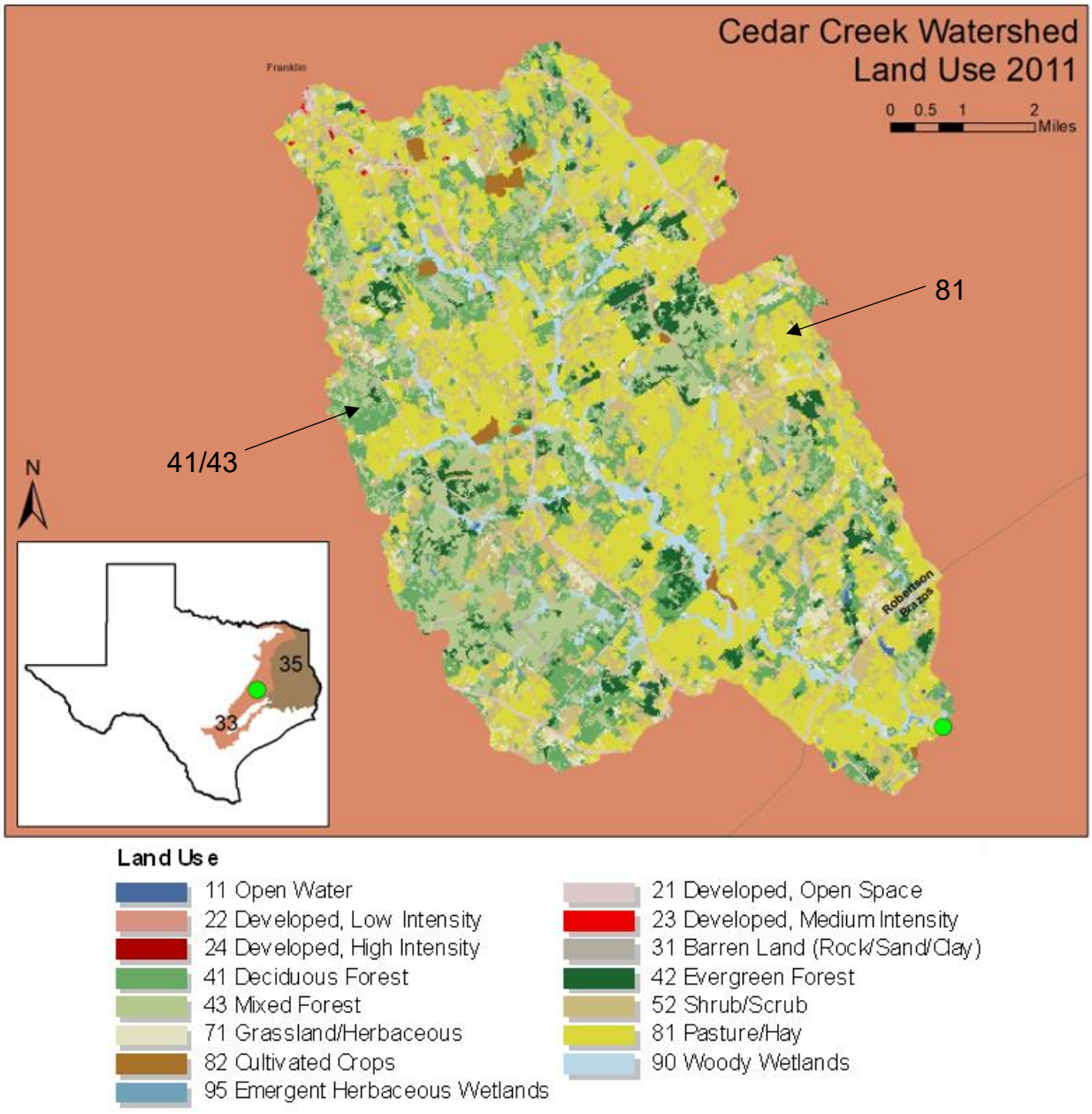

Figure 283. Map of Cedar Creek watershed location and 2011 land use; pasture/hay and forest were the most common land uses.

Sampling Dates

Physical Habitat:	August 31, 2004; October 12, 2004
Water Quality:	No samples
Fish:	August 31, 2004; October 12, 2004
Benthic Invertebrates:	August 31, 2004; October 12, 2004

Physical Characterization

Watershed and Land Use

Cedar Creek lies within the Brazos River Basin. Sample site 20529 is located 0.871 km downstream of the confluence with Smith Branch in Brazos County (Figure 283).

The Cedar Creek watershed at site 20529 is approximately 157 sq km. The sample site and lower watershed is located in Level IV Ecoregion 33c, the San Antonio Prairie; however, the majority of watershed lies within Level IV Ecoregion 33b, the Southern Post Oak Savanna. The dominant land cover in the watershed is pasture/hay at 36.85% and is present throughout the watershed (Homer et al. 2015; Figure 283 and Figure 284). Forest is a secondary land cover encompassing 32.84% of the Cedar Creek watershed. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 4.19% and total cover for cultivated crops is 0.84%.

From 1992-2011 there was a 30.27 sq km decrease in pasture/hay and a 6.29 sq km decrease in forest. There was a 23.65 sq km increase in shrub and 6 sq km increase in wetlands (Figure 285).

There are no permitted wastewater outfalls within the Cedar Creek watershed.

In Channel and Riparian Physical Habitat

Physical habitat for Cedar Creek was evaluated twice in 2004. Cedar Creek is a third order perennial stream that drains to the Navasota River. Habitat Quality Index scores are available for both sample events and indicate an intermediate aquatic life use rating (18.5-19). Riparian areas were well vegetated throughout the reach with an average riparian buffer ranging from 17 to 18 meters wide. The riparian zone was generally dominated by trees followed by grasses then shrubs. The average percentage of tree canopy cover ranged from 92% to 95%. The dominant stream substrate was sand, and the average percent of substrate gravel size or larger was 24%. Average percent instream cover was 16% to 18%. Cedar Creek ranged from 0.2-0.3 meters deep on average and 4-5 meters wide. Average stream bank slope ranged from 40-41 degrees. Stream flow at the site was measured at a minimum value of 2.3 cfs and a maximum of 3.3 cfs. Average stream bank erosion potential was 39%-50%. The deepest pool measured at Cedar Creek was 1.3 meters. Two riffles were observed at the site and there were three total stream bends.

Water Quality

No water quality data for this waterbody were available in SWQMIS as of March 2021.

Biological Characterization

Fish

The aquatic life use (based on the fish assemblage) rated as intermediate (August 2004) and high (October 2004); however, the August sample obtained a high rating when the coefficient of variability is applied. The metrics receiving the lowest rating were number of benthic invertivore species (two species), number of intolerant species (two species), and number of individuals. The

two benthic invertivore species collected were Slough Darter *Etheostoma gracile* and Dusky Darter. Intolerant species were Mimic Shiner and Dusky Darter. Twenty-two species (eight families) were collected between the two sampling events. The family Centrarchidae was represented by the greatest number of species (eight) closely followed by Cyprinidae (six).

Benthic Macroinvertebrates

A total of 326 individuals representing nine orders of macroinvertebrates were collected during the two sample events at Cedar Creek (Appendix E). Mayflies (Ephemeroptera) was the most abundant order with taxa from 10 genera and four families, representing 44.5% of the individuals collected across both sample dates. The Diptera and Trichoptera were the next most abundant orders, representing 27.3% and 12.9%, respectively, of the individuals collected. The most abundant families collected were Heptageniidae, Chironomidae, and Elmidae, representing 32.5%, 25.2%, and 7.9%, respectively, of the total number of individuals collected.

Considered collectively across both sample dates, the functional organization of the Cedar Creek macroinvertebrate assemblage was dominated by collector-gatherers, scrapers, and filtering collectors which accounted for 39.2%, 29.3%, and 16.2%, respectively, of the total number of individuals collected. The predators (13.6%) and shredders (1.8%) functional groups represented a smaller proportion of individuals.

The EPT for the two collections (14 in August 2004, 12 in October 2004) fall between the 75th and 95th percentile for the aggregated ecoregion. Tolerant taxa are well represented at Cedar Creek as indicated by the results for the biotic index (4.8 and 4.9).

Results for the Ecoregions 33 and 35 BIBI for RBP samples were relatively consistent and indicated high aquatic life use for both samples. Both scores fall between the 50th and 75th percentile of all benthic RBP IBIs for the South Central and Southern Humid, Mixed Land Use Region.

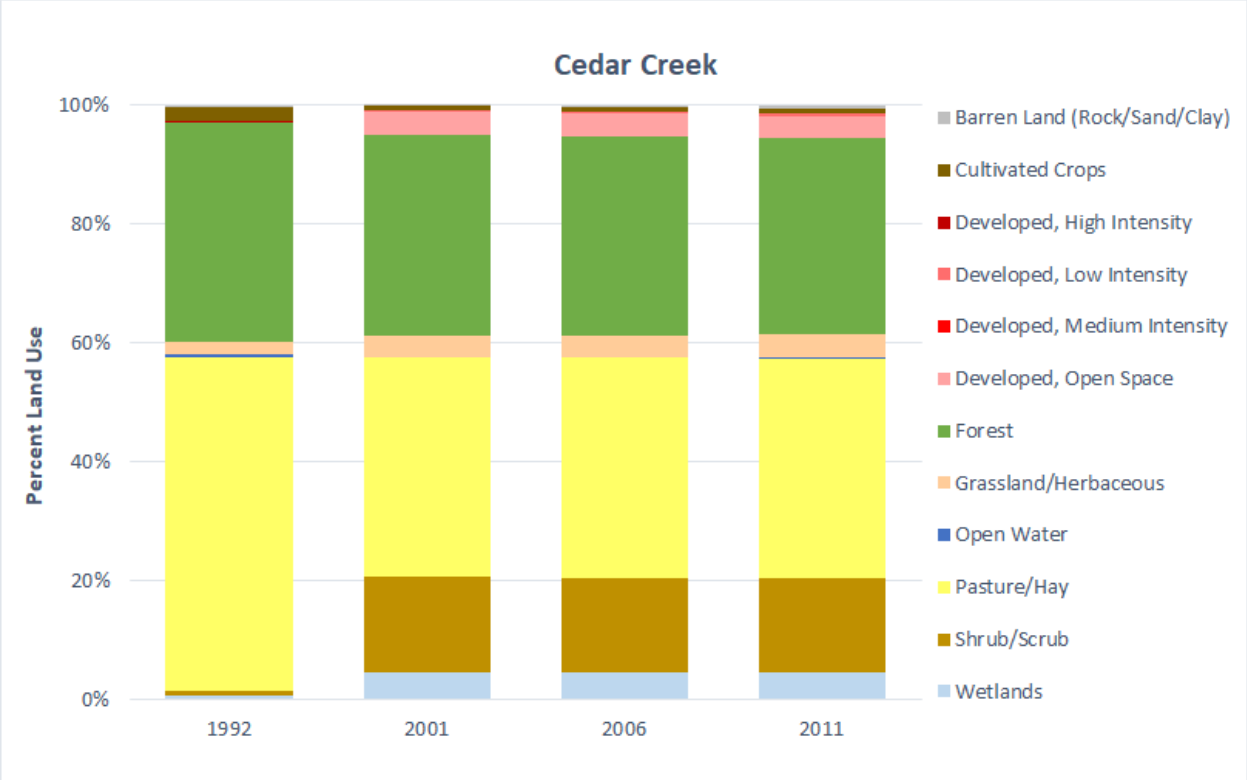

Figure 284. Percent land use in the Cedar Creek watershed from 1992-2011.

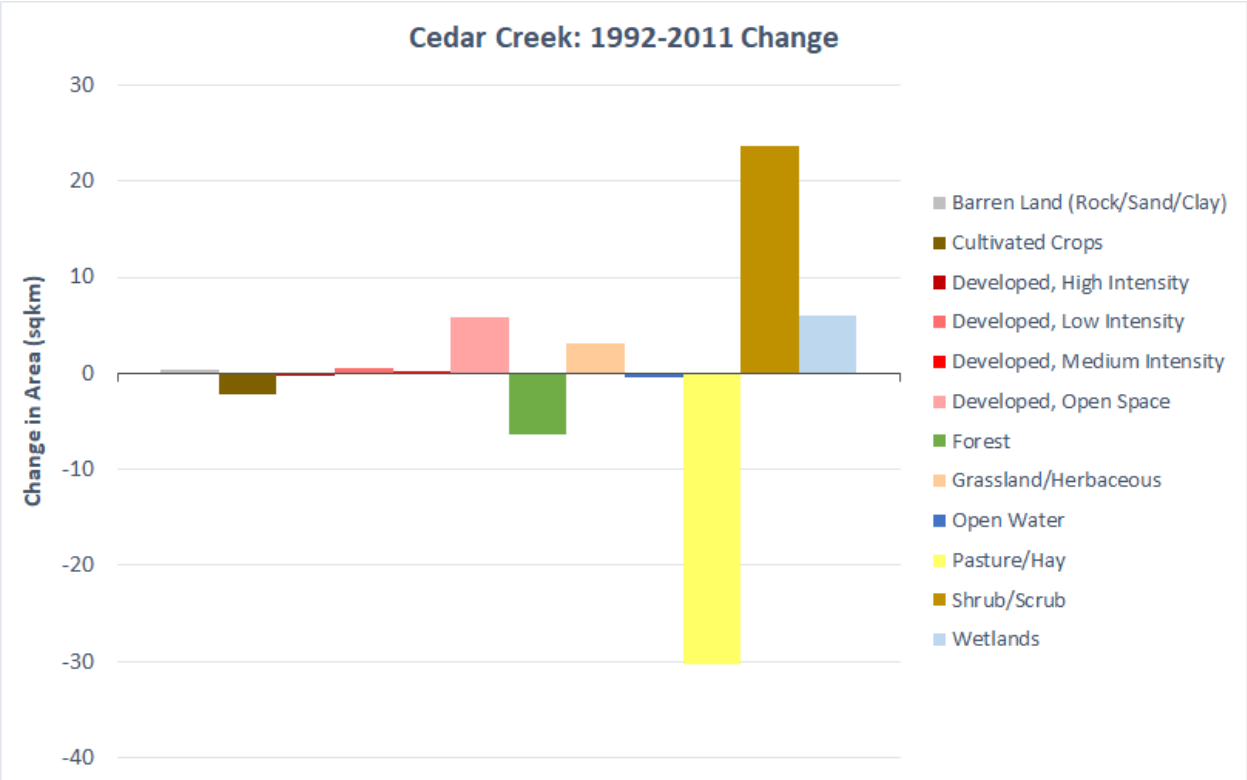

Figure 285. Land use change in area (sq km) from 1992-2011 for the Cedar Creek watershed.

CUMMINS CREEK

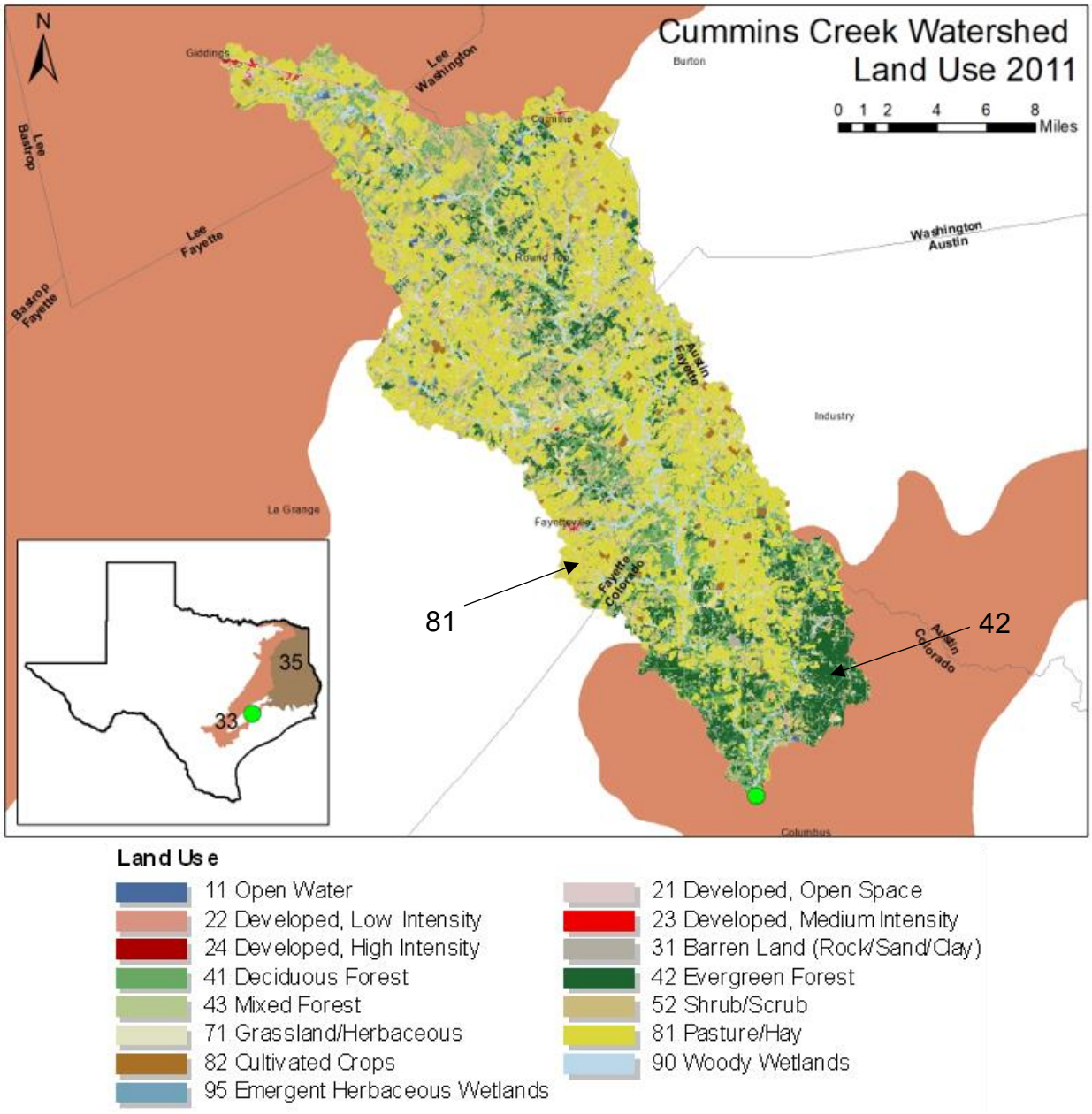

Figure 286. Map of Cummins Creek watershed location and 2011 land use; pasture/hay and forest were the most common land uses.

Sampling Dates

Physical Habitat: June 15, 1990; August 3, 2000; April 26, 2001; October 31, 2001; April 2, 2002; May 19, 2003; March 29, 2004; September 27, 2004; April 26, 2005; September 6, 2005; March 23, 2006; April 24, 2007; May 9, 2011; June 20, 2014; September 13, 2016

Water Quality: 270 sampling events

Fish:	June 25, 1990; August 3, 2000; April 26, 2001; October 31, 2001; April 2, 2002; May 19, 2003; October 1, 2003; March 29, 2004; September 27, 2004; April 26, 2005; September 6, 2005; March 23, 2006; April 24, 2007; May 9, 2011; September 13, 2016
Benthic Invertebrates:	June 25, 1990; March 22, 2000; August 3, 2000; April 26, 2001; October 31, 2001; April 2, 2002; May 19, 2003; October 1, 2003; March 29, 2004; September 27, 2004; April 26, 2005; September 6, 2005; March 23, 2006; April 24, 2007; May 9, 2011; June 20, 2014; September 13, 2016

Physical Characterization

Watershed and Land Use

Cummins Creek lies within the Colorado River Basin. Sample site 12249 is located 58 m downstream of FM 109, north of Columbus in Colorado County (Figure 286).

The Cummins Creek watershed at site 12249 is approximately 759.51 sq km. The sample site and upper watershed are located in Level IV Ecoregion 33b, the Southern Post Oak Savannah; however, the middle portion of the watershed lies within Level IV Ecoregion 32b, the Southern Blackland/Fayette Prairie. The dominant land cover in the watershed is pasture/hay at 42.63% and is present throughout the watershed but is concentrated in the middle and upper portions (Homer et al. 2015; Figure 286 and Figure 287). Forest and shrub are secondary land covers encompassing 26.32% and 14.4% of the Cummins Creek watershed, respectively. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 5.77% and total cover for cultivated crops is 1.18%.

From 1992-2011 there was a 60.76 sq km and 59.73 sq km decrease in grasslands and forest, respectively. There was a 47.67 sq km increase in pasture/hay, 37.4 sq km increase in open space development, and 35.38 sq km increase in wetlands (Figure 288).

There are three domestic wastewater outfalls (discharges < 1 million gallons per day), one permitted to the Town of Round Top, one permitted to the Falls Municipal Utility District, and one permitted to the City of Fayetteville. None of the wastewater outfalls discharge directly into Cummins Creek.

In Channel and Riparian Physical Habitat

Physical habitat for Cummins Creek was evaluated during 15 sampling events from 1990 to 2016. Cummins Creek is a fourth order perennial stream that drains to the Colorado River. Habitat Quality Index scores are available for 12 sample events and indicate a high aquatic life use rating (22-24). Riparian areas were well vegetated throughout the reach with an average riparian buffer ranging from 14 meters wide to greater than 20 meters. The riparian zone was generally dominated by grasses followed by trees then shrubs and cultivated fields. The average percentage of tree canopy cover ranged from 17% to 80%. The dominant substrate type varies

from sand to gravel to cobble for the 15 sampling events, but gravel was identified as dominant most frequently followed by sand (7 and 6 events, respectively). The average percent of substrate gravel size or larger varied from 19% to 76%. Average percent instream cover was 20% to 54% and instream cover types include gravel, algae, macrophytes, overhanging vegetation, undercut banks, root mats, snags, leaf packs and artificial substrate. Cummins Creek ranged from 0.2-0.5 meters deep on average and 8-24 meters wide. Average stream bank slope ranged from 31-68 degrees. Stream flow at the site was measured at a minimum value of 0.8 cfs and a maximum of 27 cfs. Average stream bank erosion potential was 3%-82%. The deepest pool measured at Cummins Creek was 1.6 meters. Number of riffles observed at the site varied from one to four, and total number of stream bends ranged from two to four.

Water Quality

Water samples were collected at station 12249 over 270 sampling events from January 1984 through September 2016. Parameters measured included temperature, flow, transparency, specific conductivity, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total nitrogen, phosphorus, total organic carbon, chloride, sulfate, and chlorophyll-a.

Biological Characterization

Fish

The aquatic life use ratings for Cummins Creek (based on the fish assemblage) included one intermediate, nine high, and five exceptional ratings between 1990 and 2016. Four of the samples rating as high increase to exceptional (and the intermediate rating increases to high) when the coefficient of variability is applied, resulting in a total of nine exceptional ratings. All exceptional ratings (attained without the coefficient of variability) come from the earliest sampling events (prior to 2005). The reduction in aquatic life use rating is not related to any particular metric.

Species richness ranged from 18 to 28, with a total of 46 species (11 families) collected between the 15 samples. Species collected in every sample included: Blacktail Shiner, Warmouth, Bluegill, and Longear Sunfish. Species represented by individuals in all but one sampling event included: Red Shiner, Central Stoneroller, Blackstripe Topminnow, Western Mosquitofish, Channel Catfish, Green Sunfish, Redspotted Sunfish *Lepomis miniatus*, and Dusky Darter. Four species were only represented by one individual over the course of all the collections - Slough Darter, Pallid Shiner *Hybopsis amnis*, Pugnose Minnow *Opsopoeodus emiliae*, and Black Crappie *Pomoxis nigromaculatus*. Texas Shiner appears to be a relatively recent newcomer, with a single individual first being collected in 2005. In the two most recent collections it was the most abundant fish collected. Another recent addition is Orangespotted Sunfish which was only collected in 2016. Of particular note is the collection of three Blue Sucker, a state listed threatened species, in April 2007.

Benthic Macroinvertebrates

A total of 4156 individuals representing 19 orders of macroinvertebrates were collected during the seventeen sample events at Cummins Creek (Appendix E). Mayflies (Ephemeroptera) was the most abundant order representing 31.9% of the individuals collected across all sample dates. Diptera and Trichoptera were the next most abundant orders, representing 24.6% and 18.6%, respectively, of the individuals collected. The most abundant families collected were Simuliidae, Leptohyphidae, and Hydropsychidae representing 18.6%, 8.1%, and 7.8%, respectively, of the total number of individuals collected.

Considered collectively across all sample dates, the functional organization of the Cummins Creek macroinvertebrate assemblage was dominated by filtering collectors, collector gatherers, and scrapers which accounted for 39.5%, 27%, and 17%, respectively, of the total number of individuals collected. The predators (13.1%) and shredders (3.4%) functional groups represented a smaller proportion of individuals.

The EPT ranged from a minimum of 4 to a maximum of 16 with a median value of 8, which falls between the 25th and 50th percentile of all EPT values for least disturbed streams sampled in the aggregated ecoregion. The biotic index ranged from a minimum of 3.6 to a maximum of 5.6. The median value of the biotic index, 4.1, falls between the 5th and 25th percentile of all biotic index values for least disturbed streams sampled in the aggregated ecoregion. The maximum EPT value (16) and the median and minimum values for the biotic index indicate that sensitive species are relatively common in Cummins Creek.

The East Bioregion Surber BIBI for the 1990 Surber sample fell in the exceptional aquatic life use category. Results for the Ecoregions 33 and 35 BIBI for the sixteen RBP samples collected at Cummins Creek reflect a relatively high degree of variability (CV 11.4%) ranging from 22 (limited) to 33 (high). The median of the sixteen benthic IBI scores, 27, falls between the 25th and 50th percentile of all benthic RBP IBIs for the South Central and Southern Humid, Mixed Land Use Region.

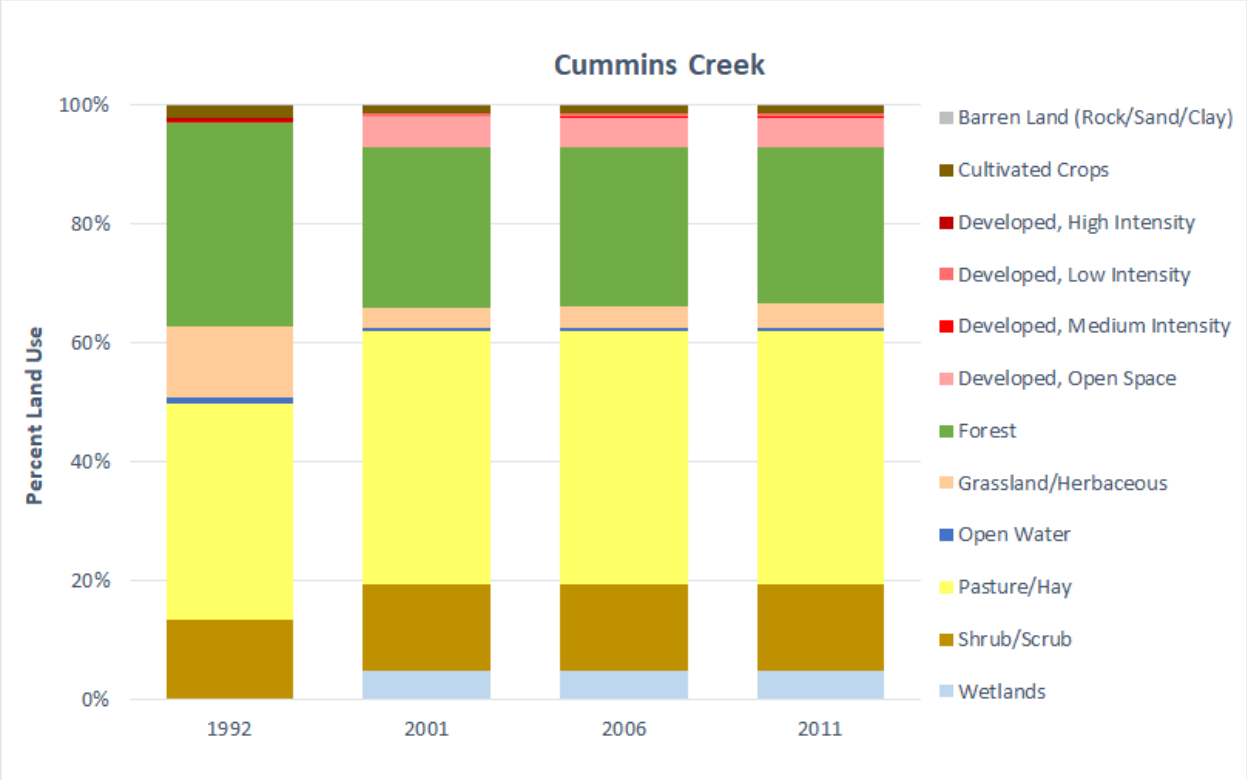

Figure 287. Percent land use in the Cummins Creek watershed from 1992-2011.

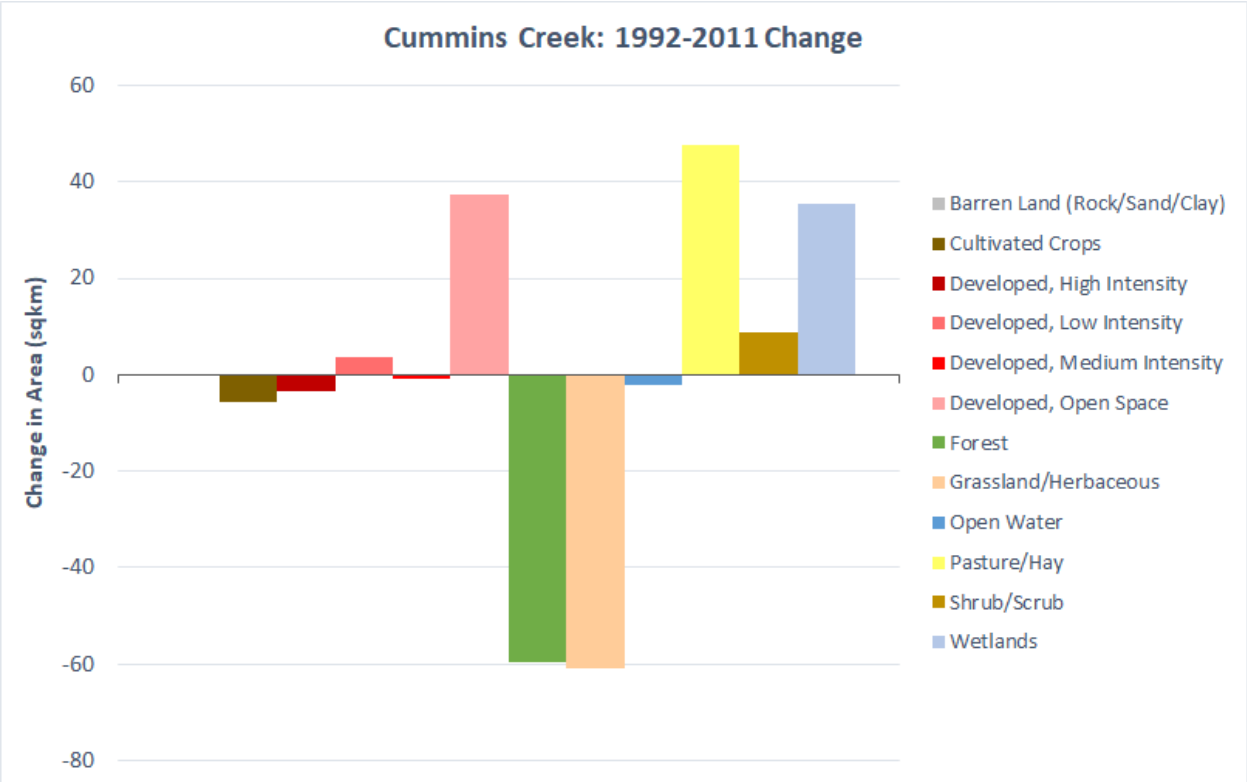

Figure 288. Land use change in area (sq km) from 1992-2011 for the Cummins Creek watershed.

CUTHAND CREEK

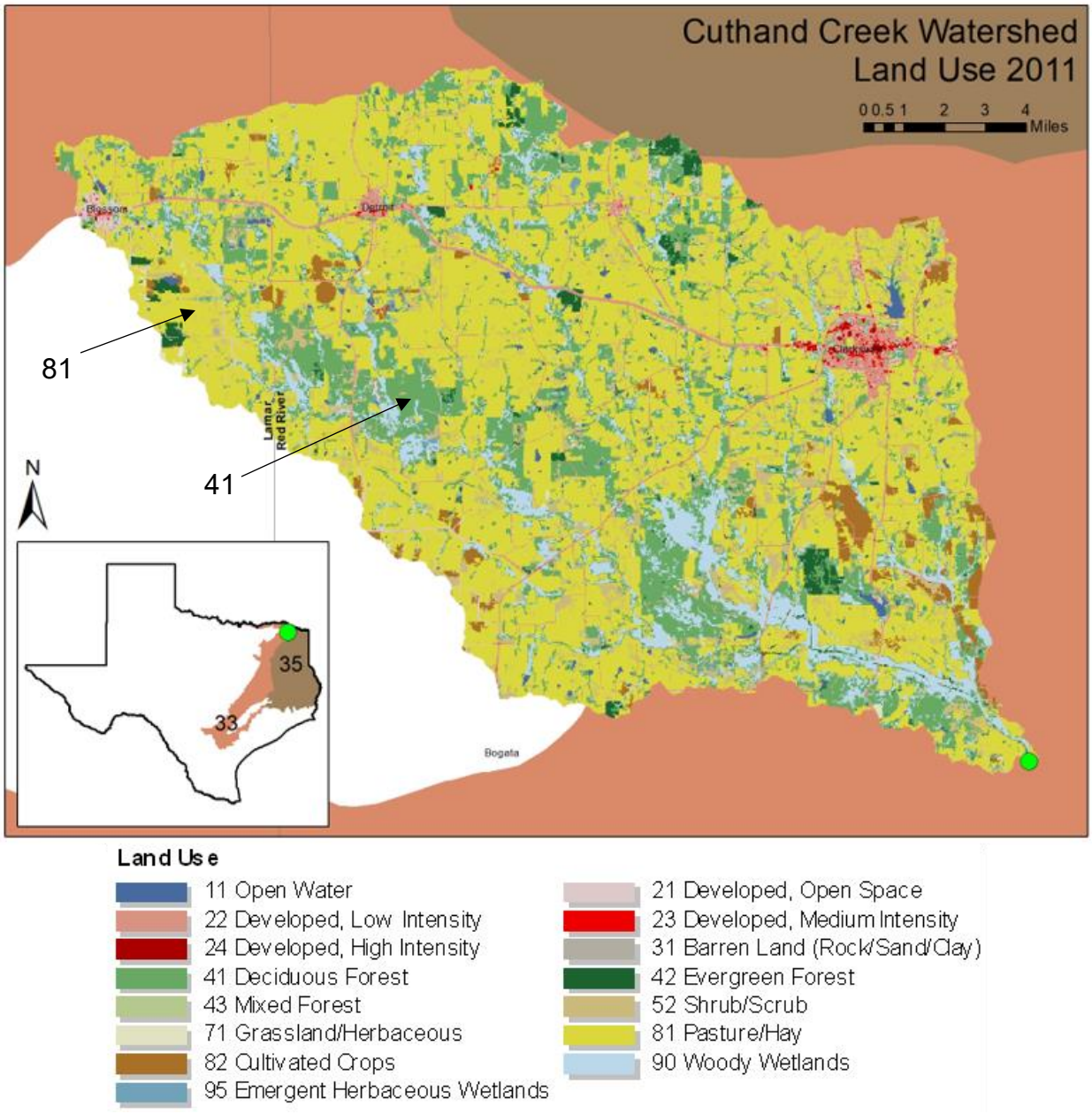

Figure 289. Map of Cuthand Creek watershed location and 2011 land use; pasture/hay and forest were the most common land uses.

Sampling Dates

Physical Habitat:	May 23, 2002
Water Quality:	7 sampling events
Fish:	May 23, 2002; July 5, 2002
Benthic Invertebrates:	May 23, 2002; July 5, 2002

Physical Characterization

Watershed and Land Use

Cuthand Creek lies within the Sulphur River Basin. Sample site 10202 is located east of Bogata, 230 m upstream of FM 1487 in Red River County (Figure 289).

The Cuthand Creek watershed at site 10202 is approximately 622.6 sq km. The sample site is located in Level IV Ecoregion 33f, the Floodplains and Low Terraces; however, the watershed spans Level IV Ecoregion 33a, the Northern Post Oak Savanna, and Ecoregion 33d, the Northern Prairie Outliers. The dominant land cover in the watershed is pasture/hay at 55.73% and is present throughout the watershed (Homer et al. 2015; Figure 289 and Figure 290). Forest is the secondary land cover encompassing 20.17% of the Cuthand Creek watershed. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 5.52% and total cover for cultivated crops is 2.4%.

From 1992-2011 there was a 52.05 sq km decrease in cultivated crops and 35.95 sq km decrease in forest. There was a 41.03 sq km increase in shrub, 19.65 sq km increase in wetlands, and 18.89 sq km increase in low intensity development (Figure 291).

There are three domestic wastewater outfalls (discharges < 1 million gallons per day), one permitted to the City of Detroit, one permitted to the City of Clarksville, and one permitted to the City of Blossom. The City of Blossom wastewater outfall discharges directly into Cuthand Creek in the upper watershed.

In Channel and Riparian Physical Habitat

Physical habitat for Cuthand Creek was evaluated on May 23, 2002. Cuthand Creek is a fourth order intermittent stream with perennial pools that drains to the Sulphur River. The Habitat Quality Index score of 18 indicates an intermediate aquatic life use rating. Riparian areas were well vegetated throughout the reach with an average riparian buffer measured at greater than 20 meters. The riparian zone was dominated by grasses, which made up an average of 39% of the total riparian species, followed by shrubs (20%) then trees (19%). The average percentage of tree canopy cover was 13%. The dominant substrate was cobble and the average percent of substrate gravel size or larger was 32%. Average percent instream cover was 54%. Cuthand Creek was 0.3 meters deep on average and 12 meters wide. Average stream bank slope was 24 degrees and the average stream bank erosion potential was 73%. Stream flow at the site was 20 cfs. No pools were identified on Cuthand Creek at the time of sampling. One riffle was observed at the site and there was one poorly defined stream bend.

Water Quality

Water samples were collected at station 10202 over 7 sampling events from August 1984 through July 2002. Parameters measured included temperature, flow, transparency, specific conductivity, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total nitrogen, phosphorus, chloride, sulfate, and chlorophyll-a.

Biological Characterization

Fish

Seventeen species (nine families) were collected between the two sampling events. The families yielding the greatest number of species were Ictaluridae (four), Centrarchidae (four), and Cyprinidae (3). Red Shiner was the most abundant species in both collections. The aquatic life use rating for both fish collections was only intermediate. The fish assemblage was dominated by tolerant species (78-95% of the individuals collected), yielded a low number of benthic invertivore species, and had a low percentage of piscivores.

Benthic Macroinvertebrates

A total of 253 individuals representing 12 orders of macroinvertebrates were collected during the two sample events at Cuthand Creek (Appendix E). Caddisflies (Trichoptera) was the most abundant order with the family Hydropsychidae accounting for 37.9% of the individuals collected across both sample dates. Ephemeroptera and Odonata were the next most abundant orders, representing 28.4% and 12.6%, respectively, of the individuals collected. The most abundant families collected were Hydropsychidae, Caenidae, and Baetidae, representing 37.9%,12.6%, and 12.2%, respectively, of the total number of individuals collected.

Considered collectively across all sample dates, the functional organization of the Cuthand Creek macroinvertebrate assemblage was dominated by filtering collectors, collector gatherers, and predators which accounted for 42.3%, 20.6%, and 20.36%, respectively, of the total number of individuals collected. The scrapers (16.4%) and shredders (0.4%) functional groups represented a smaller proportion of individuals.

The EPT was 5 for the sample collected May 2002 and 4 for the sample collected July 2002. These values are relatively low, falling at and just below the 5th percentile for all EPT values for least disturbed streams sampled in the aggregated ecoregion. The biotic index was 4.8 for the May sample which falls between the 25th and 50th percentile for all biotic index values for least disturbed streams in the aggregated ecoregion. In July, the value obtained for the biotic index was 6.3, which exceeds the value obtained for 75% of the ecoregion 33/35 least disturbed streams samples. The relatively low EPT values and the relatively high values for the biotic index indicate that tolerant species are relatively common in Cuthand Creek.

Results for the Ecoregions 33 and 35 BIBI for the May 2002 RBP sample indicated limited aquatic life use, while the score for the July sample indicated intermediate aquatic life use. The two IBI scores fall between the 25th and 50th percentiles of all benthic RBP IBIs for the South Central and Southern Humid, Mixed Land Use Region.

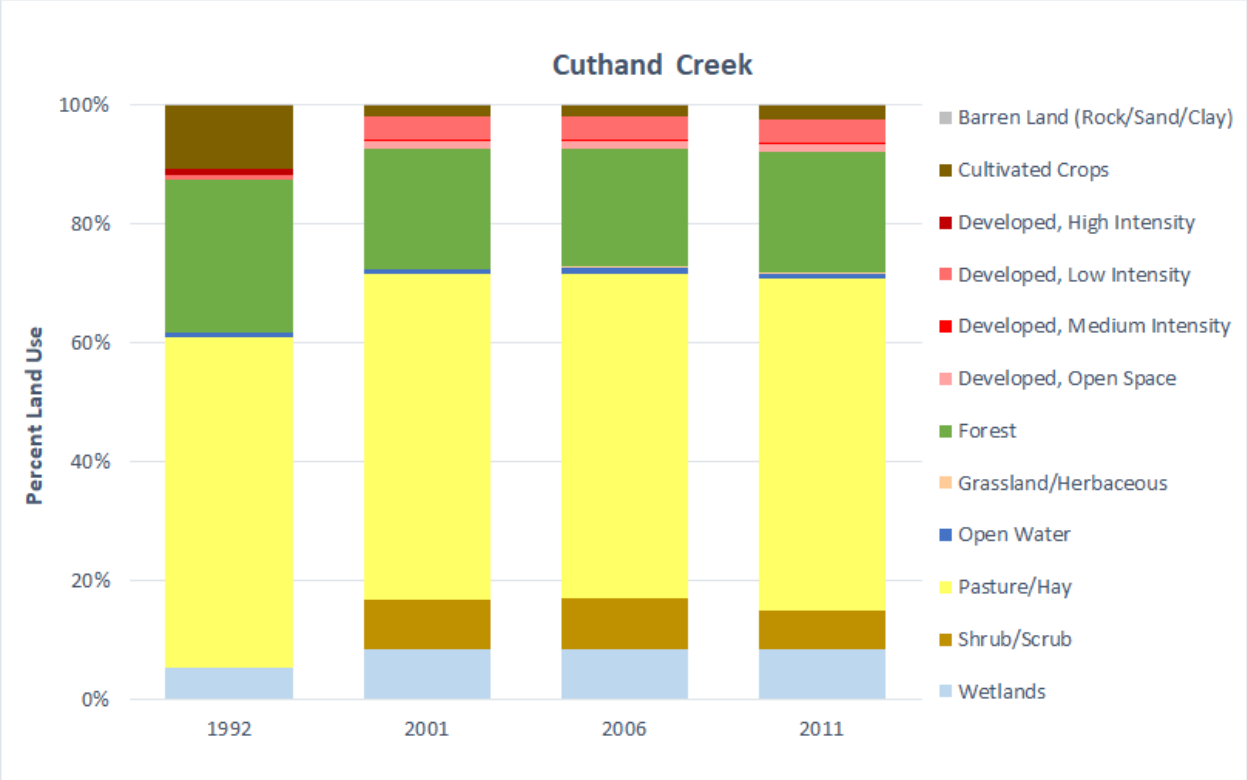

Figure 290. Percent land use in the Cuthand Creek watershed from 1992-2011.

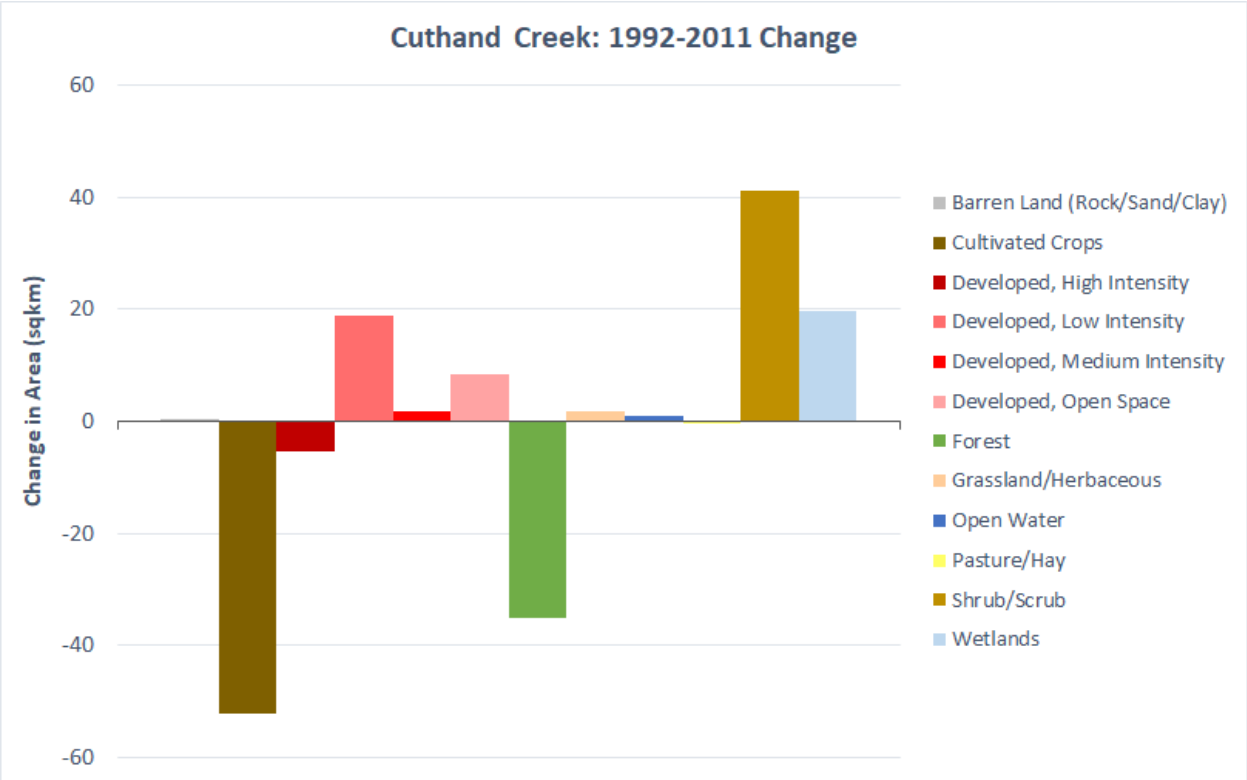

Figure 291. Land use change in area (sq km) from 1992-2011 for the Cuthand Creek watershed.

DAVIDSON CREEK

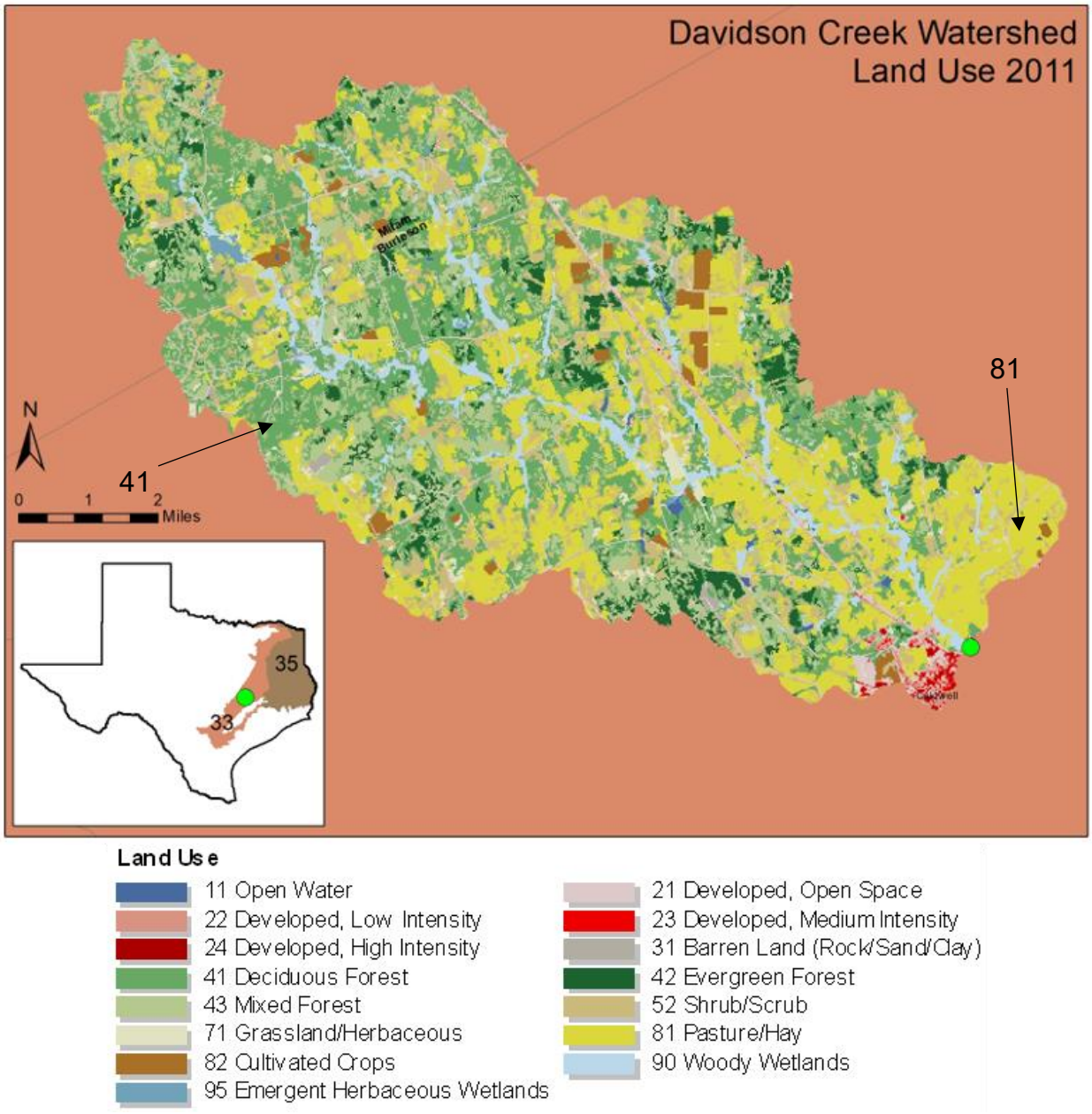

Figure 292. Map of Davidson Creek watershed location and 2011 land use; forest and pasture/hay were the most common land uses.

Sampling Dates

Physical Habitat:	August 18, 1988; June 30, 2003; September 10, 2003
Water Quality:	111 sampling events
Fish:	August 17, 1988; April 13, 1989; June 30, 2003; September 10, 2003
Benthic Invertebrates:	August 18, 1988; June 30, 2003; September 10, 2003

Physical Characterization

Watershed and Land Use

Davidson Creek lies within the Brazos River Basin. Sample site 11729 is located downstream of SH 21, 0.8 km northeast of Caldwell in Burleson County (Figure 292).

The Davidson Creek watershed at site 11729 is approximately 178.11 sq km. The sample site is located in Level IV Ecoregion 33c, the San Antonio Prairie, and the majority of the watershed lies within Level IV Ecoregion 33b, the Southern Post Oak Savanna. The dominant land cover in the watershed is forest at 44.33% and is most concentrated in the middle and upper watershed (Homer et al. 2015; Figure 292 and Figure 293). Pasture/hay and shrub are the secondary land covers encompassing 26.82% and 13.96% of the Davidson Creek watershed, respectively. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 5.19% and total cover for cultivated crops is 1.83%.

From 1992-2011 there was a 14.22 sq km decrease in grasslands and 8.18 sq km decrease in forest. There was a 9.33 sq km increase in wetlands and an 8.19 sq km increase in shrub (Figure 294).

There are no permitted wastewater outfalls within the Davidson Creek watershed.

In Channel and Riparian Physical Habitat

Physical habitat for Davidson Creek was evaluated during three sampling events from 1988 to 2003. Davidson Creek is an intermittent stream with perennial pools that drains to Yegua Creek below Somerville Lake. Habitat Quality Index scores are available for two sample events and indicate an intermediate aquatic life use rating (18-19). Riparian areas were well vegetated throughout the reach with an average riparian buffer measured at greater than 20 meters for all sampling events. The riparian zone was generally dominated by trees followed by shrubs then grasses. The average percentage of tree canopy cover ranged from 63% to 82%. The dominant stream substrate was silt, and the average percent of substrate gravel size or larger was 0%. Average percent instream cover was 37% to 59% and instream cover types include snags, large and small woody debris, and root mats. Davidson Creek ranged from 0.3-0.5 meters deep on average and 5-7 meters wide. Average stream bank slope ranged from 58-65 degrees. Stream flow at the site was 0 cfs in 1988, but it was not measured during the two sampling events in 2003. Average stream bank erosion potential was 47%-61%. The deepest pool measured at Davidson Creek was 0.6 meters. No riffles were observed at the site, and total number of stream bends ranged from two to six.

Water Quality

Water samples were collected at station 11729 over 111 sampling events from August 1988 through February 2020. Parameters measured included temperature, flow, transparency, specific conductivity, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total nitrogen,

phosphorus, total organic carbon, chloride, sulfate, and chlorophyll-a. Additional sampling events were initiated at station 20388 starting in 2018.

Biological Characterization

Fish

Nineteen species (eight families) were collected over the course of four sampling events. The family Centrarchidae yielded the greatest number of species (seven). Western Mosquitofish was the most abundant species in the collections from the 1980's, whereas Bluegill was the most abundant one in 2003. Species unique to the 2003 collections included Black Bullhead, Yellow Bullhead, Common Carp, and Redear Sunfish. No species were unique to the early collections. The aquatic life use rating (based upon the fish assemblage) was high (despite the paucity of benthic invertivore species and lack of intolerant species) for all the samples except the one from 1989 which rated intermediate; however, when the coefficient of variability is applied to the intermediate score, it also rates as high.

Benthic Macroinvertebrates

A total of 1,012 individuals representing eleven orders of macroinvertebrates (Appendix E) were collected during the three sample events at Davidson Creek. Oligochaetes and Diptera represented 94% of the individuals collected. Ephemeroptera and Odonata were the next most abundant orders, each representing 1.3% of the individuals collected.

Considered collectively across both sample dates, the functional organization of the Davidson Creek macroinvertebrate assemblage was dominated by collector-gatherers and predators which accounted for 65% and 33%, respectively, of the total number of individuals collected. The shredder and scraper functional groups each represented 1% of the total number collected. The EPT for individual samples varied from zero for the 1988 Surber sample to two for the sample collected in June 2003. These values are relatively low, falling below the 5th percentile for all EPT values for least disturbed streams sampled in the aggregated ecoregion. Two of the three values for biotic index exceed the 95th percentile for all biotic index values in the ecoregion reflecting a dominance of tolerant taxa.

The East Bioregion Surber BIBI for the 1988 Surber sample fell in the intermediate aquatic life use category, while the Ecoregions 33 and 35 BIBI for both samples from 2003 fell in the limited aquatic life use category.

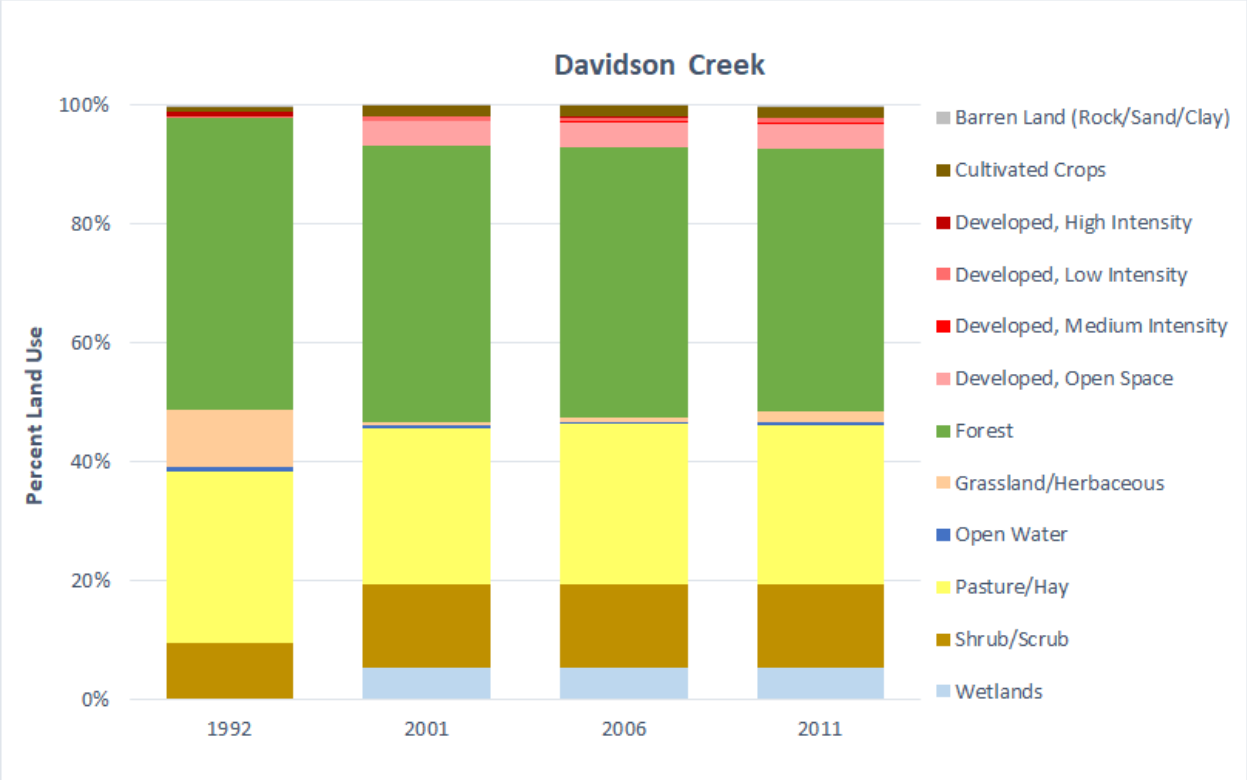

Figure 293. Percent land use in the Davidson Creek watershed from 1992-2011.

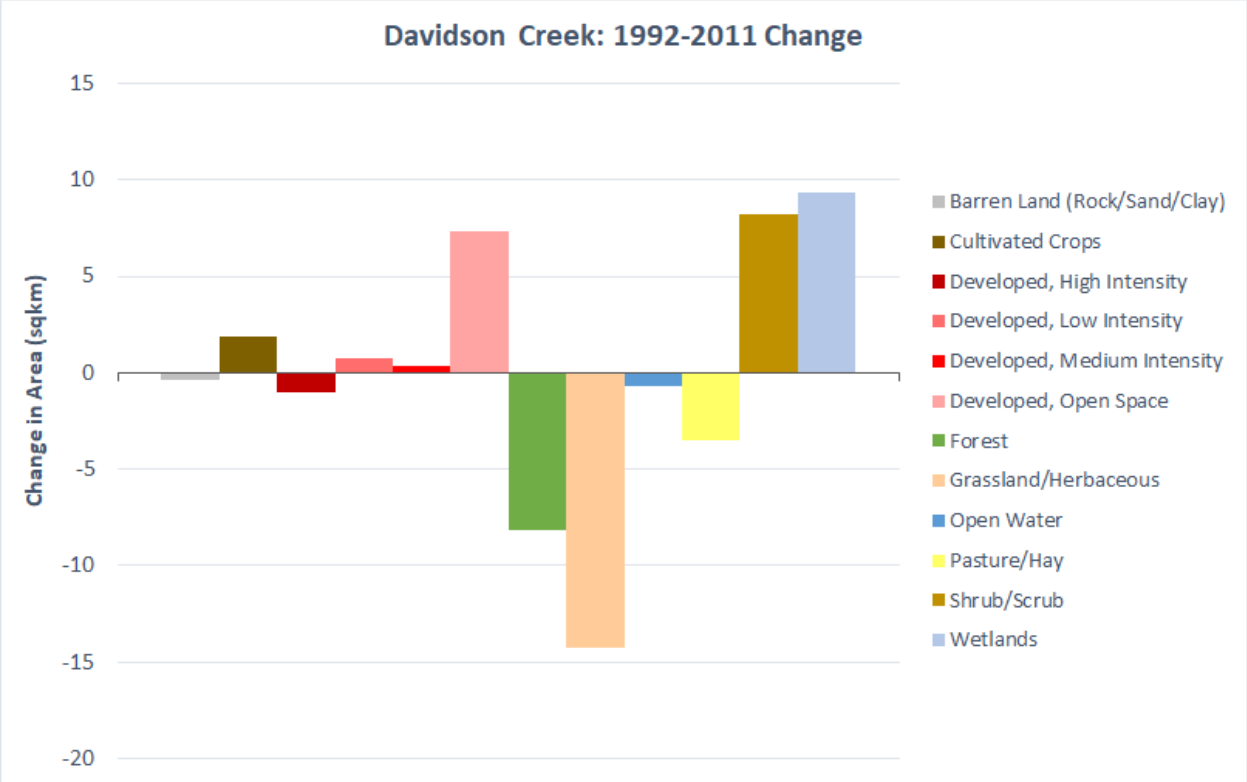

Figure 294. Land use change in area (sq km) from 1992-2011 for the Davidson Creek watershed.

KICKAPOO CREEK

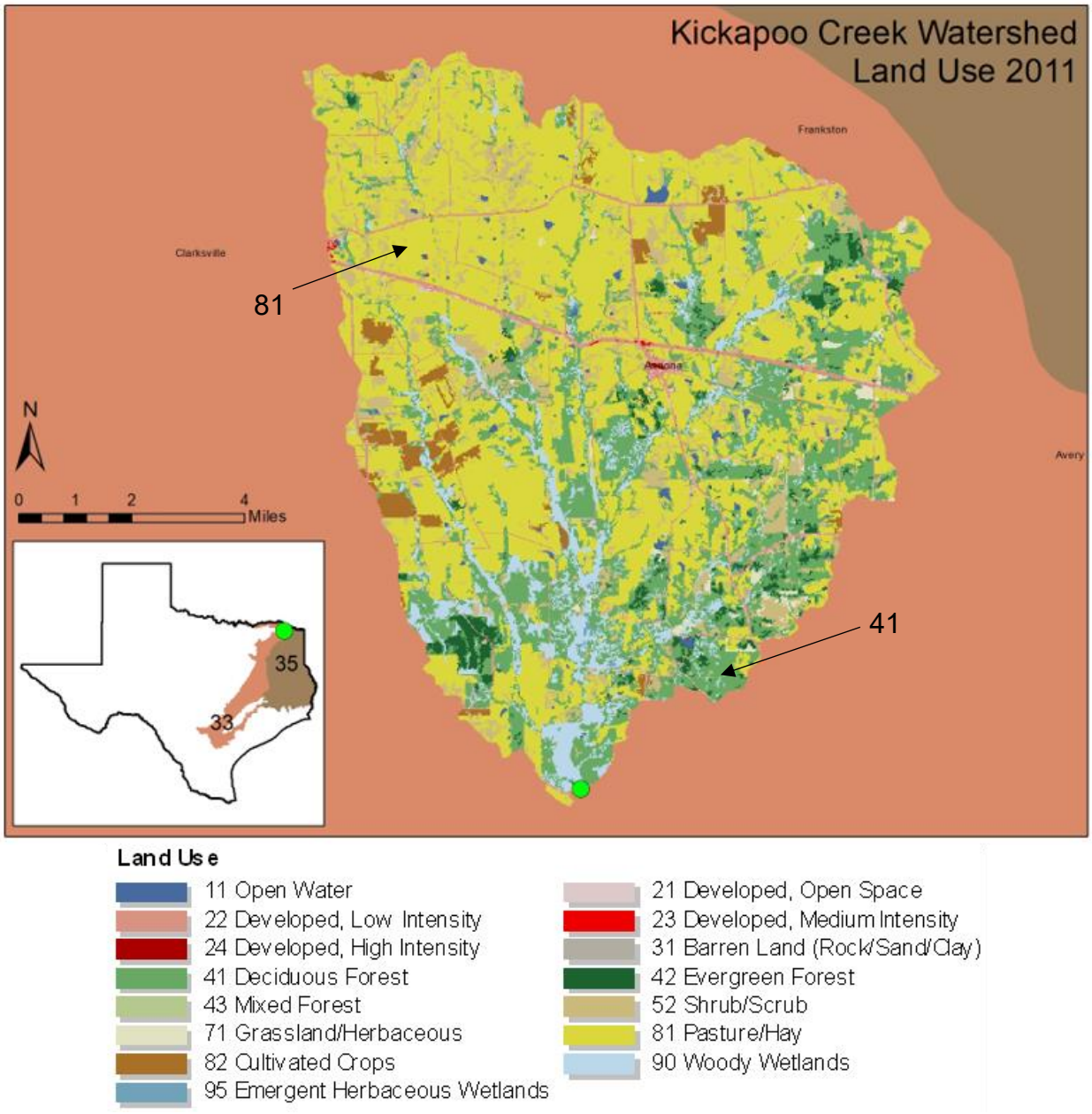

Figure 295. Map of Kickapoo Creek watershed location and 2011 land use; pasture/hay and forest were the most common land uses.

Sampling Dates

Physical Habitat:	May 23, 2002
Water Quality:	14 sampling events
Fish:	May 23, 2002; July 5, 2002
Benthic Invertebrates:	May 23, 2002; July 5, 2002

Physical Characterization

Watershed and Land Use

Kickapoo Creek lies within the Sulphur River Basin. Sample site 17342 is located at FM 412, approximately 11.27 km south of Annona in Red River County (Figure 295).

The Kickapoo Creek watershed at site 17342 is approximately 246.89 sq km. The sample site is located in Level IV Ecoregion 33f, the Floodplains and Low Terraces; however, the watershed spans Level IV Ecoregion 33a, the Northern Post Oak Savanna, and Ecoregion 33d, the Northern Prairie Outliers. The dominant land cover in the watershed is pasture/hay at 50.44% and is present throughout the watershed, but most concentrated in the middle and upper watershed (Homer et al. 2015; Figure 295 and Figure 296). Forest is the secondary land cover encompassing 25.03% of the Kickapoo Creek watershed. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 4.43% and total cover for cultivated crops is 2.43%.

From 1992-2011 there was a 14.35 sq km decrease in cultivated crops, 11.97 sq km decrease in forest, and 10.84 sq km decrease in pasture/hay. There was a 22.71 sq km increase in shrub and an 8.47 sq km increase in low intensity development (Figure 297).

There is one domestic wastewater outfall (discharges < 1 million gallons per day) permitted to the City of Annona and one larger wastewater outfall (discharges ≥ 1 million gallons per day) permitted to Ervin Don Crutcher to authorize the discharge of wet decking wastewater and stormwater. Neither of these wastewater outfalls discharge directly into Kickapoo Creek.

In Channel and Riparian Physical Habitat

Physical habitat for Kickapoo Creek was evaluated on May 23, 2002. Kickapoo Creek is a perennial stream that drains to Cuthand Creek. The Habitat Quality Index score of 12 indicates a limited aquatic life use rating. The average riparian buffer was measured at 12.5 meters. The riparian zone was dominated by grasses, which made up an average of 38% of the total riparian species, followed by shrubs and trees (20% each). The average percentage of tree canopy cover was 43%. The dominant substrate was clay and the average percent of substrate gravel size or larger was 1%. Average percent instream cover was 9%. Kickapoo Creek was 0.4 meters deep on average and 7 meters wide. Average stream bank slope was 37 degrees, and the average stream bank erosion potential was 65%. Stream flow at the site was 5.7 cfs. The deepest pool measured at Kickapoo Creek was 1.8 meters. No riffles or stream bends were observed at the site.

Water Quality

Water samples were collected at station 17342 over 14 sampling events from February 2002 through July 2019. Parameters measured included temperature, flow, transparency, specific conductivity, dissolved oxygen, pH, ammonia, total Kjeldahl nitrogen, total nitrogen, phosphorus, chloride, sulfate, and chlorophyll-a.

Biological Characterization

Fish

Seventeen species (seven families) were collected between the two sampling events. The richest family was Centrarchidae with eight species. Cyprinidae was the only other family with more than one species, with a total of four. Red Shiner was the most abundant species. The aquatic life use rating for both fish collections was only intermediate. The creek had a low number of individuals, benthic invertivore species, and intolerant species. Greater than 50% of the individuals collected were tolerant species.

Benthic Macroinvertebrates

A total of 198 individuals representing nine orders of macroinvertebrates were collected during the two sample events at Kickapoo Creek (Appendix E). Ephemeroptera, Coleoptera, and Trichoptera were the three most abundant orders collected representing 27%, 18%, and 17%, respectively, of the individuals collected. Diptera (13%), Hemiptera (13%), and Decapoda (6.6%) were also relatively well represented in benthic samples from Kickapoo Creek.

Considered collectively across both sample dates, the functional organization of the macroinvertebrate assemblage was relatively balanced among collector-gatherers, predators, and filtering collectors which accounted for 35%, 23%, and 22%, respectively, of the total number of individuals collected. The shredder (1%) functional group was the least abundant.

The EPT was five for the May 2002 collection and three for the July 2002 sample, which are at and below the 5th percentile for all EPT values for least disturbed streams in ecoregion aggregate 33/35. The value for the biotic index for the May 2002 sample (5.3) falls between the 50th and the 75th percentiles and the value for the July 2002 sample (6.9) is above the 95th percentile. Overall, these metrics reflect an assemblage that is tolerant relative to other macroinvertebrate assemblages in least disturbed streams in ecoregion aggregate 33/35.

Results for the Ecoregions 33 and 35 BIBI for the May 2002 RBP sample indicated limited aquatic life use, while the score for the July sample indicated intermediate aquatic life use.

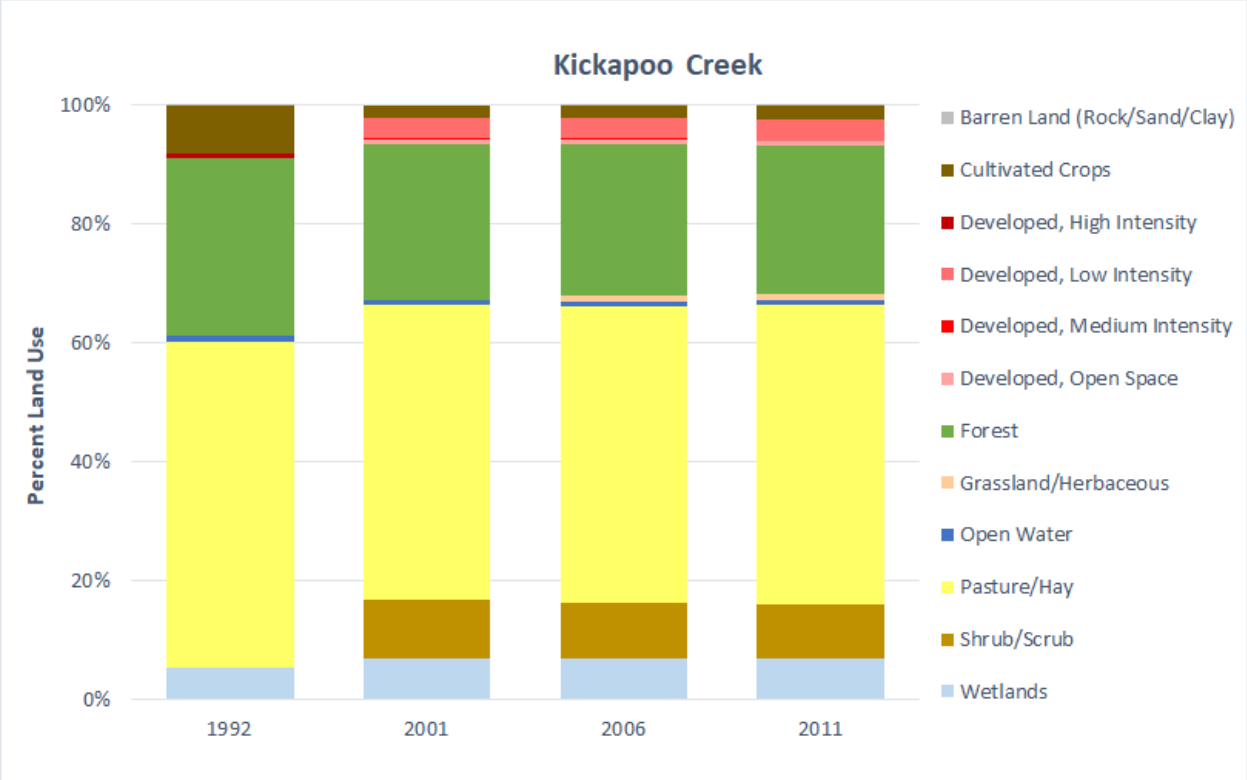

Figure 296. Percent land use in the Kickapoo Creek watershed from 1992-2011.

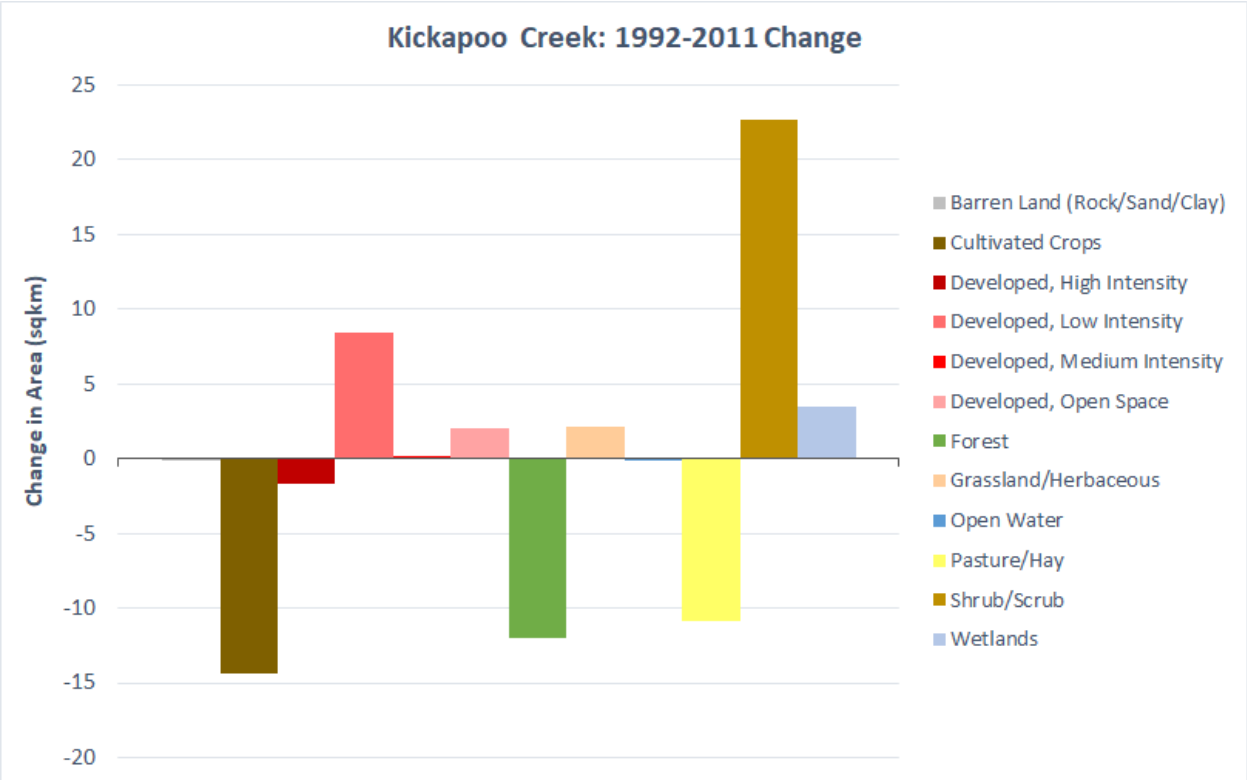

Figure 297. Land use change in area (sq km) from 1992-2011 for the Kickapoo Creek watershed.

LITTLE MUSTANG CREEK

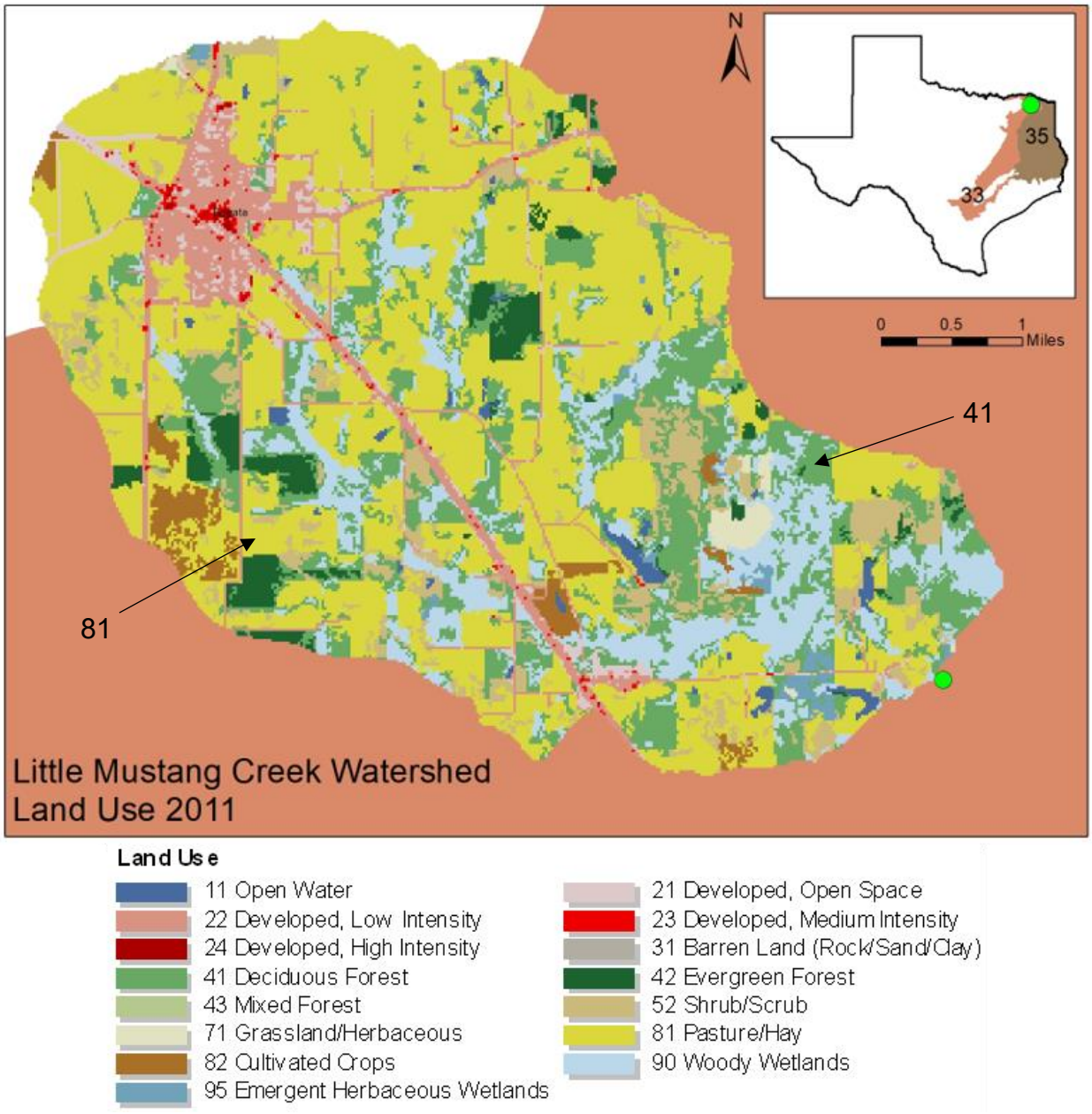

Figure 298. Map of Little Mustang Creek watershed location and 2011 land use; pasture/hay and forest were the most common land uses.

Sampling Dates

Physical Habitat:	May 23, 2002
Water Quality:	6 sampling events
Fish:	July 19, 2000; May 23, 2002; July 5, 2002
Benthic Invertebrates:	May 23, 2002; July 5, 2002

Physical Characterization

Watershed and Land Use

Little Mustang Creek lies within the Sulphur River Basin. Sample site 17343 is located at CR 1410, southeast of Bogata in Red River County (Figure 298).

The Little Mustang Creek watershed at site 17343 is approximately 59.23 sq km. The sample site and majority of the watershed are located in Level IV Ecoregion 33a, the Northern Post Oak Savanna, while the extreme upper portions of the watershed cross into Ecoregion 32a, the Northern Blackland Prairie. The dominant land cover in the watershed is pasture/hay at 45.71% and is present throughout the watershed (Homer et al. 2015; Figure 298 and Figure 299). Forest and wetlands are the secondary land covers encompassing 20.63% and 12.52% of the Little Mustang Creek watershed, respectively. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 10.02% and total cover for cultivated crops is 2.02%.

From 1992-2011 there was a 7.47 sq km decrease in forest and approximately 3 sq km decrease in both cultivated crops and pasture/hay cover. There was a 4.39 sq km increase in shrub, a 4.27 sq km increase in wetlands, and a 3.4 sq km increase in low intensity development (Figure 300).

There is one domestic wastewater outfall (discharges < 1 million gallons per day) permitted to the City of Bogata which does not discharge directly into Little Mustang Creek.

In Channel and Riparian Physical Habitat

Physical habitat for Little Mustang Creek was evaluated on May 23, 2002. Little Mustang Creek is an intermittent stream with perennial pools that drains to the Sulphur River. The Habitat Quality Index score of 13 indicates a limited aquatic life use rating. The average riparian buffer was measured at 12.6 meters. The riparian zone was dominated by grasses, which made up an average of 42% of the total riparian species, followed by trees (26%) then shrubs (20%). The average percentage of tree canopy cover was 81%. The dominant substrate was silt and the average percent of substrate gravel size or larger was 3%. Average percent instream cover was 22%. Little Mustang Creek was 0.4 meters deep on average and 3.7 meters wide. Average stream bank slope was 37 degrees, and the average stream bank erosion potential was 62%. Stream flow at the site was 1.0 cfs. No pools were identified on Little Mustang Creek at the time of sampling. No riffles were observed at the site and there was one moderately defined stream bend.

Water Quality

Water samples were collected at station 17343 over 6 sampling events from February 2002 through July 2002. Parameters measured included temperature, flow, transparency, specific conductivity, dissolved oxygen, pH, ammonia, total Kjeldahl nitrogen, phosphorus, chloride, sulfate, and chlorophyll-a.

Biological Characterization

Fish

Twenty-three species (eight families) were collected over the three sampling events. The families with the greatest species richness were Centrarchidae with eight and Cyprinidae with six. Golden Shiner was the most abundant fish species in the earliest collection but was overtaken by Bluegill in the latter two collections. The fish assemblage in Little Mustang Creek appears to have declined since the original sample in 2000, when the aquatic life use rated as high. The 2002 collections yielded one-half the species richness collected in 2000 and subsequent reductions in native cyprinid richness and number of benthic invertivore species resulting in aquatic life use ratings of intermediate. Drought conditions in 2002 likely influenced the fish collections. Perhaps the assemblage has bounced back since.

Benthic Macroinvertebrates

A total of 394 individuals representing 11 orders of macroinvertebrates were collected during the two sample events at Little Mustang Creek (Appendix E). Trichoptera, Decapoda, and Ephemeroptera were the three most abundant orders observed, comprising 37.3%, 26.16%, and 21.1% of the total individuals collected, respectively. Coleoptera (8.9%), Diptera (2.0%), and Plecoptera (1.5%) were the three next most abundant taxa in the samples from Little Mustang Creek.

Considered collectively across both sample dates, the functional organization of the macroinvertebrate assemblage was dominated by filtering collectors, collector-gatherers, and scrapers which accounted for 39%, 16.2%, and 15%, respectively, of the total number of individuals collected. The predators functional group was the least abundant representing only 3.7% of the total number of individuals collected.

The EPT was four for both samples which is at and below the 25th percentile for all EPT values for least disturbed streams in ecoregion aggregate 33/35. The value for the biotic index for the May 2002 sample (4.2) falls between the 5th and the 25th percentiles and the value for the July 2002 sample (5) falls between the 50th and the 75th percentiles for all biotic index values in the ecoregion reflecting a fair amount of variability in the relative tolerance of the Little Mustang Creek macroinvertebrate assemblage.

Results for the Ecoregions 33 and 35 BIBI for RBP samples indicated limited aquatic life use for both samples.

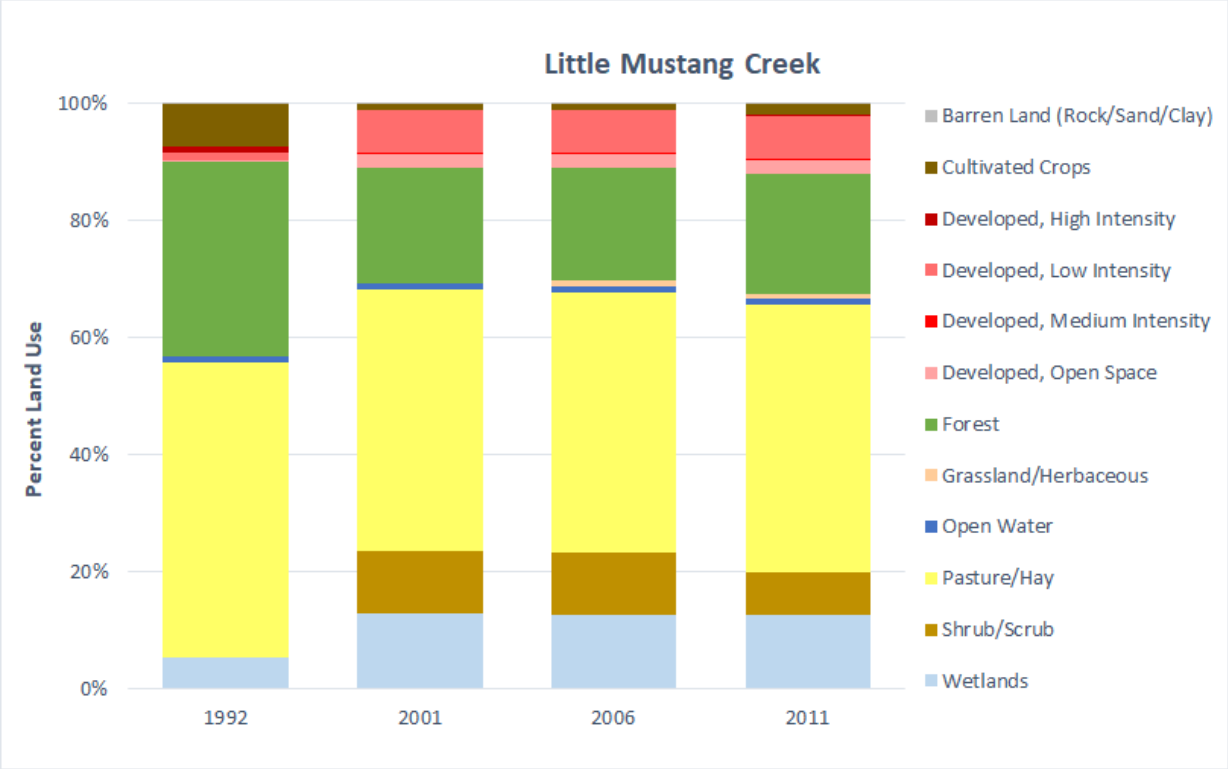

Figure 299. Percent land use in the Little Mustang Creek watershed from 1992-2011.

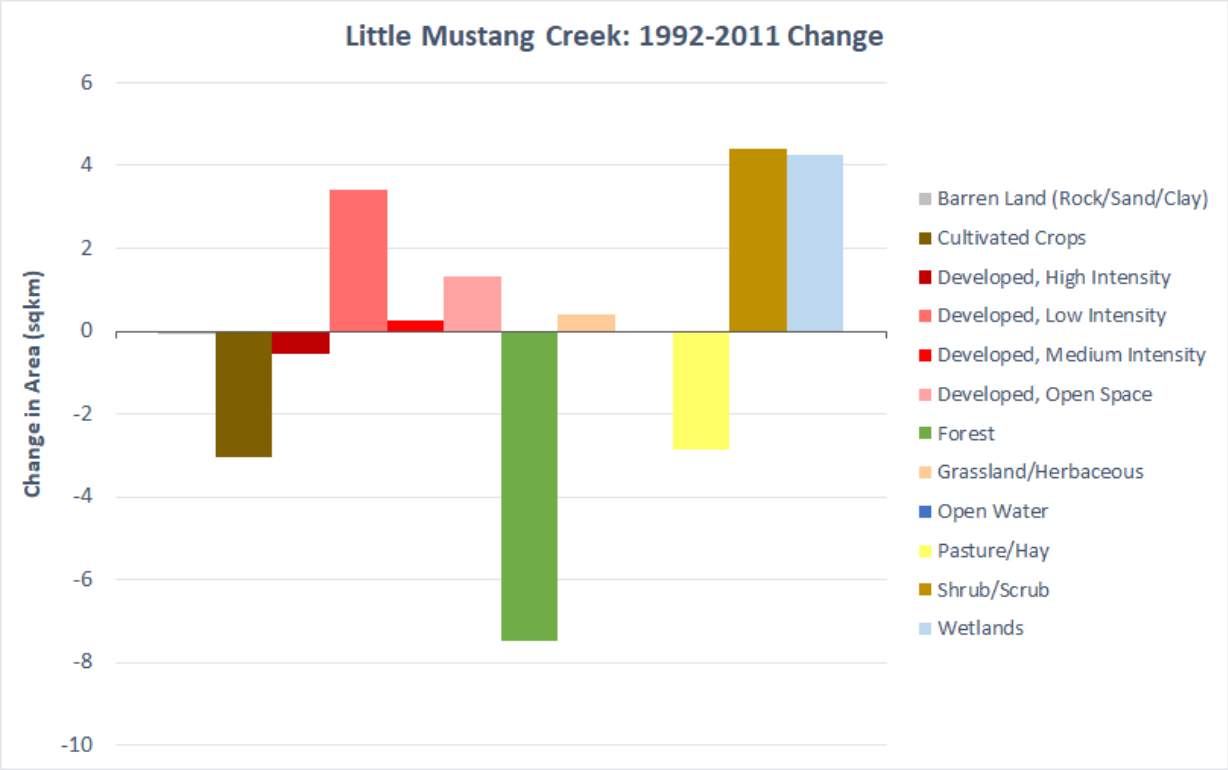

Figure 300. Land use change in area (sq km) from 1992-2011 for the Little Mustang Creek watershed.

LOWER KEECHI CREEK

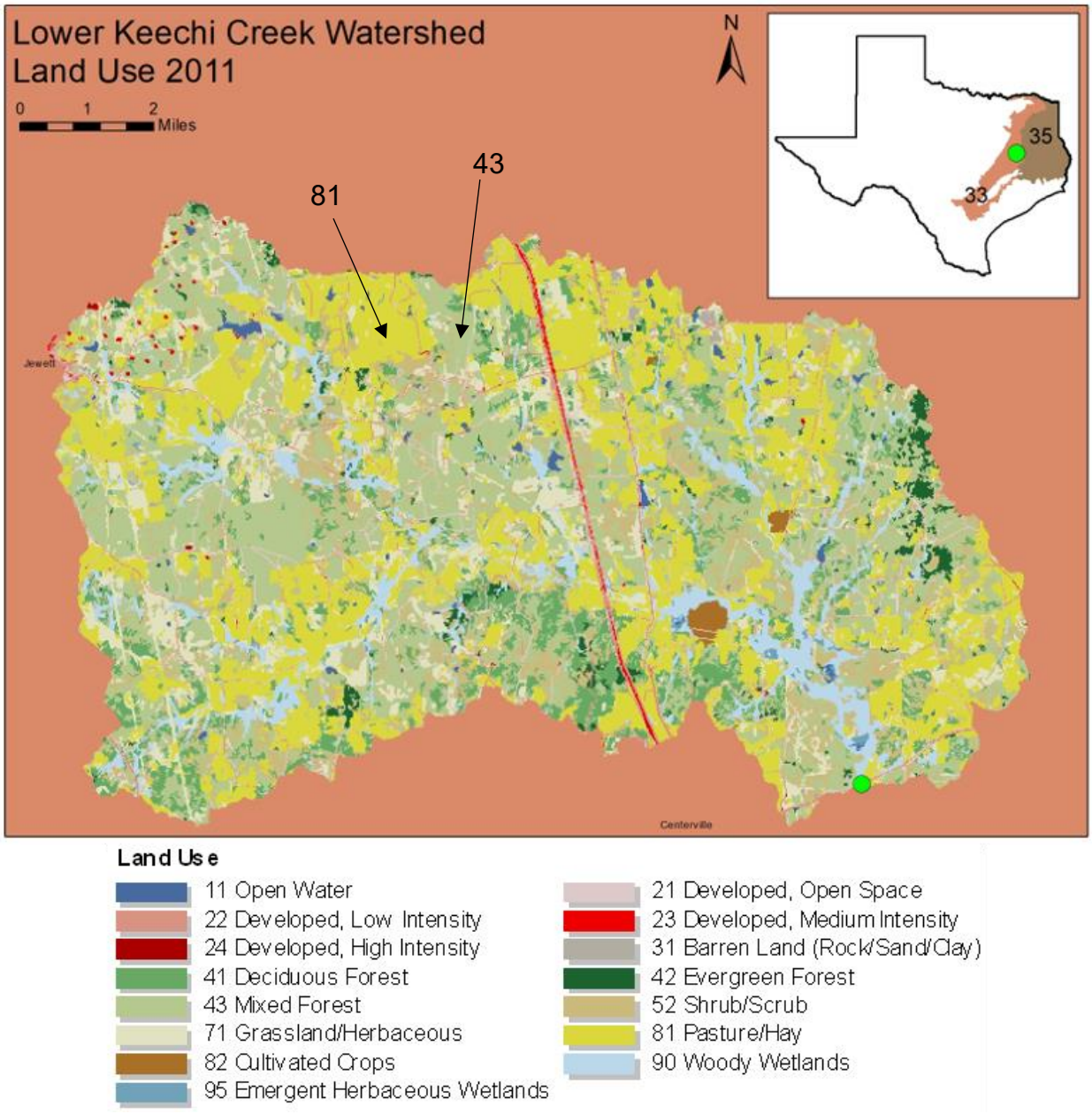

Figure 301. Map of Lower Keechi Creek watershed location and 2011 land use; forest and pasture/hay were the most common land uses.

Sampling Dates

Physical Habitat:	August 17, 1988
Water Quality:	4 sampling events
Fish:	August 17, 1988; April 12, 1989
Benthic Invertebrates:	August 17, 1988

Physical Characterization

Watershed and Land Use

Lower Keechi Creek lies within the Trinity River Basin. Sample site 10822 is located at SH 7, 4.18 km east of Centerville in Leon County (Figure 301).

The Lower Keechi Creek watershed at site 10822 is approximately 248.12 sq km. The entire watershed is located in Level IV Ecoregion 33b, the Southern Post Oak Savanna. The dominant land cover in the watershed is forest at 37.23% and is present throughout the watershed (Homer et al. 2015; Figure 301 and Figure 302). Pasture/hay is the secondary land cover encompassing 26.89%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 5.47% and total cover for cultivated crops is 0.39%.

From 1992-2011 there was a 60.06 sq km decrease in forest and a 22.93 sq km decrease in pasture/hay. There was a 29.14 sq km increase in shrub and a 25.54 sq km increase in grasslands (Figure 303).

There is one domestic wastewater outfall (discharges < 1 million gallons per day) permitted to the City of Jewett which discharges directly into Lower Keechi Creek.

In Channel and Riparian Physical Habitat

Physical habitat for Lower Keechi Creek was evaluated on August 17, 1988. Lower Keechi Creek is a perennial stream that drains to the Trinity River above Lake Livingston. The riparian width was 18 meters. The riparian zone was dominated by trees, which made up an average of 50% of the total riparian species, followed by shrubs (25%) then grasses (15%). The average percentage of tree canopy cover was 48%. The dominant substrate was fine sand, and the average percent of substrate that was gravel size or larger was 12%. Average percent instream cover was 51%. Lower Keechi Creek had an average depth of 0.4 meters and a maximum depth of 1.3 meters. The average width was 6.5 meters and average stream bank slope was 52 degrees. Stream flow at the site was 0.9 cfs. Average stream bank erosion potential was 71%. Seven riffles were observed at the site and there was one stream bend.

Water Quality

Water samples were collected at station 10822 over 4 sampling events from August 1988 through July 1999. Parameters measured included temperature, flow, specific conductance, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total nitrogen, phosphorus, chloride, sulfate and chlorophyll-a.

Biological Characterization

Fish

Lower Keechi Creek was sampled for fish in the summer of 1988 and spring of 1989, wherein it received an aquatic life use rating of high and intermediate, respectively. When the coefficient of variability is applied to the spring sample, it also yields a high rating. Twenty-two species (11

families) were collected between the two sampling events. Centrarchidae and Cyprinidae were the richest families, yielding seven and five species, respectively. Blacktail and Ribbon shiner were the two most abundant species.

Benthic Macroinvertebrates

A total of 99 individuals representing seven orders of macroinvertebrates were collected during the sample event at Keechi Creek (Appendix E). Coleoptera, Diptera, and Pelecypoda (*Corbicula* sp.) were the three most abundant orders collected representing 50.5%, 24.2%, and 7.1%, respectively, of the individuals collected. Ephemeroptera (5.1%), Odonata (5.1%), Oligochaeta (5.1%), and Hemiptera were the only other orders represented in the sample.

The functional organization of the Keechi Creek macroinvertebrate assemblage was dominated by collector-gatherers, scrapers, and predators which accounted for 39.7%, 26.8%, and 15.5%, respectively, of the total number of individuals collected. The filtering collectors (10.6%) and shredders (7.4%) were present, but each represented lower relative abundance.

The EPT was four for the sample which is below the 25th percentile for all EPT values for least disturbed streams in ecoregion aggregate 33/35. The value for the biotic index (6.7) is equal to the 95th percentile for all biotic index values in the ecoregion indicating a relatively tolerant macroinvertebrate assemblage in Keechi Creek.

Results for the Surber sample BIBI falls in the range indicating a high aquatic life use for the Keechi Creek macroinvertebrate assemblage.

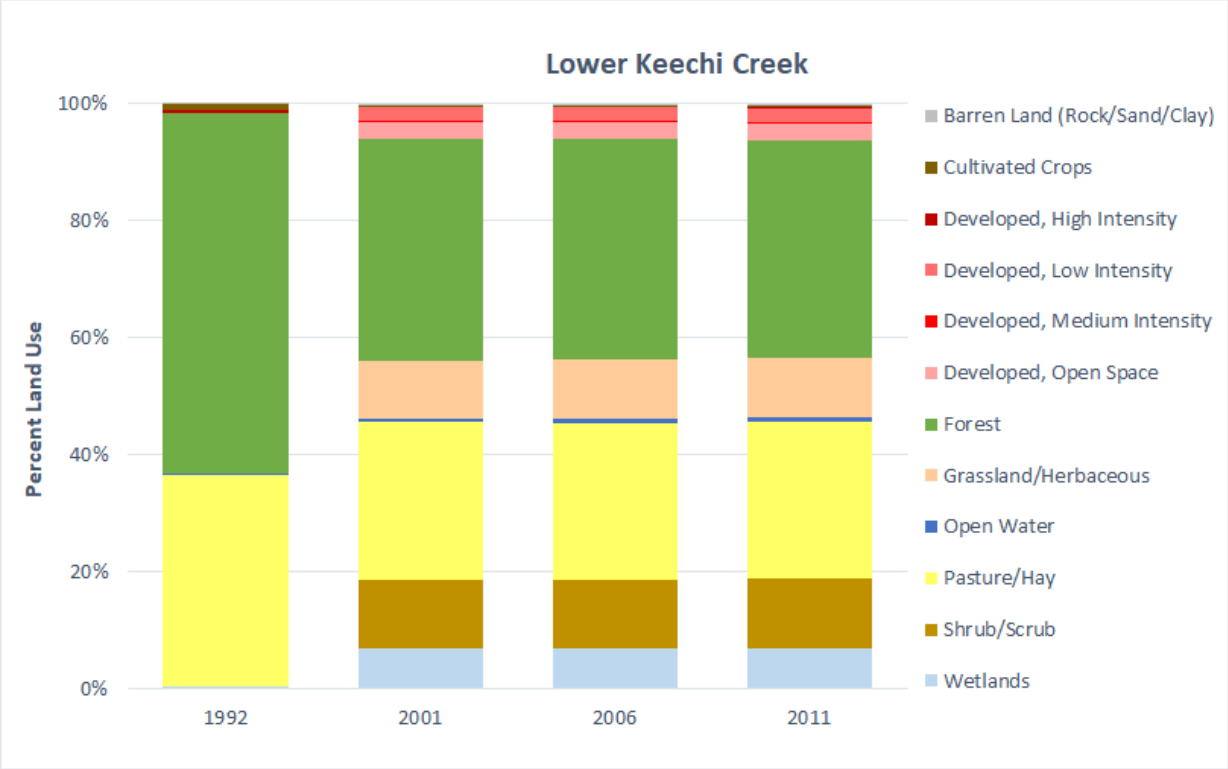

Figure 302. Percent land use in the Lower Keechi Creek watershed from 1992-2011.

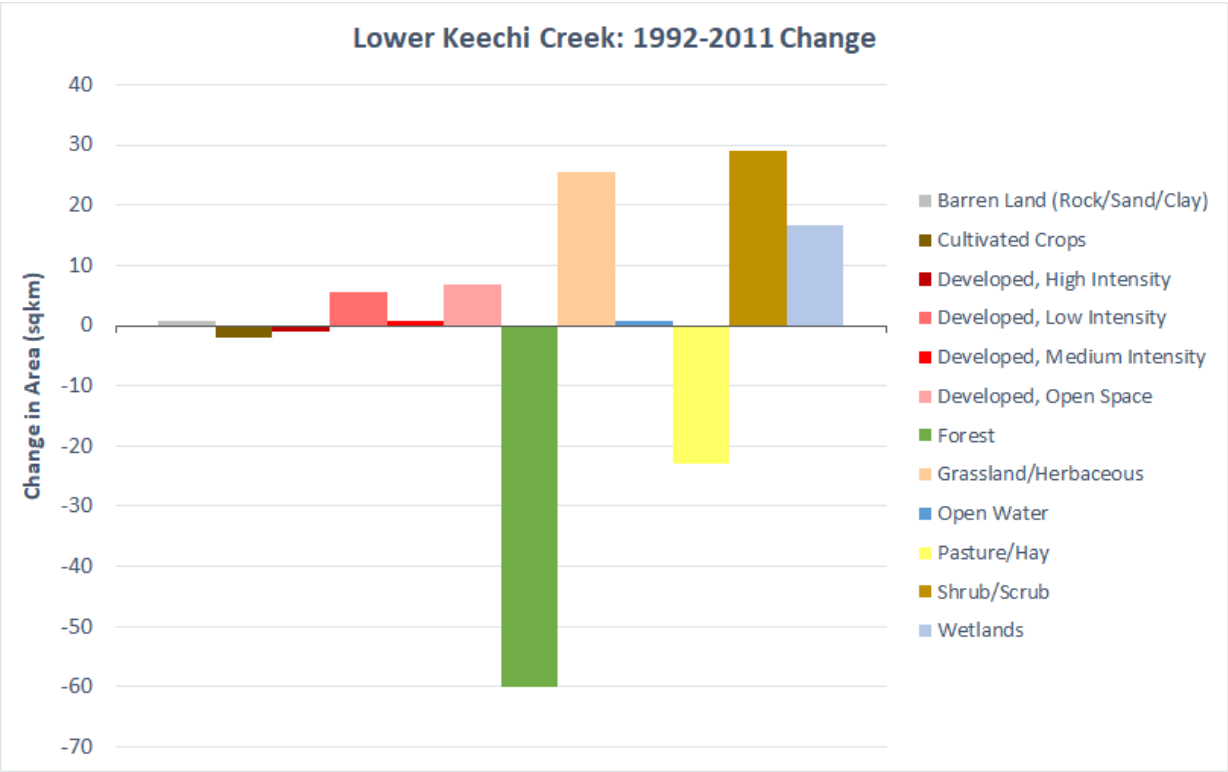

Figure 303. Land use change in area (sq km) from 1992-2011 for the Lower Keechi Creek watershed.

MIDDLE YEGUA CREEK

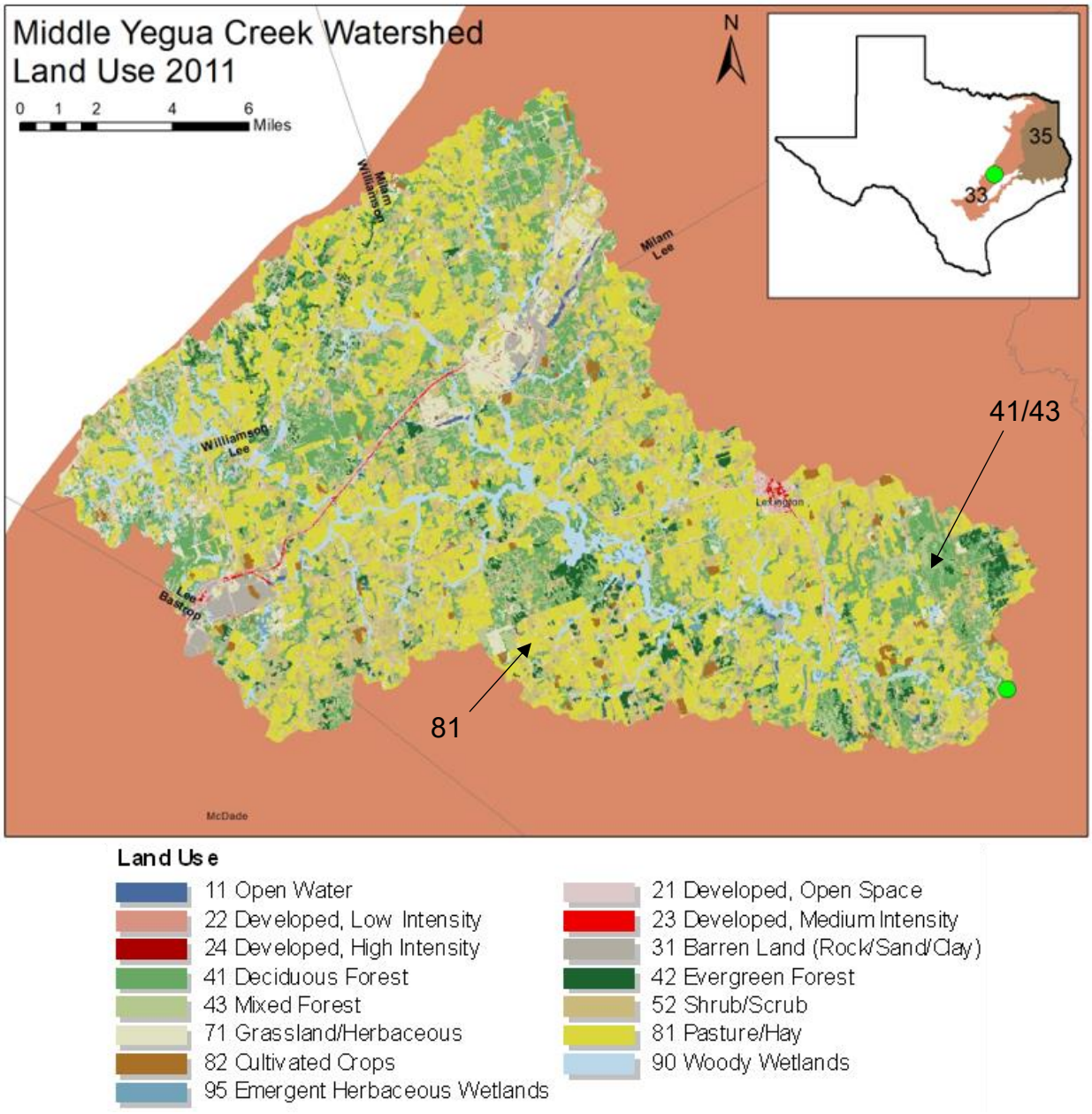

Figure 304. Map of Middle Yegua Creek watershed location and 2011 land use; pasture/hay and forest were the most common land uses.

Sampling Dates

Physical Habitat:	September 3, 1986
Water Quality:	29 sampling events
Fish:	September 4, 1986; August 21, 2000
Benthic Invertebrates:	October 13, 1987 (x2)

Physical Characterization

Watershed and Land Use

Middle Yegua Creek lies within the Brazos River Basin. Sample site 11839 is located at County Road 121, 7.72 km south of Dime Box in Lee County (Figure 304).

The Middle Yegua Creek watershed at site 11839 is approximately 1108.81 sq km. The station and most of the watershed are located in Level IV Ecoregion 33b, the Southern Post Oak Savanna, and a small part of the watershed crosses Level IV Ecoregion 33c, the San Antonio Prairie. The dominant land cover in the watershed is pasture/hay at 39.11% and is present throughout the watershed (Homer et al. 2015; Figure 304 and Figure 305). Forest is the secondary land cover encompassing 24.35%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 5.42% and total cover for cultivated crops is 2.33%.

From 1992-2011 there was a 190.64 sq km decrease in forest and an 88.59 sq km decrease in grassland. There was a 90.05 sq km increase in shrub and an 89.23 sq km increase in pasture/hay (Figure 306).

There are three domestic wastewater outfalls (discharges < 1 million gallons per day) and three industrial wastewater outfalls (discharges ≥ 1 million gallons per day) within the Middle Yegua Creek watershed. One domestic wastewater facility is permitted to the City of Lexington, one to Aqua Water Supply Corporation in the City of Bastrop, and one to Manville Water Supply Corporation. The three industrial wastewater facilities are permitted to Luminant Mining Co, LLC, a coal mining company. None of these facilities discharge directly into Middle Yegua Creek.

In Channel and Riparian Physical Habitat

Physical habitat for Middle Yegua Creek was evaluated on September 3, 1986. Middle Yegua Creek is a perennial stream that drains to Yegua Creek upstream of the confluence with Somerville Lake. The riparian width was 23 meters. The riparian zone was dominated by trees, which made up an average of 60% of the total riparian species, followed by shrubs and grasses (20% each). The average percentage of tree canopy cover was 60%. The dominant substrate was fine sand, and the average percent of substrate that was gravel size or larger was 30%. Average percent instream cover was 43%. Middle Yegua Creek had an average depth of 0.5 meters and a maximum depth of 1.3 meters. The average width was 3.9 meters and the average stream bank slope was 40 degrees. Stream flow at the site was 0.9 cfs. Average stream bank erosion potential was 51%. Four riffles were observed at the site and there were two total stream bends.

Water Quality

Water samples were collected at stations 11838, 18750, 18751 over 29 sampling events from January 2000 through July 2008. Parameters measured included temperature, flow, transparency, specific conductance, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total

nitrogen, phosphorus, total organic carbon, chloride, sulfate and chlorophyll-a. Additional sampling events were initiated at stations 11838, 11840, 18750 starting in 2018 as part of routine monitoring and a special study. Continuous flow data associated with station 11840 is available from USGS gage 08109700 (Figure 307).

Biological Characterization

Fish

Twenty-five species (10 families) were collected between the two sampling events. Cyprinidae yielded the greatest species richness with ten. Western mosquitofish was the most abundant fish species in 1986. Blacktail Shiner was the most abundant fish species in 2000. The aquatic life use (based upon the fish assemblage) declined from high to intermediate between 1986 and 2000. The major reasons for the decline in score were a 50% reduction in native cyprinid species, collection of only one intolerant species (two were collected in 1988), and a reduction in percentage of piscivores from 7.1% to 2.3%. The minnow species missing from the 2000 collection were mostly comprised of common water quality tolerant species, except for Mimic Shiner which is considered intolerant of low dissolved oxygen conditions (Linam and Kleinsasser 1998). Tadpole Madtom, the other intolerant species collected in 1988, was also absent from the 2000 collection; however, Dusky Darter was added to the species list in 2000 making it the only water quality intolerant species. Though the number of piscivorous species remained relatively stable (three in 1988, two in 2000), the species composition changed significantly (only one species common to both collections) and the number of individuals declined dramatically.

Benthic Macroinvertebrates

A total of 493 individuals representing 11 orders of macroinvertebrates were collected at two sample sites on Middle Yegua Creek in 1987 (Appendix E). Oligochaeta, Pelecypoda (*Corbicula* sp.), and Diptera were the three most abundant orders collected representing 38.3%, 21.8%, and 19.8%, respectively, of the individuals collected. Ephemeroptera (6.9%), Coleoptera (5.7%), and Odonata (2.9%) were the three next most abundant orders. Caddisflies (Trichoptera) were relatively diverse, with five genera represented, but only accounted for 1.2% of total numbers of individuals collected.

Considered collectively across both sample sites, the functional organization of the Middle Yegua Creek macroinvertebrate assemblage was dominated by collector-gatherers, filtering collectors, and predators which accounted for 52.7%, 28.7%, and 10.6%, respectively, of the total number of individuals collected. Scrapers (6.5%) and shredders (1.5%) were present but in less relative abundance.

The EPT was five for the sample collected at site 11841 at US 77 and seven for the sample collected at site 11839 at Lee CR which fall at the 25th percentile and just below the 50th percentile for all EPT values for least disturbed streams in ecoregion aggregate 33/35. The value for the biotic index at site 11841 was 7 which exceeds the 95th percentile for the ecoregion while

the index value at site 11839 was 5.8 which falls between the 75th and 95th percentile for all biotic index values in the ecoregion indicating a relatively tolerant macroinvertebrate assemblage in Middle Yegua Creek.

Results for the Surber sample BIBI were consistent across both sites, 39 for site 11841 and 43 for site 11839. The BIBI value for site 11841 indicates a high aquatic life use while site 11839 indicates an exceptional aquatic life use for the Middle Yegua Creek macroinvertebrate assemblage.

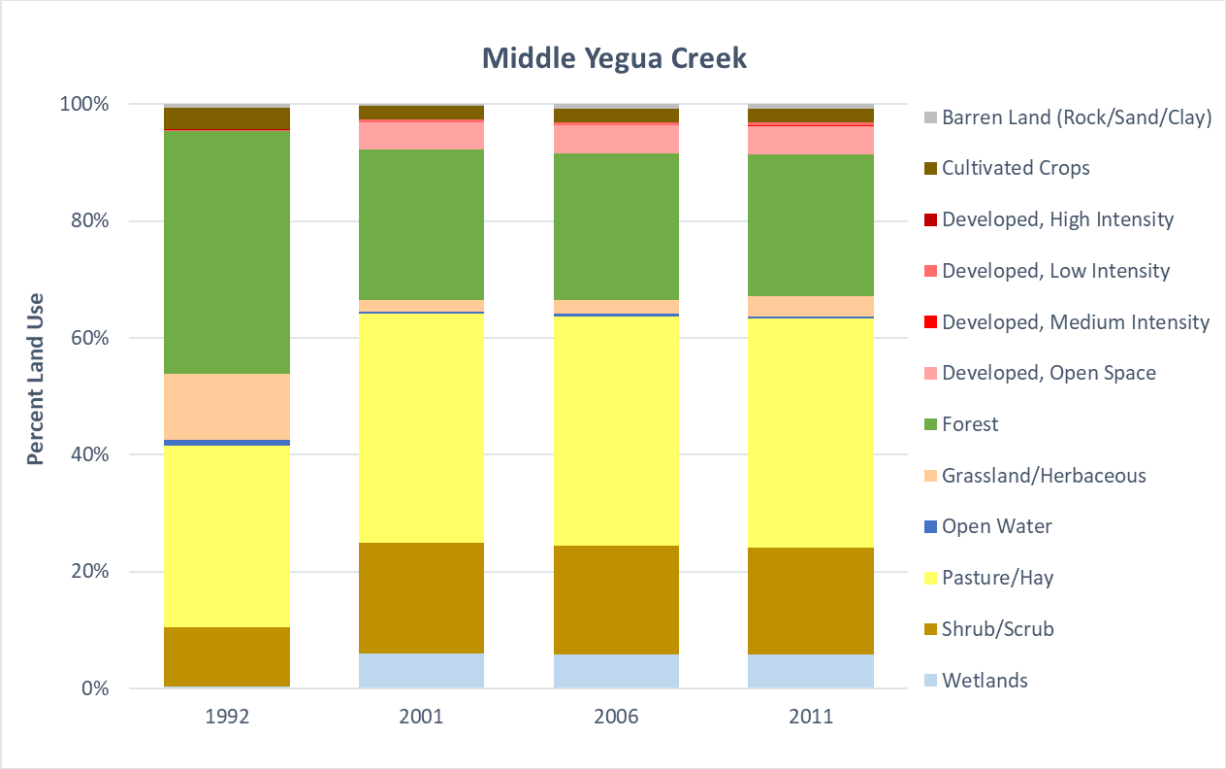

Figure 305. Percent land use in the Middle Yegua Creek watershed from 1992-2011.

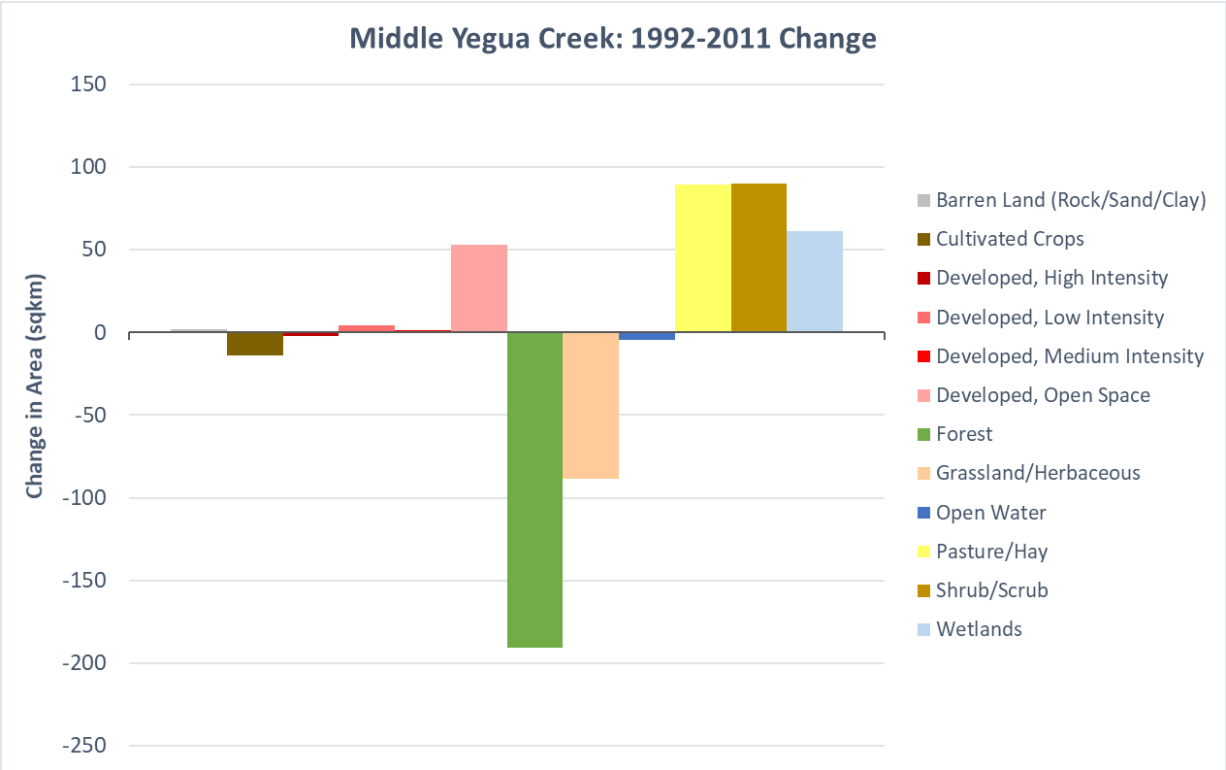

Figure 306. Land use change in area (sq km) from 1992-2011 for the Middle Yegua Creek watershed.

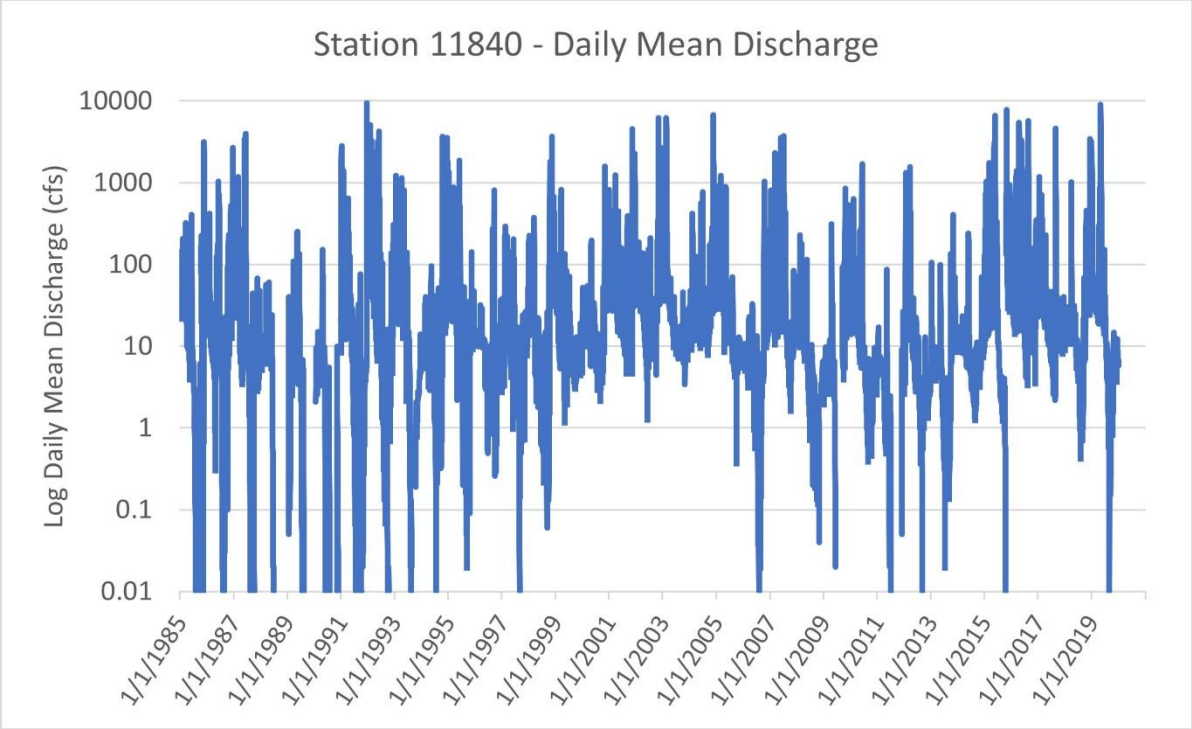

Figure 307. Log transformed daily mean discharge for Middle Yegua Creek at station 11840.

MILL CREEK

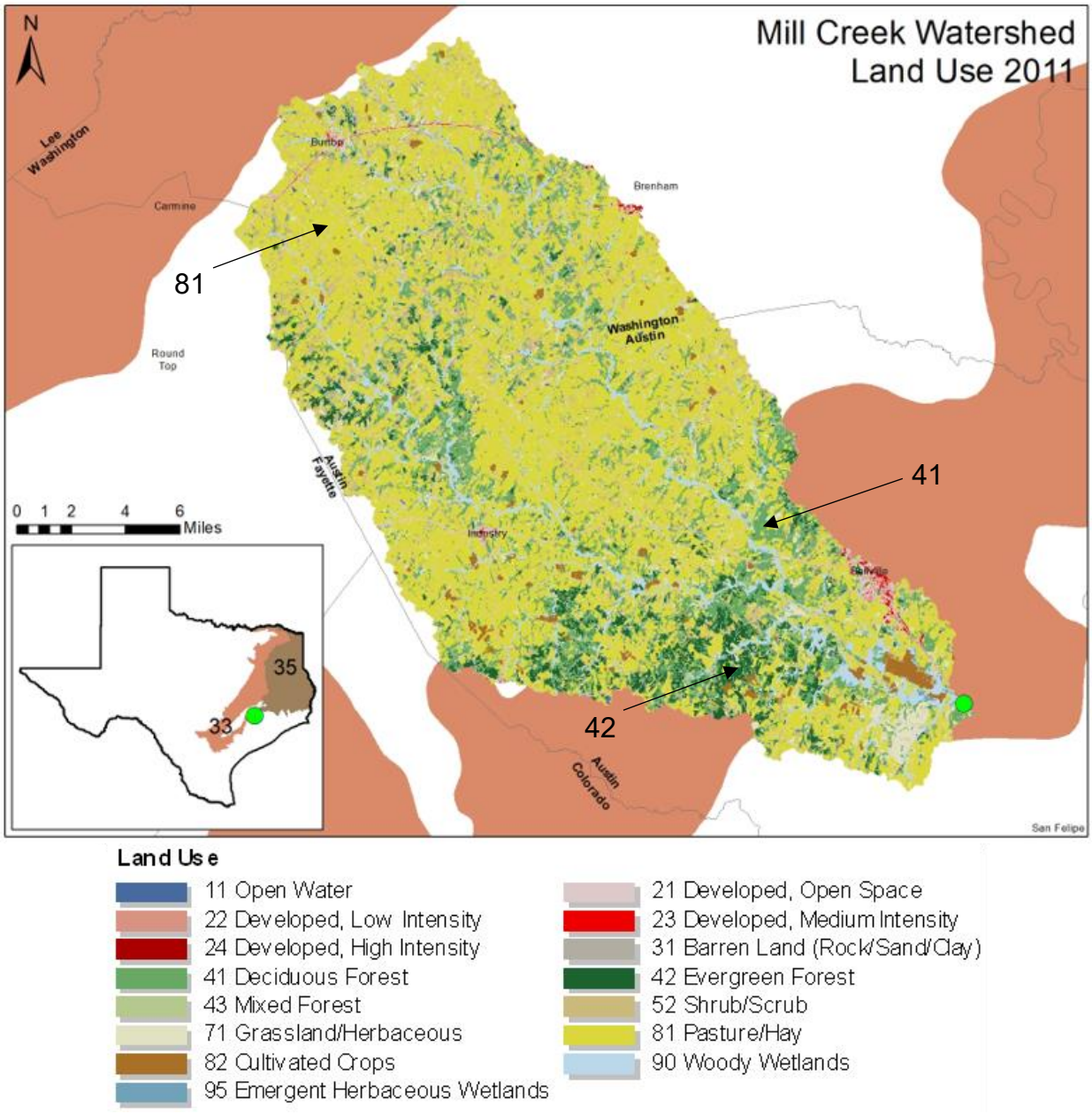

Figure 308. Map of Mill Creek watershed location and 2011 land use; pasture/hay and forest were the most common land uses.

Sampling Dates

Physical Habitat: July 19, 1988; April 5, 2004; May 19, 2005; May 17, 2006; August 15, 2007; July 1, 2008; June 10, 2009; April 27, 2010; July 22, 2010; May 10, 2011; April 17, 2012; April 16, 2013; May 12, 2014; July 29, 2014; August 4, 2015; October 3, 2016

Water Quality: 157 sampling events

Fish:	July 19, 1988; January 26, 2000; May 17, 2000; July 26, 2000; July 11, 2001; October 10, 2001; May 1, 2002; August 19, 2002; November 20, 2002; May 6, 2003; August 4, 2003; April 5, 2004; July 29, 2004; May 19, 2005; July 7, 2005; May 17, 2006; August 30, 2006; August 15, 2007; October 11, 2007; July 1, 2008; June 10, 2009; August 20, 2009; April 27, 2010; July 21, 2010; May 10, 2011; April 17, 2012; April 16, 2013; May 12, 2014; July 29, 2014; August 4, 2015; October 5, 2016; May 18, 2017; August 16, 2017
Benthic Invertebrates:	July 19, 1988; January 26, 2000; May 17, 2000; July 26, 2000; July 11, 2001; October 10, 2001; May 1, 2002; August 19, 2002; November 20, 2002; May 6, 2003; August 4, 2003; April 5, 2004; July 29, 2004; May 19, 2005; July 7, 2005; May 17, 2006; August 30, 2006; August 15, 2007; October 11, 2007; July 1, 2008; June 10, 2009; August 20, 2009; April 29, 2010; July 23, 2010; May 10, 2011; April 17, 2012; August 21, 2012; April 16, 2013; May 12, 2014; July 29, 2014; August 4, 2015; October 5, 2016

Physical Characterization

Watershed and Land Use

Mill Creek lies within the Brazos River Basin. Sample site 11576 is located at SH 36 southeast of Bellville in Austin County (Figure 308).

The Mill Creek watershed at site 11576 is approximately 975.78 sq km. The station and lower watershed are located in Level IV Ecoregion 33b, the Southern Post Oak Savannah, and the middle and upper watershed lay within Level IV Ecoregion 32b, the Southern Blackland/Fayette Prairie. The dominant land cover in the watershed is pasture/hay at 54.45% and is present throughout the watershed (Homer et al. 2015; Figure 308 and Figure 309). Forest is the secondary land cover encompassing 19.83%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 6.18% and total cover for cultivated crops is 1.46%.

From 1992-2011 there was a 69.41 sq km decrease in pasture/hay and a 34.16 sq km decrease in forest. There was a 52.77 sq km increase in wetlands and a 51.68 sq km increase in open space development (Figure 310).

There are four domestic wastewater outfalls (discharges < 1 million gallons per day) and one industrial wastewater outfall (discharges ≥ 1 million gallons per day) within the Mill Creek watershed. The domestic wastewater facilities are permitted to the City of Bellville, the City of Burton, the City of Industry, and U.S. Steel Tubular Productions Inc, which manufactures steel pipes. U.S. Steel Tubular Productions Inc. has a second permit for the industrial wastewater facility. None of these facilities discharge directly into Mill Creek.

In Channel and Riparian Physical Habitat

Physical habitat for Mill Creek was evaluated at two sites during 16 sampling events from 1988 to 2016. Mill Creek is a perennial stream that drains to the Brazos River north of Sealy. Habitat Quality Index scores are available for 13 sample events and indicate an intermediate to high aquatic life use rating (14-23). Riparian areas were moderate throughout the reach with an average riparian buffer ranging from 4 to 15 meters wide. The riparian zone was generally dominated by trees followed by grasses then shrubs. The average percentage of tree canopy cover ranged from 8% to 94%. The dominant stream substrate was sand, and the average percent of substrate gravel size or larger varied from 0% to 34%. Average percent instream cover was 11% to 26% and instream cover types include overhanging vegetation, undercut banks, woody debris, root mats, algae, and gravel. Mill Creek ranged from 0.1-0.5 meters deep on average and 5-20 meters wide. Average stream bank slope ranged from 19-44 degrees. Stream flow at the site was measured at a minimum value of 1.4 cfs and a maximum of 55 cfs. Average stream bank erosion potential was 8%-54%. The deepest pool measured at Mill Creek was greater than two meters. Number of riffles observed at the site varied from zero to three, and total number of stream bends ranged from two to nine.

Water Quality

Water samples were collected at station 11576 over 150 sampling events from April 1982 through February 2020, and at station 11574 over 7 sampling events from July 1988 through July 1999. Parameters measured at both stations included temperature, flow, transparency, specific conductance, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total nitrogen, phosphorus, total organic carbon, chloride, sulfate and chlorophyll-a. Continuous 24-hour data was collected at station 11576.

Continuous flow data associated with station 11576 is available from USGS gage 08111700 (Figure 311). Between January 1985 through December 2019, the median flow was 22.8 cfs. Daily average flows ranged from 0 cfs to 65,700 cfs, though flows were greater than 1000 cfs about 3.7 percent during this time period. Data have been log transformed to better visualize flow patterns.

Biological Characterization

Fish

The thirty-three fish samples collected between 1988 and 2017 yielded the following aquatic life use ratings: exceptional (2), high (21), intermediate (7), and limited (3). The two exceptional ratings came from successive samples collected in July 2014 and August 2015. There never was an instance of successive ratings of intermediate or limited. These lower ratings were interspersed throughout the years and are most likely a reflection of natural variability. To that end, when the coefficient of variability is applied, two limited ratings increase to intermediate, four intermediates to high, and one high to exceptional.

The fish assemblage was fairly consistent throughout the years and ranged in richness from seven (November 2002, one of the dates receiving a limited aquatic life use) to 22. Mean species richness was 15. A total of 52 different species (13 families) were collected as part of the 33 sampling events. Centrarchidae and Cyprinidae were the richest families, each yielding 14 species. Orangespotted Sunfish was first collected in 2009 and became a fairly consistent part of the assemblage thereafter. Blacktail Shiner and Longear Sunfish were present in every collection. Mountain Mullet *Agonostomus monticola*, Black Bullhead, Bowfin *Amia calva*, Threadfin Shad *Dorosoma petenense*, Bantam Sunfish *Lepomis symmetricus*, Smallmouth Bass, Weed Shiner, and Common Carp were each collected once and, in each instance, represented by only one individual. Only three collections had non-native species. In addition to the single representatives of Smallmouth Bass (2000) and Common Carp (1988) already mentioned, two Redbreast Sunfish were collected in 2016.

Benthic Macroinvertebrates

Considering the one Surber sample and 31 RBP samples collectively, a total of 8184 individuals representing 149 taxa from 22 orders of macroinvertebrates were collected from Mill Creek (Appendix E). The Ephemeroptera, Trichoptera, Odonata, Diptera, Coleoptera, Veneroida, Amphipoda, and Megaloptera were the most commonly collected orders, collectively accounting for 95.5 percent of the total number of individuals collected. The Hemiptera and Decapoda were the only other orders which comprised at least one percent of the collections.

The East Bioregion Surber BIBI for the July 1988 Surber sample fell in the exceptional aquatic life use category. The Ecoregions 33 and 35 BIBIs for each of the RBP samples fell in the following aquatic life use categories:

- Exceptional (May 2002, April 2004, May 2006, July 2010, August 2012)
- High (July 2001, October 2001, August 2002, November 2002, May 2003, August 2003, July 2004, May 2005, July 2005, August 2006, August 2007, October 2007, July 2008, June 2009, August 2009, April 2010, May 2011, April 2013, July 2014, August 2015, October 2016)
- Intermediate (January 2000, May 2000, July 2000, April 2012, May 2014)

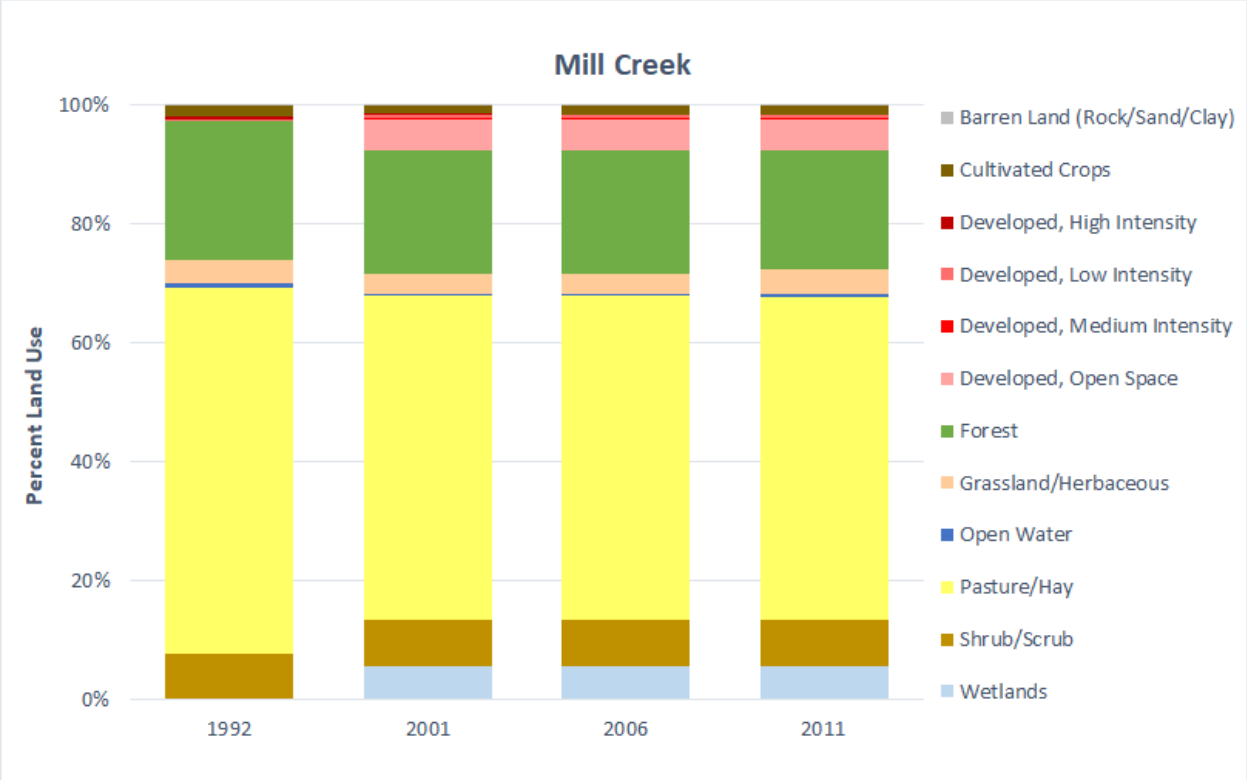

Figure 309. Percent land use in the Mill Creek watershed from 1992-2011.

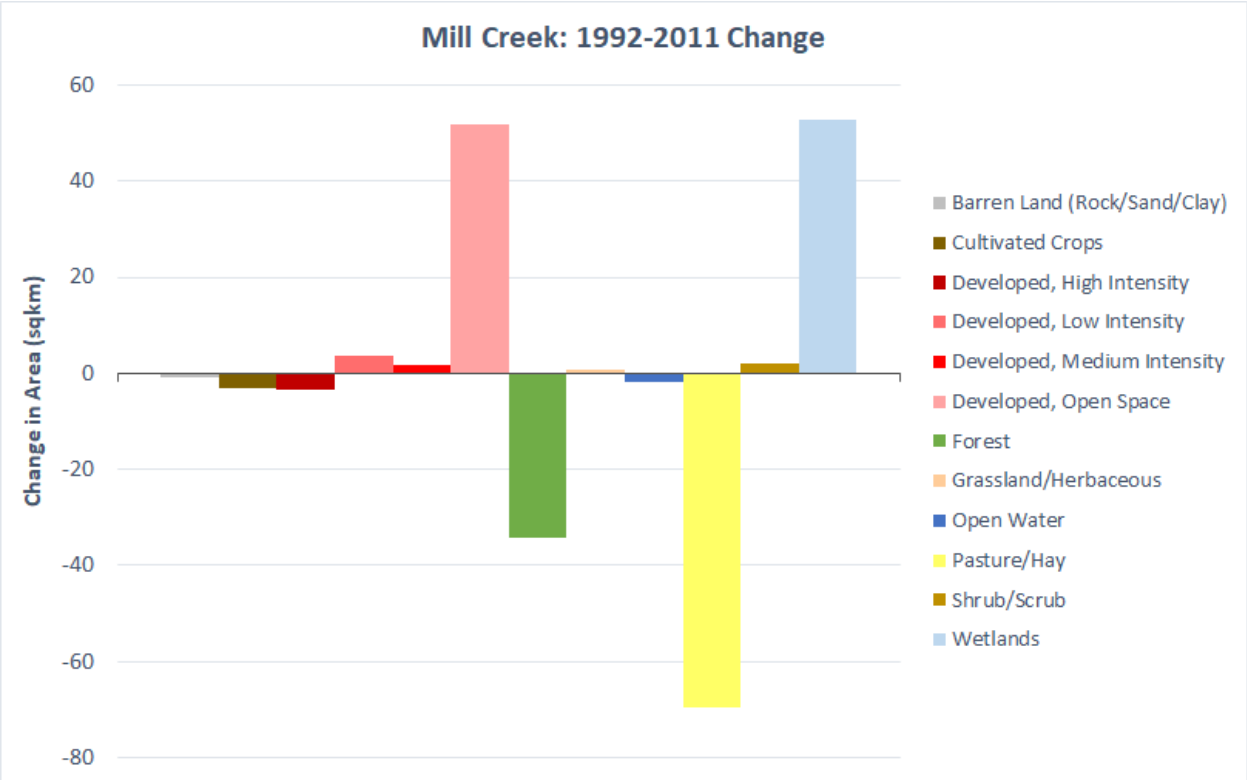

Figure 310. Land use change in area (sq km) from 1992-2011 for the Mill Creek watershed.

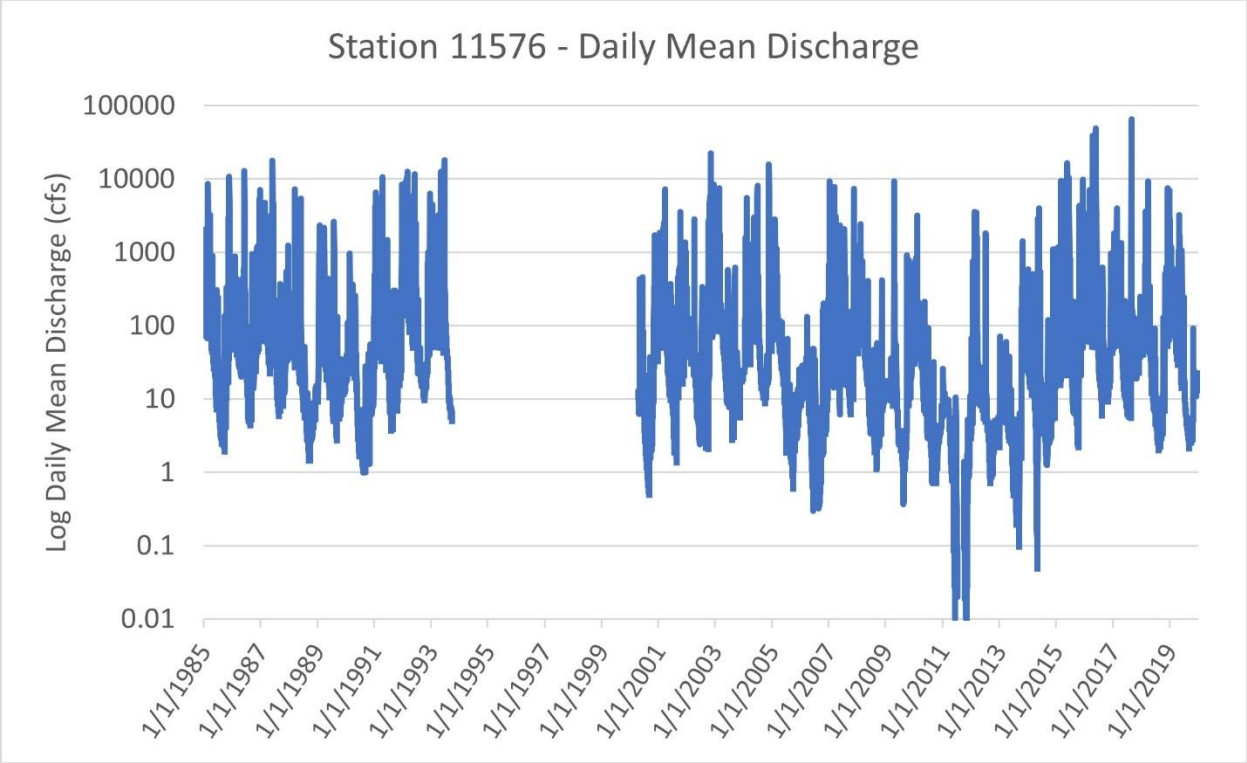

Figure 311. Log transformed daily mean discharge for Mill Creek at station 11576.

PONDS CREEK

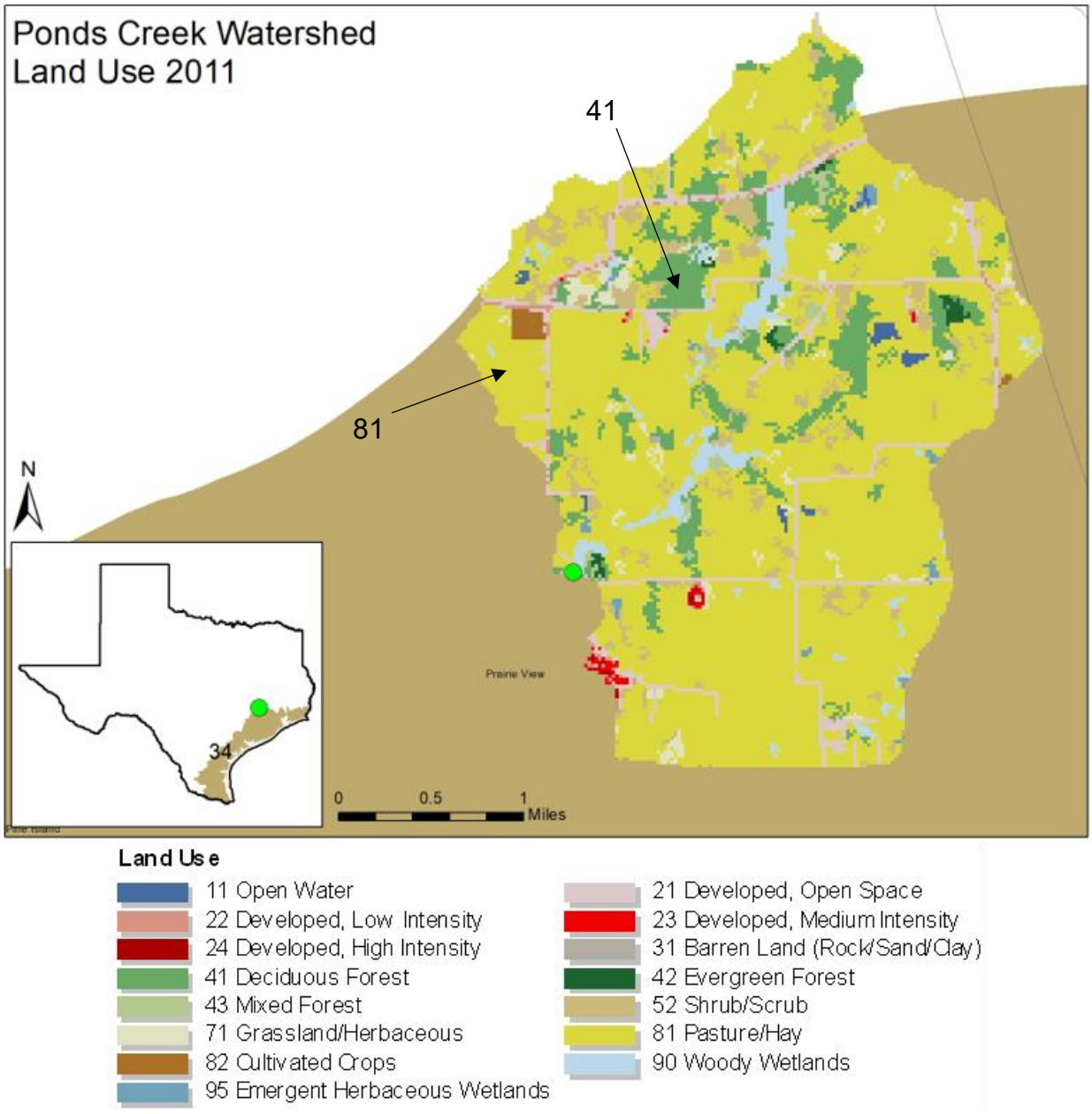

Figure 312. Map of Ponds Creek watershed location and 2011 land use; pasture/hay and forest were the most common land uses.

Sampling Dates

Physical Habitat:	July 19, 1988; June 13, 2003; August 18, 2003
Water Quality:	18 sampling events
Fish:	July 19, 1988; June 13, 2003; August 18, 2003
Benthic Invertebrates:	July 19, 1988; June 13, 2003; August 18, 2003

Physical Characterization

Watershed and Land Use

Ponds Creek lies within the Brazos River Basin. Sample site 11579 is located 69 m downstream of East Obannion Street in Prairie View, 3.54 km north of US 290 in Waller County (Figure 312).

The Ponds Creek watershed at site 11579 is approximately 20.21 sq km. The vast majority of the watershed lies within the Level IV Ecoregion 34a, the Northern Humid Gulf Coastal Prairies. A very small portion of the northeast watershed lies within the Level IV Ecoregion 33b, Southern Post Oak Savannah. The dominant land cover in the watershed is pasture/hay at 71.21% and present throughout the watershed (Homer et al. 2015; Figure 312 and Figure 313). Forest is the secondary land cover encompassing 10.48% and is most dense in the upper watershed. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 5.94% and cultivated crops cover 0.39% of the watershed.

From 1992-2011 there was a 1.51 sq km decrease in pasture/hay and a 1.04 sq km decrease in cultivated crops. There was a 1.14 sq km increase in shrub and a 1 sq km increase in open space development (Figure 314).

There are no permitted wastewater outfalls within the Ponds Creek watershed.

In Channel and Riparian Physical Habitat

Physical habitat for Ponds Creek was evaluated during three sampling events from 1988 to 2003. Ponds Creek is an intermittent stream with perennial pools that drains to Clear Creek, which is a tributary of the Brazos River below the Navasota River. Habitat Quality Index scores are available for two sample events and indicate a limited aquatic life use rating (11-13). Riparian areas were well vegetated throughout the reach with an average riparian buffer measured at 20 meters or greater for all sampling events. The riparian zone was generally dominated by trees followed by shrubs then grasses. The average percentage of tree canopy cover ranged from 56% to 87%. The dominant stream substrate was sand, and the average percent of substrate gravel size or larger varied from 0% to 27%. Average percent instream cover was 10% to 16% and instream cover types include snags, woody debris, undercut banks, and overhanging vegetation. Ponds Creek ranged from 0.1-0.2 meters deep on average and 2-4 meters wide. Average stream bank slope ranged from 24-55 degrees. Stream flow at the site was 0.01 cfs in 1988, but it was not measured during the two sampling events in 2003. Average stream bank erosion potential was 44%-58%. The deepest pool measured at Ponds Creek was 0.8 meters. Number of riffles observed at the site varied from zero to five, and there were two total stream bends.

Water Quality

Water samples were collected at station 11579 over 18 sampling events from July 1988 through August 2010. Parameters measured included temperature, flow, transparency, specific

conductance, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total nitrogen, phosphorus, total organic carbon, chloride, sulfate and chlorophyll-a.

Biological Characterization

Fish

Nineteen species (eight families) were collected over the course of the three sampling events. Centrarchidae yielded the greatest richness with six species. Western Mosquitofish was the most abundant species in 1988 and August 2003 while Blacktail Shiner yielded the greatest number of individuals in June 2003. One species, Grass Pickerel *Esox americanus vermiculatus*, was only collected in 1988; however, it was only represented by one individual. Species unique to the 2003 collections include Largemouth Bass, Slough Darter, Blackstripe Topminnow, and Blackspotted Topminnow *Fundulus olivaceus*. The aquatic life use (based upon the fish assemblage) rated high for each sample.

Benthic Macroinvertebrates

A total of 1,084 individuals representing 16 orders of macroinvertebrates were collected (Appendix E). The caddisfly (Trichoptera) genus *Cheumatopsyche* accounted for 33% of the total number of individuals collected. This genus and three others (*Oecetis*, *Chimarra*, and *Trianodes*), which were present in much lower relative abundance, collectively comprised 35.3% of total numbers.

Diptera and Pelecypoda (*Eupera cubensis, Pisidium* sp., and *Sphaerium* sp.) were the two next most abundant orders collected representing 14% and 11%, respectively, of the individuals collected. Odonata (10.8%), Ephemeroptera (9.5%), and Coleoptera (8.4%) were the three next most abundant orders.

The filtering collectors accounted for 45.5% of the individuals collected and dominated the functional organization of the Ponds Creek macroinvertebrate assemblage. The predators and collector gatherers were the next most abundant functional groups comprising 22.6% and 18.4%, respectively, of the total number of individuals collected. The scrapers (8.9%) and shredders (4.6%) were present but in less relative abundance.

For the two samples collected in June and August 2003 the EPT was four and zero, respectively. In contrast, the EPT was 12 for the Surber sample collected in 1988, which falls between the 50th percentile and the 75th percentile for all EPT values for least disturbed streams in ecoregion aggregate 33/35. Notably, the mayfly *Centroptilum* sp. and the caddisfly *Trianodes* sp. (both of which are considered relatively intolerant) were collected in 1988, possibly reflecting favorable dissolved oxygen and flow conditions; however, the value for the biotic index was 5.7 which exceeds the 75th percentile for the ecoregion aggregate indicating a relatively tolerant macroinvertebrate assemblage in Ponds Creek.

The East Bioregion Surber BIBI for the 1988 sample fell in the exceptional aquatic life use category for the Ponds Creek macroinvertebrate assemblage. Results for the Ecoregions 33 and

35 BIBI for the June 2003 sample indicated an intermediate aquatic life use and the August 2003 sample fell in the limited aquatic life use category.

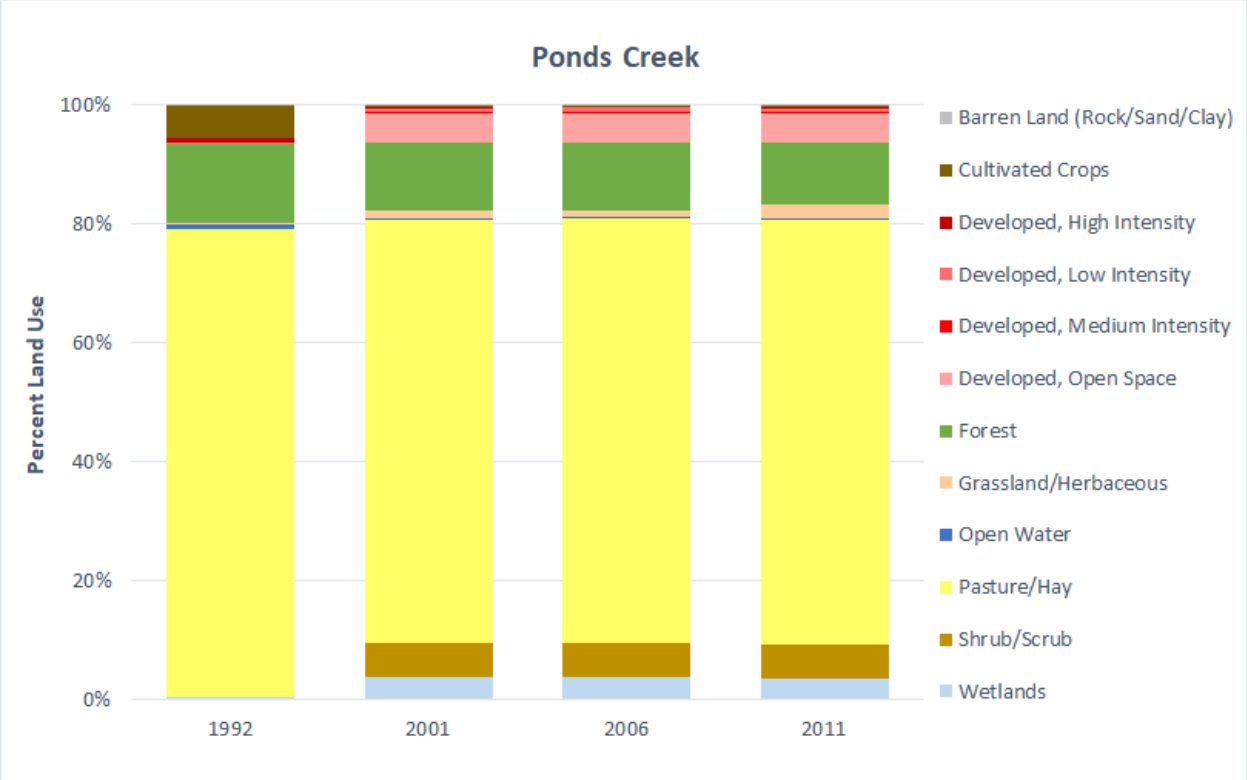

Figure 313. Percent land use in the Ponds Creek watershed from 1992-2011.

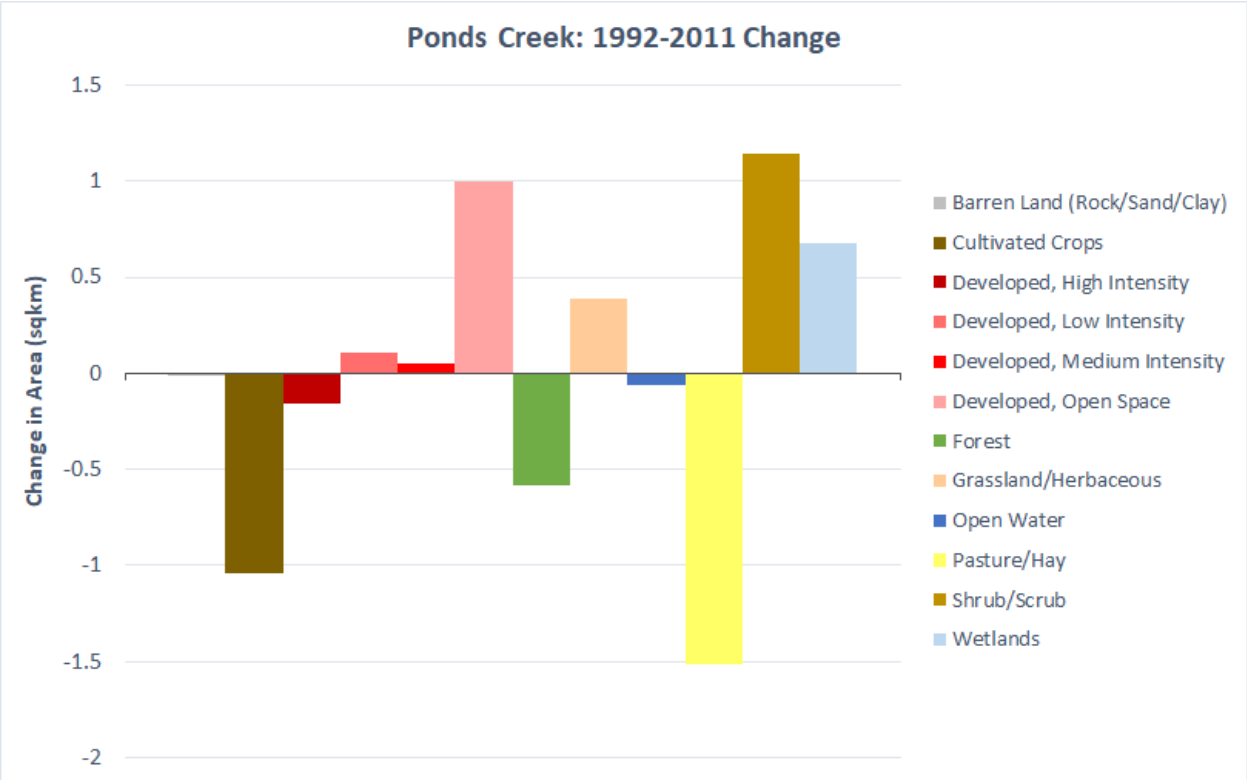

Figure 314. Land use change in area (sq km) from 1992-2011 for the Ponds Creek watershed.

SMACKOVER CREEK

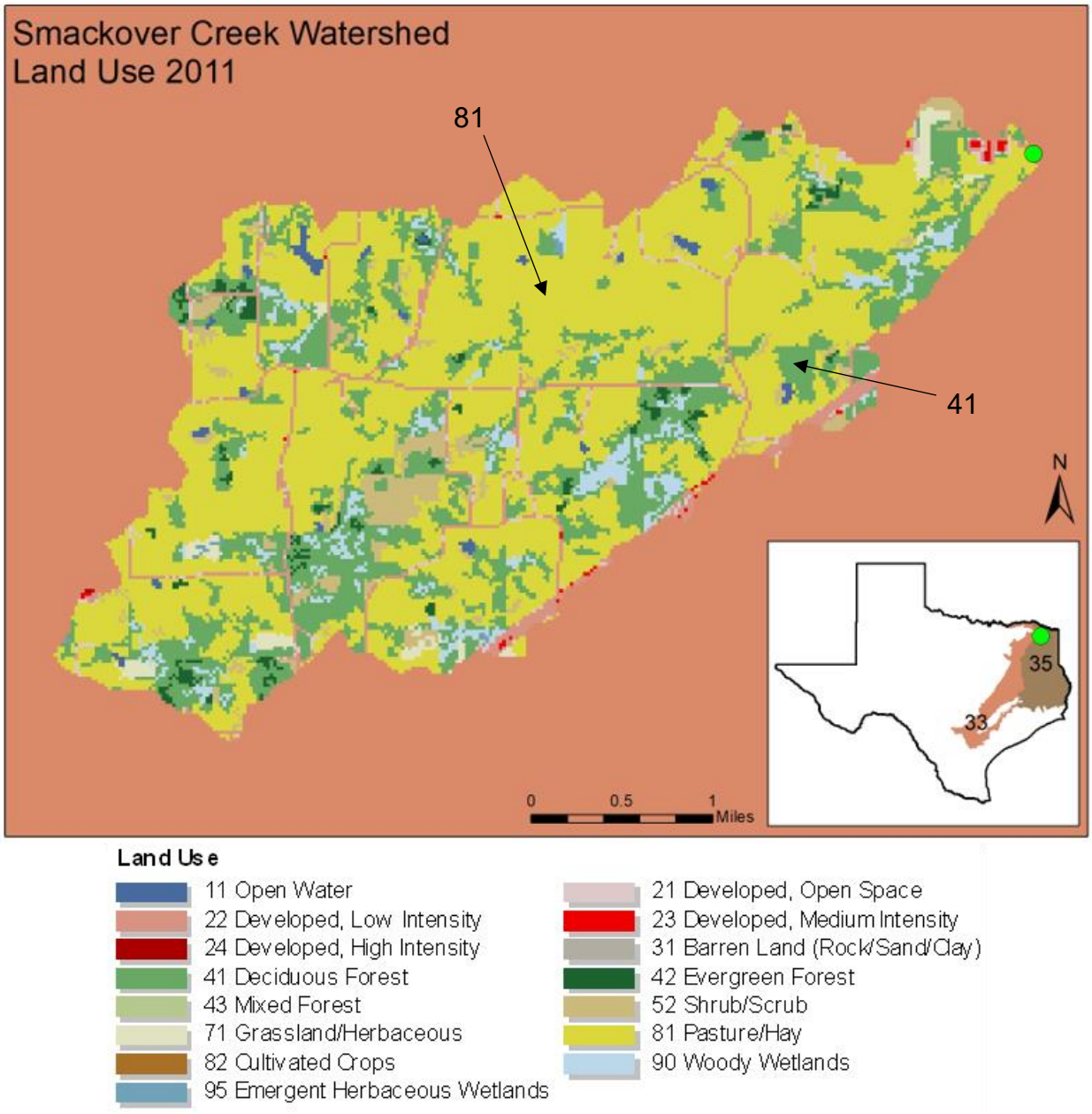

Figure 315. Map of Smackover Creek watershed location and 2011 land use; pasture/hay and forest were the most common land uses.

Sampling Dates

Physical Habitat:	June 2, 2008; July 14, 2008
Water Quality:	4 sampling events
Fish:	June 2, 2008; July 14, 2008
Benthic Invertebrates:	June 2, 2008; July 14, 2008

Physical Characterization

Watershed and Land Use

Smackover Creek lies within the Sulphur River Basin. Sample site 20101 is located at CR 3445, north of IH-30 in Titus County (Figure 315).

The Smackover Creek watershed at site 20101 is approximately 24.78 sq km. The entire watershed is located within Level IV Ecoregion 33a, the Northern Post Oak Savanna. The dominant land cover in the watershed is pasture/hay at 58.87% and is present throughout the watershed (Homer et al. 2015; Figure 315 and Figure 316). Forest is the secondary land cover encompassing 24.59%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 6.35% and there is no cultivated crop cover present within the watershed.

From 1992-2011 there was a 3.28 sq km decrease in pasture/hay, a 1.18 sq km increase in low intensity development, and a 1.07 sq km increase in shrub (Figure 317).

There are no permitted wastewater outfalls within the Smackover Creek watershed.

In Channel and Riparian Physical Habitat

Physical habitat for Smackover Creek was evaluated during two sampling events in 2008. Smackover Creek is a perennial stream that drains to White Oak Creek, which is a tributary to the South Sulphur River. Habitat Quality Index scores are available for both sample events and indicate an intermediate aquatic life use rating (17-18). Riparian areas were well vegetated throughout the reach with an average riparian buffer measured at greater than 20 meters. The riparian zone was generally dominated by trees followed by grasses then shrubs. The average percentage of tree canopy cover was 98%. The dominant stream substrate was silt, and the average percent of substrate gravel size or larger varied from 13% to 21%. Average percent instream cover was 21% and instream cover types include snags and woody debris. Smackover Creek ranged from 0.4-0.5 meters deep on average and 4-5 meters wide. Average stream bank slope ranged from 39-52 degrees. Stream flow at the site was measured at a minimum value of 0.4 cfs and a maximum of 0.8 cfs. Average stream bank erosion potential was 66%-81%. The deepest pool measured at Smackover Creek was 1.5 meters. Number of riffles observed at the site varied from zero to two, and there were two total stream bends.

Water Quality

Water samples were collected at station 20101 over 4 sampling events from November 2007 through July 2008. Parameters measured included temperature, flow, transparency, specific conductance, dissolved oxygen, pH, ammonia, total Kjeldahl nitrogen, phosphorus, chloride, sulfate and chlorophyll-a. Continuous 24-hour data was also collected at this site.

Biological Characterization

Fish

Two fish sampling events were conducted during the summer of 2008. The first one rated as having an intermediate aquatic life use, the second rated as high. When the coefficient of variability is applied the intermediate rating rises to high. A total of 15 species (seven families) were collected between the two samples. More than one-half of the species were members of the family Centrarchidae with Bluegill being the most abundant species present. No minnow species were collected as part of the June sample and only two were collected in July (one being a tolerant species - Golden Shiner). Benthic invertivore and intolerant species were represented by one Dusky Darter in June and catch per unit effort was low in both sampling events. Both samples yielded a high percentage of tolerant species.

Benthic Macroinvertebrates

Considering both sample dates, a total of 324 individuals representing 10 orders of macroinvertebrates were collected at Smackover Creek (Appendix E). Caddisfly (Trichoptera) genus *Hydropsyche* accounted for 34.9% of the total number of individuals collected. Diptera, Amphipoda, and Coleoptera were the next most abundant orders comprising 25.3%, 12%, and 11.4%, respectively, of the total number of individuals collected. Ephemeroptera (9.6%), Oligochaeta (2.8%), Pelecypoda (1.9%), Megaloptera (0.9%), Gastropoda (0.6%), and Hemiptera (0.6%) were also present in collections at lower relative abundance.

Considering both sample dates collectively, the filtering collectors accounted for 45.5% of the individuals collected and dominated the functional organization of the Smackover Creek macroinvertebrate assemblage. The collector gatherers and the predators were the next most abundant functional groups comprising 24.3% and 14.9%, respectively, of the total number of individuals collected. The scrapers (8%) and shredders (7.3%) were present but in less relative abundance.

The EPT was 3 for the June 2008 sample and 4 for the July sample, both of which falls below the 25th percentile for all EPT values for least disturbed streams in ecoregion aggregate 33/35. The value for the biotic index was 5.2 for the June sample and 5 for the July sample, both of which are just above the 50th percentile of all biotic index values for least disturbed streams in ecoregion aggregate 33/35 indicating a moderately tolerant macroinvertebrate assemblage.

Both samples were collected using RBP protocols. The Ecoregions 33 and 35 BIBI was relatively consistent with results for both sample dates falling in the range indicating an intermediate aquatic life use for the Smackover Creek macroinvertebrate assemblage.

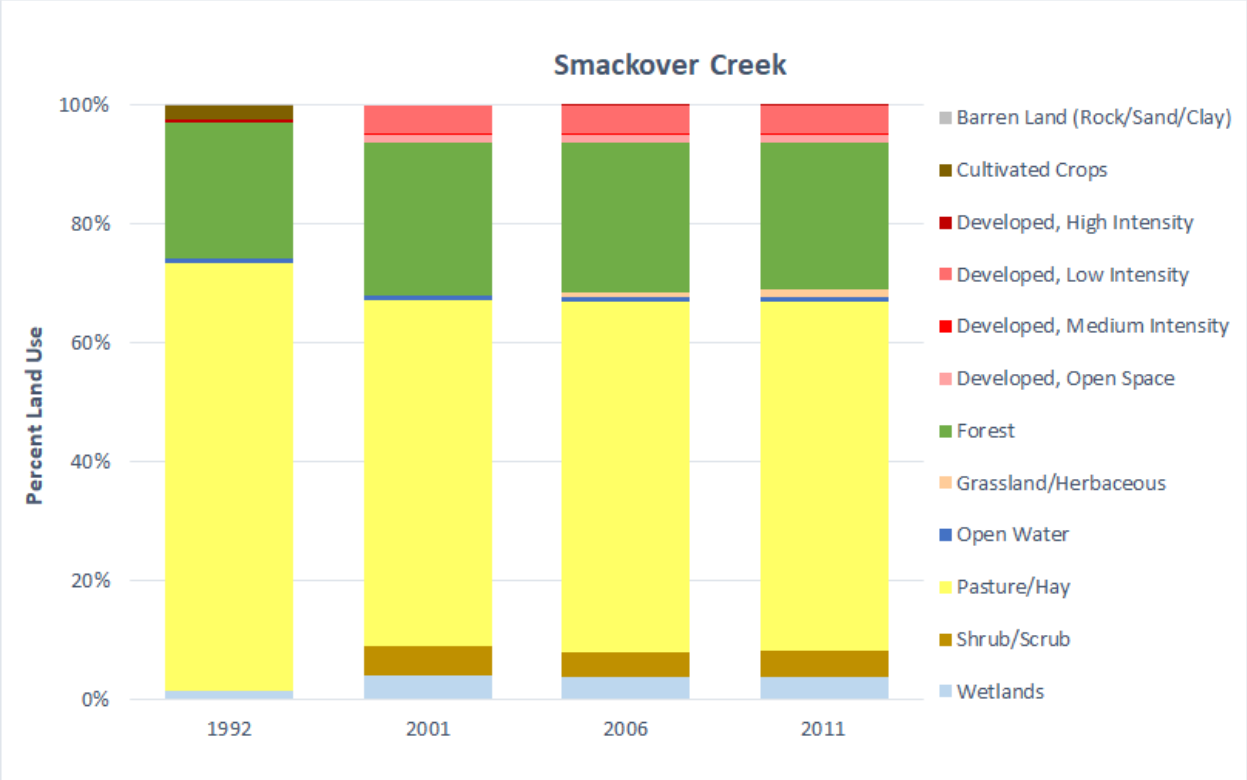

Figure 316. Percent land use in the Smackover Creek watershed from 1992-2011.

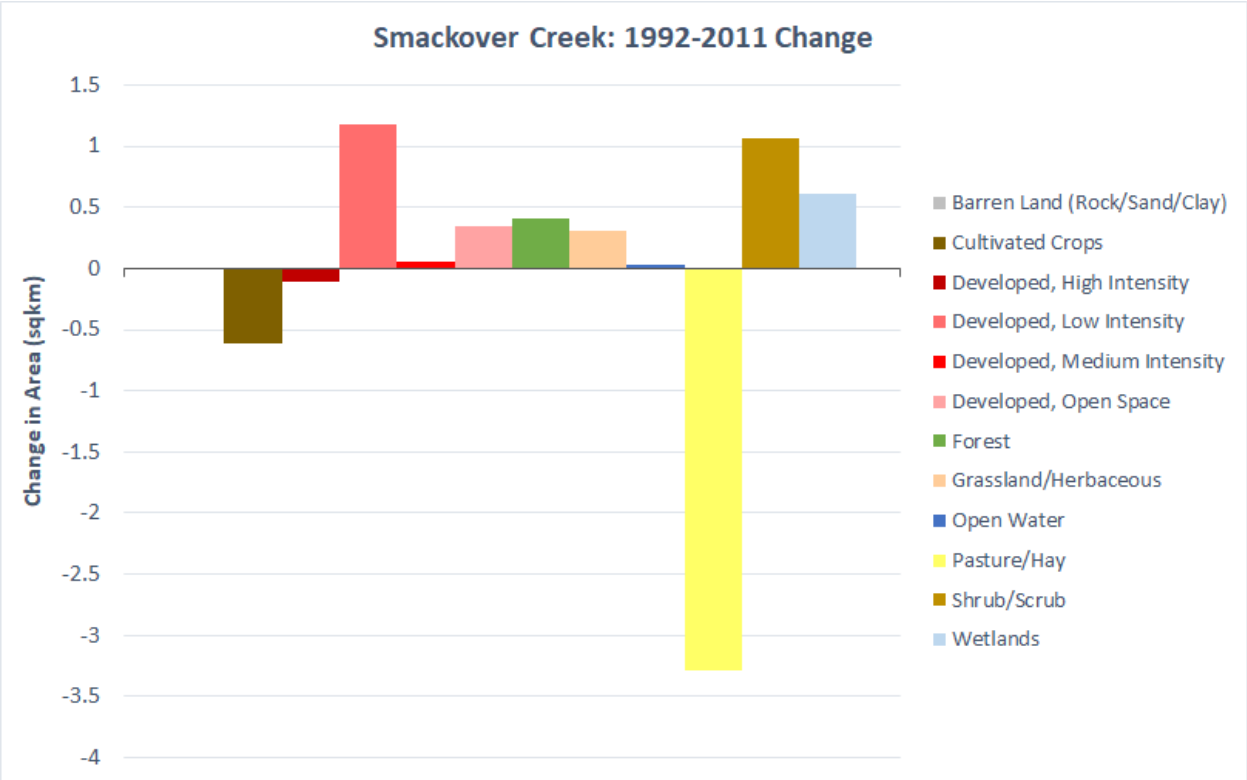

Figure 317. Land use change in area (sq km) from 1992-2011 for the Smackover Creek watershed.

WHEELOCK CREEK

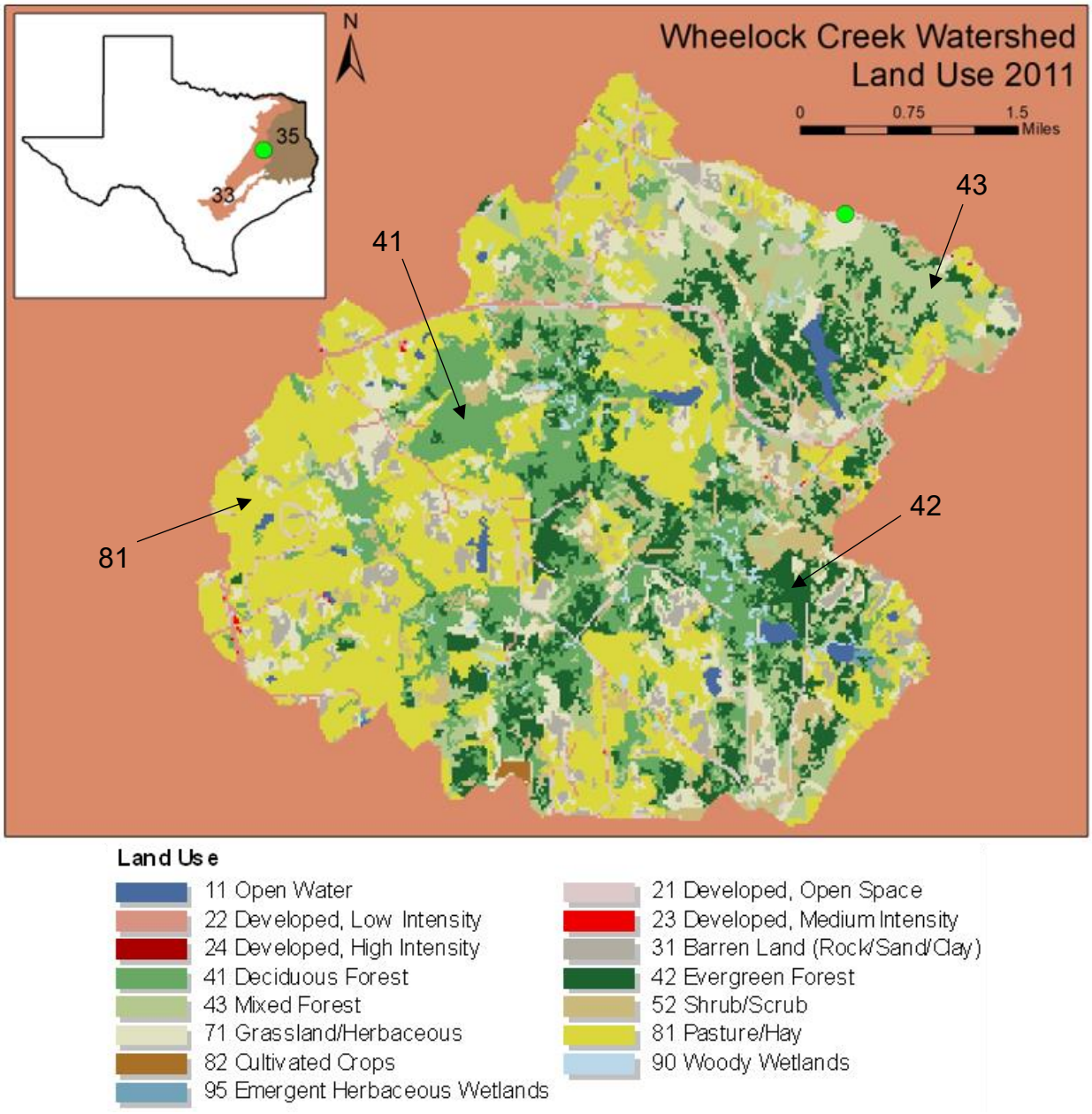

Figure 318. Map of Wheelock Creek watershed location and 2011 land use; forest and pasture/hay were the most common land uses.

Sampling Dates

Physical Habitat:	August 17, 1988
Water Quality:	4 sampling events
Fish:	August 17, 1988; April 12, 1989
Benthic Invertebrates:	August 17, 1988

Physical Characterization

Watershed and Land Use

Wheelock Creek lies within the Trinity River Basin. Sample site 10821 is located upstream of CR W 212, 12.23 km southeast of Buffalo in Leon County (Figure 318).

The Wheelock Creek watershed at site 10821 is approximately 46.25 sq km. The entire watershed is located within Level IV Ecoregion 33b, the Southern Post Oak Savanna. The dominant land cover in the watershed is forest at 40.55% and is present throughout the watershed (Homer et al. 2015; Figure 318 and Figure 319). Pasture/hay is the secondary land cover encompassing 31.8%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 4.78% and total cover for cultivated crops is 0.14%.

From 1992-2011 there was an 8.42 sq km decrease in pasture/hay and a 2.75 sq km decrease in forest. There was a 4.72 sq km increase in grassland and a 2.94 sq km increase in shrub (Figure 320).

There are no permitted wastewater outfalls within the Wheelock Creek watershed.

In Channel and Riparian Physical Habitat

Physical habitat for Wheelock Creek was evaluated on August 17, 1988. Wheelock Creek is a perennial stream that drains to Buffalo Creek, which is a tributary to Upper Keechi Creek in Leon County. The riparian width was 46 meters. The riparian zone was dominated by trees, which made up an average of 70% of the total riparian species, followed by shrubs and grasses (15% each). The average percentage of tree canopy cover was 58%. The dominant substrate was fine sand, and the average percent of substrate that was gravel size or larger was 18%. Average percent instream cover was 15%. Wheelock Creek had an average depth of 0.2 meters and a maximum depth of 0.5 meters. The average width was 2.7 meters and average stream bank slope was 42 degrees. Stream flow at the site was 0.8 cfs. Average stream bank erosion potential was 37%. Five riffles were observed at the site and there were two total stream bends.

Water Quality

Water samples were collected at station 10821 over 4 sampling events from August 1988 through July 1999. Parameters measured included temperature, flow, specific conductance, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total nitrogen, phosphorus, chloride, sulfate and chlorophyll-a.

Biological Characterization

Fish

Wheelock Creek was sampled for fish in the summer of 1988 and spring of 1989. On both occasions it received an aquatic life use rating of high. Twenty species (six families) were collected between the two sampling events. Centrarchidae and Cyprinidae were the richest families with six and five species, respectively. Blacktail Shiner was the most abundant species.

Benthic Macroinvertebrates

A total of 901 individuals representing 10 orders of macroinvertebrates were collected from Wheelock Creek (Appendix E). Diptera, Coleoptera, Ephemeroptera, and Trichoptera were the four most abundant orders comprising 28.9%, 22%, 21.1%, and 18.3%, respectively, of the total number of individuals collected. Odonata (6%), Oligochaeta (1.3%), Hemiptera (0.9%), Nematoda (0.9%), Megaloptera (0.4%), and Lepidoptera (0.1%) were also present in collections at lower relative abundance.

Collector gatherers (41.6%), scrapers (28.8%), and predators (18.6%) were the dominant functional groups. The EPT was 14 for the August 1988 sample which equals the 75th percentile for all EPT values for least disturbed streams in ecoregion aggregate 33/35. The value for the biotic index was 4.3, which falls between the 5th and 25th percentiles of all biotic index values for least disturbed streams in ecoregion aggregate 33/35.

Results for the Surber sample BIBI for the August 1988 sample was 47 which falls in the range indicating an exceptional aquatic life use.

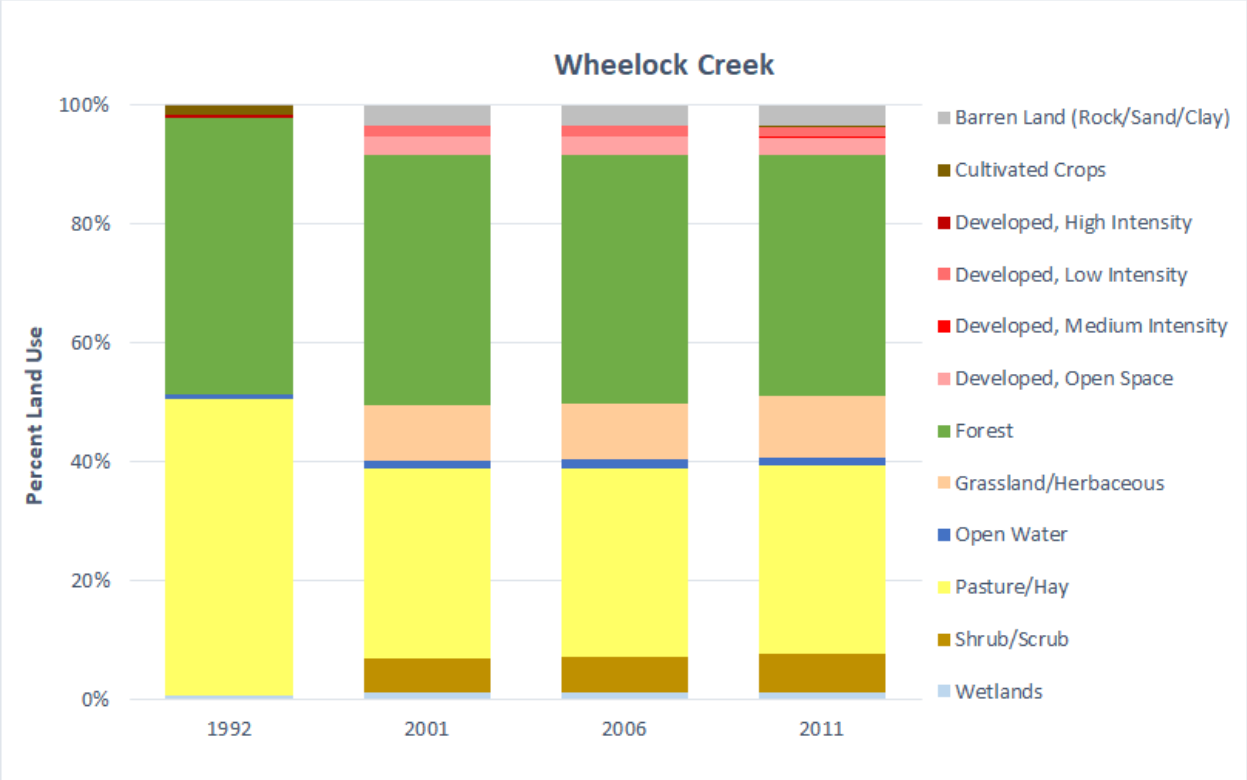

Figure 319. Percent land use in the Wheelock Creek watershed from 1992-2011.

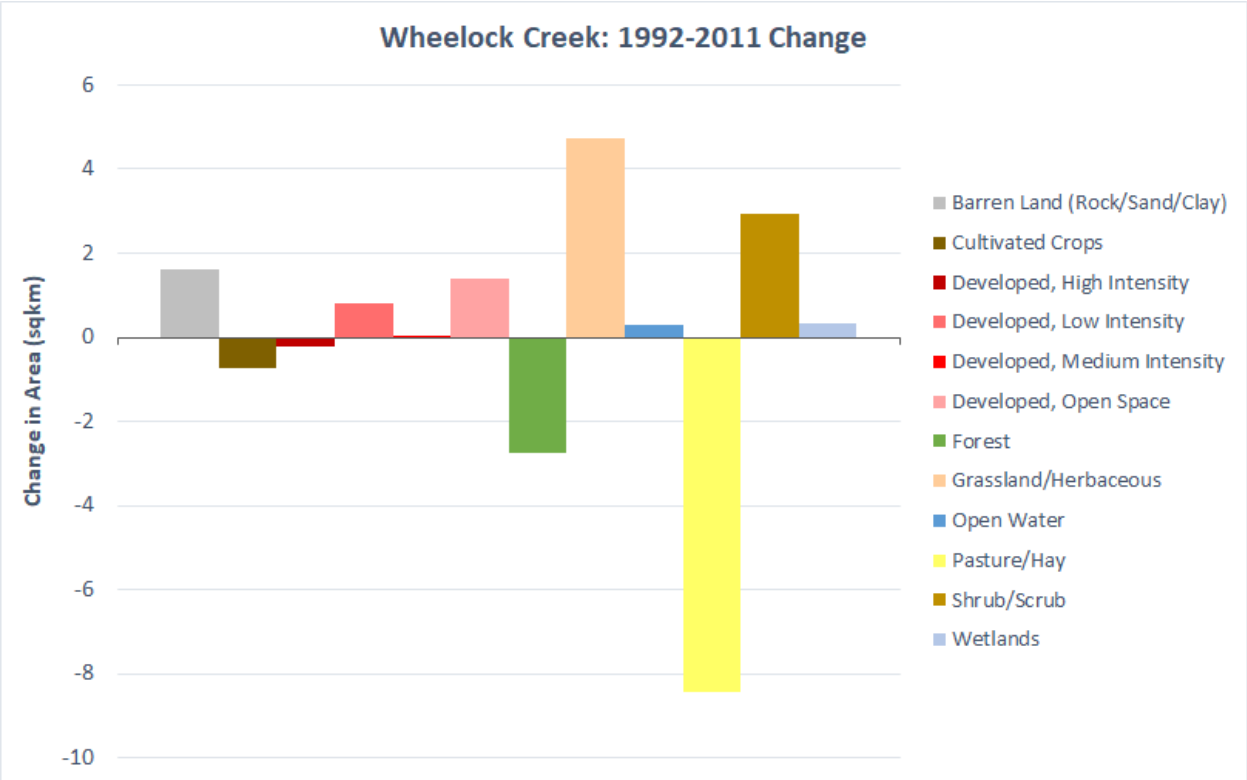

Figure 320. Land use change in area (sq km) from 1992-2011 for the Wheelock Creek watershed.

Ecoregion 35 Characterization

The South Central Plains Ecoregion (Ecoregion 35) is often referred to as the "piney woods" (Figure 275). This region is part of a much larger area of pine-hardwood forest that extends into Louisiana, Arkansas, and Oklahoma. Elevations range from 61 to 152 m above sea level (TPWD Landscape Ecology Program webpage).

Most of the region is characterized by irregular plains and represents the western extent of the coniferous forests of the southeastern U.S. (Griffith et al. 2007). Loblolly pine *Pinus taeda* and shortleaf pine *P. echinata* dominate forested areas of the ecoregion. Acidic sands and sandy loams are the most typical soils across the ecoregion (Griffith et al. 2007). Forests and woodland occupy approximately two thirds of the ecoregion. Cropland constitutes a relatively small portion of Ecoregion 35, primarily in the Red River floodplain (Griffith et al. 2007). Economic activities include lumber, pulpwood, and oil and gas production. Griffith et al. (2007) identified six Level IV ecoregions within the South Central Plains in Texas and provide greater details on the physiographic characteristics of this ecoregion. Greater detail on the physiographic characteristics of the region is also given in this report in the physical characterization for each sample site.

Table 12. Streams in Ecoregion 35.

Beach Creek	Frazier Creek	Peach Creek
Beech Creek	Irons Bayou	Piney Creek
Big Cypress Creek	James (Jim) Bayou	San Pedro Creek
Black Bayou	Lake Creek	West Fork San Jacinto River
Black Cypress Bayou	Little Cypress Bayou	White Oak Creek
East Fork San Jacinto River	Little Pine Island Bayou	

BEACH CREEK

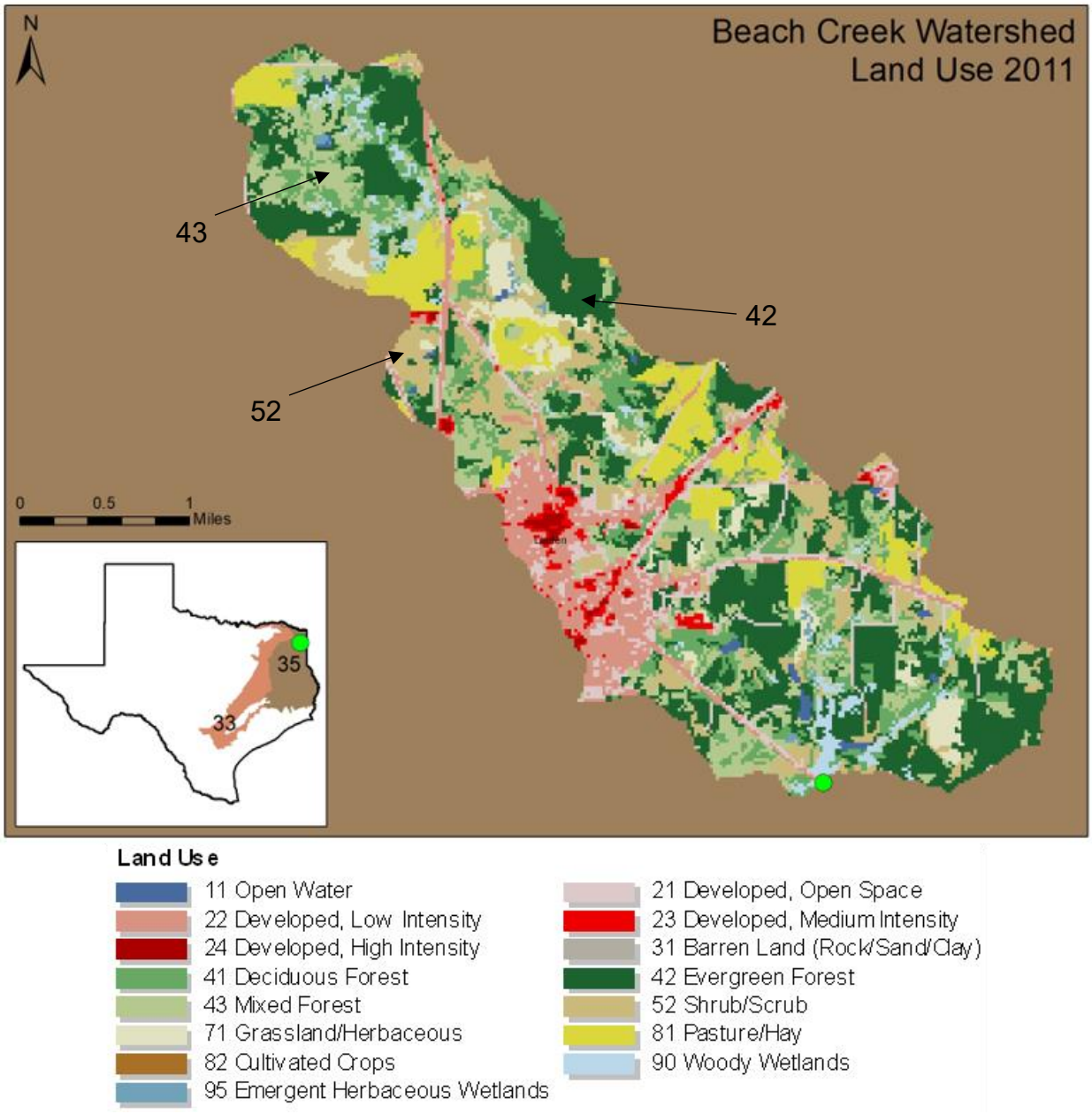

Figure 321. Map of Beach Creek watershed location and 2011 land use; forest and shrub/scrub were the most common land uses.

Sampling Dates

Physical Habitat:	June 29, 2004; August 17, 2004
Water Quality:	9 sampling events (Station 10256)
Fish:	June 29, 2004; August 17, 2004
Benthic Invertebrates:	June 29, 2004; August 17, 2004

Physical Characterization

Watershed and Land Use

Beach Creek lies within the Cypress Creek Basin. Sample site 10256 is located at FM 125 southeast of Linden in Cass County (Figure 321).

The Beach Creek watershed at site 10256 is approximately 21.43 sq km. The entire watershed is located within Level IV Ecoregion 35a, the Tertiary Uplands. The dominant land cover in the watershed is forest at 53.57% and is present throughout the watershed (Homer et al. 2015; Figure 321 and Figure 322). Shrub is the secondary land cover encompassing 11.83%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 17.19% and there is no cultivated crop cover present within the watershed.

From 1992-2011 there was a 3.76 sq km decrease in forest and a 1.93 sq km decrease in pasture/hay. There was a 2.54 sq km increase in shrub, 1.28 sq km increase in low intensity development, and a 1.24 sq km increase in open space development (Figure 323).

There is one domestic wastewater outfall (discharges < 1 million gallons per day) within the Beach Creek watershed permitted to the City of Linden that discharges directly into Beach Creek.

In Channel and Riparian Physical Habitat

Physical habitat for Beach Creek was evaluated during two sampling events in 2004. Beach Creek is a perennial stream that drains to James Bayou southeast of Linden. Habitat Quality Index scores are available for both sample events and indicate a high aquatic life use rating (20-20.5). Riparian areas were well vegetated throughout the reach with an average riparian buffer measured at greater than 20 meters. The riparian zone was generally dominated by trees followed by grasses then shrubs. The average percentage of tree canopy cover was 100%. The dominant stream substrate was sand, and the average percent of substrate gravel size or larger was 0%. Average percent instream cover was 10% to 13% and instream cover types include overhanging vegetation, undercut banks, woody debris, and root mats. Beach Creek ranged from 0.2-0.5 meters deep on average and 4-5 meters wide. Average stream bank slope ranged from 42-50 degrees. Stream flow at the site was measured at a minimum value of 0.2 cfs and a maximum of 24 cfs. Average stream bank erosion potential was 25%. The deepest pool measured at Beach Creek was 1.2 meters. No riffles were observed at the site and there were five stream bends.

Water Quality

Water samples were collected at station 10256 over 9 sampling events from August 1981 through August 2004. Parameters measured included temperature, flow, transparency, specific conductance, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total nitrogen, phosphorus, total organic carbon, chloride, sulfate and chlorophyll-*a*. Continuous 24-hour data was also recorded at station 10256.

Biological Characterization

Fish

Twenty species (10 families) were collected between the two samples. Centrarchidae yielded the most species with six. Western Mosquitofish was the most abundant species in June while Pirate Perch *Aphredoderus sayanus* was the most abundant one in August. The aquatic life use (based upon the fish assemblage) scored as high.

Benthic Macroinvertebrates

Considering both samples collectively, a total of 353 individuals representing 12 orders of macroinvertebrates were collected at Beach Creek (Appendix E). Diptera, Amphipoda, Odonata, and Coleoptera were the four most abundant orders comprising 50.4%, 11.9%, 10.8%, and 9.1%, respectively, of the total number of individuals collected. Less abundant orders include Hemiptera (6.8%), Ephemeroptera (4%), Pelecypoda (2%), Decapoda (1.7%), and Oligochaeta (1.7%). Trichoptera, Hirudinea, and Turbellaria were also present in collections at lower relative abundance collectively representing 1.7% of total numbers collected.

The functional organization of the Beach Creek macroinvertebrate assemblage was relatively similar for both sample dates. Considering both dates collectively, predators, collector gatherers, and filtering collectors were the most abundant functional groups comprising 43%, 29%, and 19.2% of the individuals, respectively. Shredders (6.5%) and scrapers (2.3%) were the least abundant functional groups collected.

Considering both sample dates, a total of five EPT taxa were collected at Beach Creek. This just exceeds the 25th percentile (4.8) for all EPT values for least disturbed streams in ecoregion aggregate 33/35. The value for the biotic index was relatively consistent for both samples with a maximum value of 6.6 for the sample collected in June 2004 and a minimum of 6.3 for the August 2004 sample. Both values fall between the 75th and 95 percentiles of all biotic index values for least disturbed streams in ecoregion aggregate 33/35 reflecting a relatively tolerant macroinvertebrate assemblage in Beach Creek.

The Ecoregions 33 and 35 BIBI scores for both the June and August 2004 samples fell in the range indicating a limited aquatic life use.

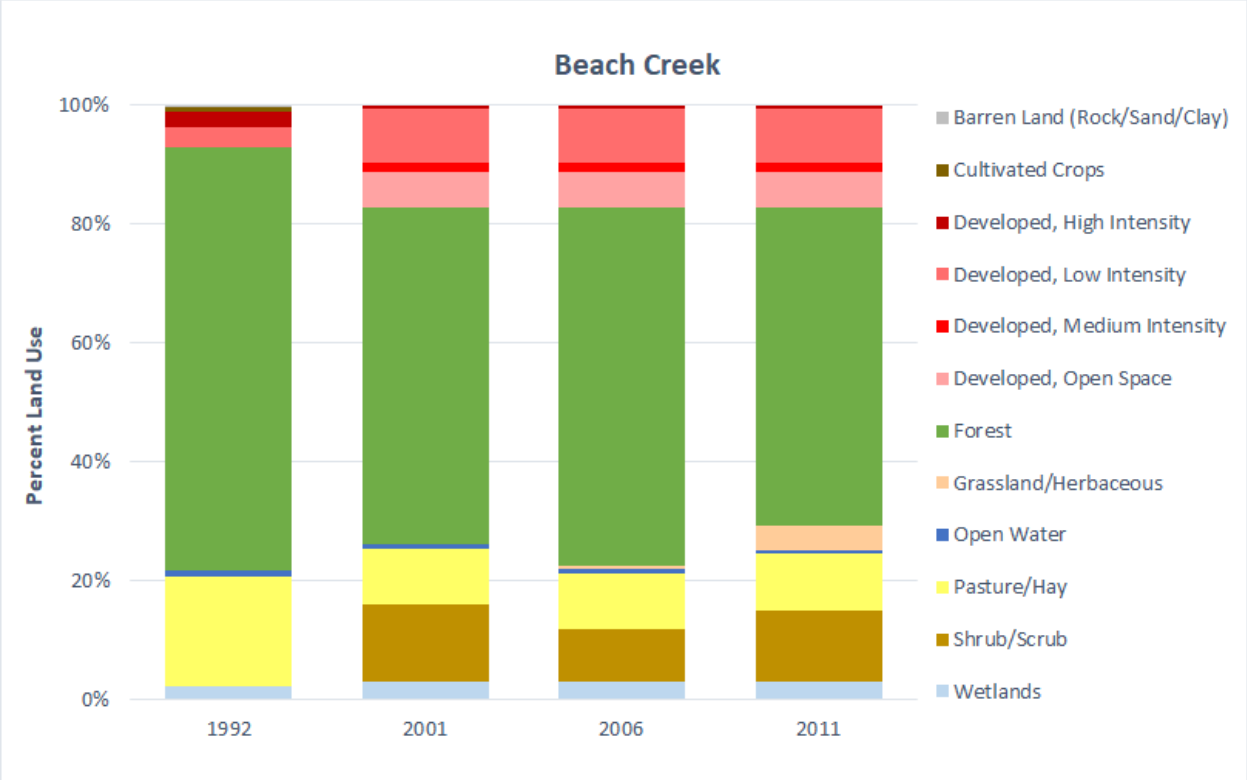

Figure 322. Percent land use in the Beach Creek watershed from 1992-2011.

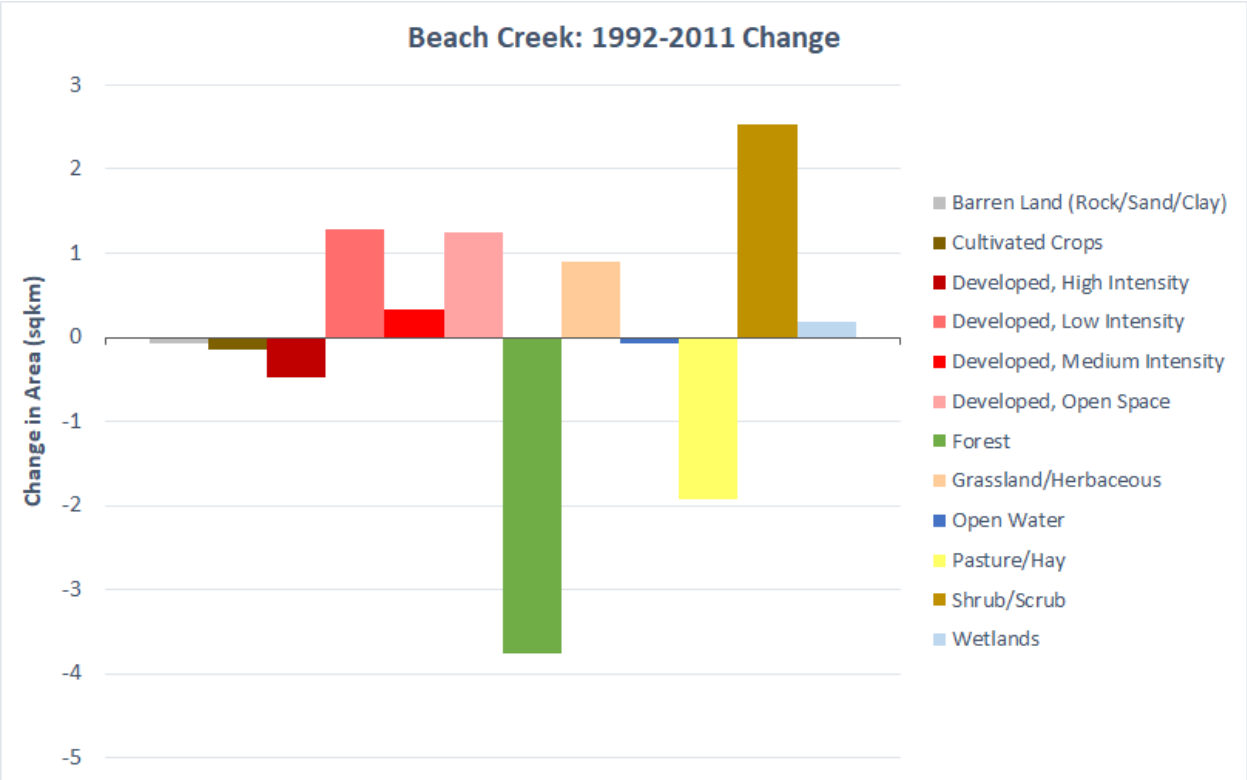

Figure 323. Land use change in area (sq km) from 1992-2011 for the Beach Creek watershed.

BEECH CREEK

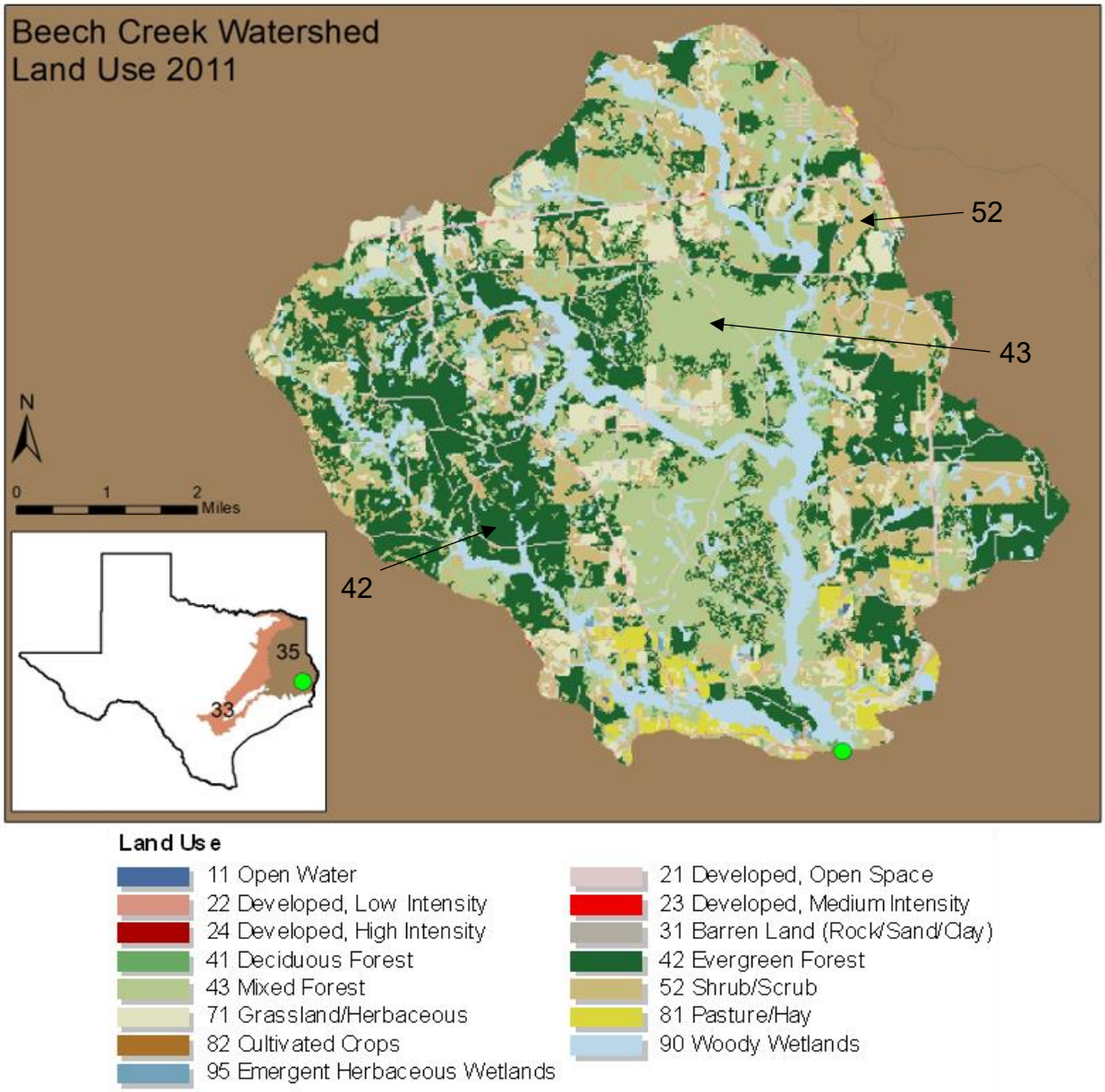

Figure 324. Map of Beech Creek watershed location and 2011 land use; forest and shrub/scrub were the most common land uses.

Sampling Dates

Physical Habitat:	Station 10529: September 12, 1989; June 26, 2003; August 20, 2003; Station 17903: June 24, 2003; August 20, 2003
Water Quality:	47 sampling events (Stations 17903 and 10529)
Fish:	September 12, 1989; June 26, 2003; August 20, 2003
Benthic Invertebrates:	Station 10529: September 13, 1989; June 26, 2003; August 20, 2003; Station 17903: June 24, 2003; August 20, 2003

Physical Characterization

Watershed and Land Use

Beech Creek lies within the Neches River Basin. Sample site 10529 is located at FM 1013 west of Spurger in Tyler County (Figure 324).

The Beech Creek watershed at site 10529 is approximately 117 sq km. The sampling location and majority of the watershed lay within Level IV Ecoregion 35f, the Flatwoods. The eastern portion of the watershed lies within Level IV Ecoregion 35e, the Southern Tertiary Uplands. The dominant land cover in the watershed is forest at 53.78% and is present throughout the watershed (Homer et al. 2015; Figure 324 and Figure 325). Shrub is the secondary land cover encompassing 17.31%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 5.12% and there is no cultivated crop cover present within the watershed.

From 1992-2011 there was a 41.35 sq km decrease in forest and a 6.25 sq km decrease in pasture/hay. There was a 20.25 sq km increase in shrub, 13.11 sq km increase in wetlands, and 10.5 sq km increase in grassland (Figure 326).

There are no permitted wastewater outfalls within the Beech Creek watershed.

In Channel and Riparian Physical Habitat

Physical habitat for Beech Creek was evaluated at two sites during five sampling events from 1989 to 2003. Beech Creek is a perennial stream that drains to Village Creek in Hardin County. Both sites are located near the southern boundary of the Beech Creek Unit within the Big Thicket National Preserve. Habitat Quality Index scores are available for four sample events and indicate a limited to high aquatic life use rating (11-20). Riparian areas were well vegetated throughout the reach with an average riparian buffer measured at greater than 20 meters. The riparian zone was generally dominated by trees followed by shrubs then grasses. The average percentage of tree canopy cover ranged from 73% to 94%. The dominant stream substrate was sand, and the average percent of substrate gravel size or larger was less than 1%. Average percent instream cover varied from 9% to 76% and instream cover types include overhanging vegetation, leaf packs, snags, woody debris, root mats, and algae. Beech Creek ranged from 0.2-0.3 meters deep on average and 3-5 meters wide. Average stream bank slope ranged from 19-32 degrees. Stream flow at the site was 2.2 cfs in 1989, but it was not measured during the sampling events in 2003. Average stream bank erosion potential was 10%-58%. The deepest pool measured at Beech Creek was 1.2 meters. Number of riffles observed at the site varied from zero to two, and total number of stream bends ranged from zero to six.

Water Quality

Water samples were collected at stations 17903 and 10529. Station 10529 was sampled 35 times from September 1989 through October 2018; station 17903 was sampled from May 2003 through September 2004 over 12 events. Parameters measured at both stations included

temperature, flow, transparency, specific conductance, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total nitrogen (only station 10529), phosphorus, total organic carbon, chloride, sulfate and chlorophyll-a. Continuous 24-hour data was recorded at both stations 17903 and 10529.

Biological Characterization

Fish

Twenty-seven species (11 families) were collected over the course of the three samples. Centrarchidae yielded the greatest species richness with seven. Pirate Perch was the most numerous fish in 1989, while Western Mosquitofish and Ribbon Shiner took that position in June and August 2003, respectively. Five species were unique to the 1989 collection and included Blacktail Shiner, Slough Darter, Blackstripe Topminnow, Redfin Shiner *Lythrurus umbratilis*, and Tadpole Madtom. Ribbon Shiner and Pugnose Minnow were only collected in 2003. Based upon the fish assemblage, the 1989 and June 2003 samples rated as having a high aquatic life use while the August 2003 sample rated as exceptional.

Benthic Macroinvertebrates

A total of 1,483 individuals representing 18 orders of macroinvertebrates were collected during the five sample events at Beech Creek (Appendix E). Coleoptera, Diptera, and Oligochaeta were the three most abundant orders collected representing 28.5%, 25.8%, and 10.9%, respectively, of the individuals collected. Isopoda (7.6%), Trichoptera (6.6%), and Ephemeroptera (6%) were the only other orders which represented five or greater percent of the total individuals in the samples from Beech Creek.

The functional organization of the Beech Creek macroinvertebrate assemblage was dominated by collector-gatherers, scrapers, and predators which accounted for 48.5%, 17%, and 16.8%, respectively, of the total number of individuals collected. Filtering collectors (10.6%) and shredders (7.1%) were present, but each represented lower relative abundance.

The EPT varied from a minimum of zero for the August 2003 sample from Station 17903 to a maximum of 16 for the 1989 Surber sample, which equals the 95th percentile for all EPT values for least disturbed streams in ecoregion aggregate 33/35. The average value for the biotic index (5.6) is between the 75th and the 95th percentile for all biotic index values in the ecoregion aggregate indicating a relatively tolerant macroinvertebrate assemblage in Beech Creek.

Results for the Surber sample (45) BIBI fall in the range indicating an exceptional aquatic life use for the Beech Creek macroinvertebrate assemblage. The Ecoregions 33 and 35 BIBI scores for the June and August 2003 samples from Station 10529 as well as the June 2003 sample from Station 17903 fell in the range indicating an intermediate aquatic life use category. The Ecoregions 33 and 35 BIBI score for the August 2003 sample from Station 17903 fell in the limited aquatic life use category.

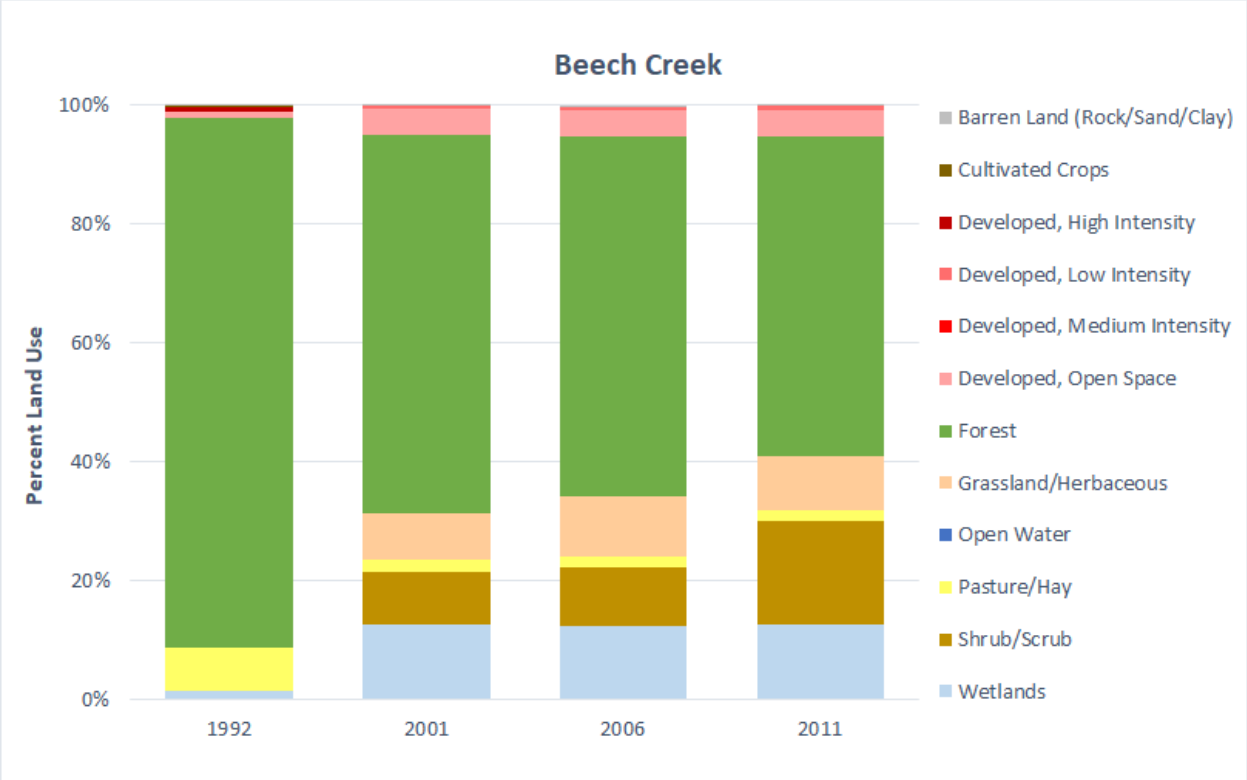

Figure 325. Percent land use in the Beech Creek watershed from 1992-2011.

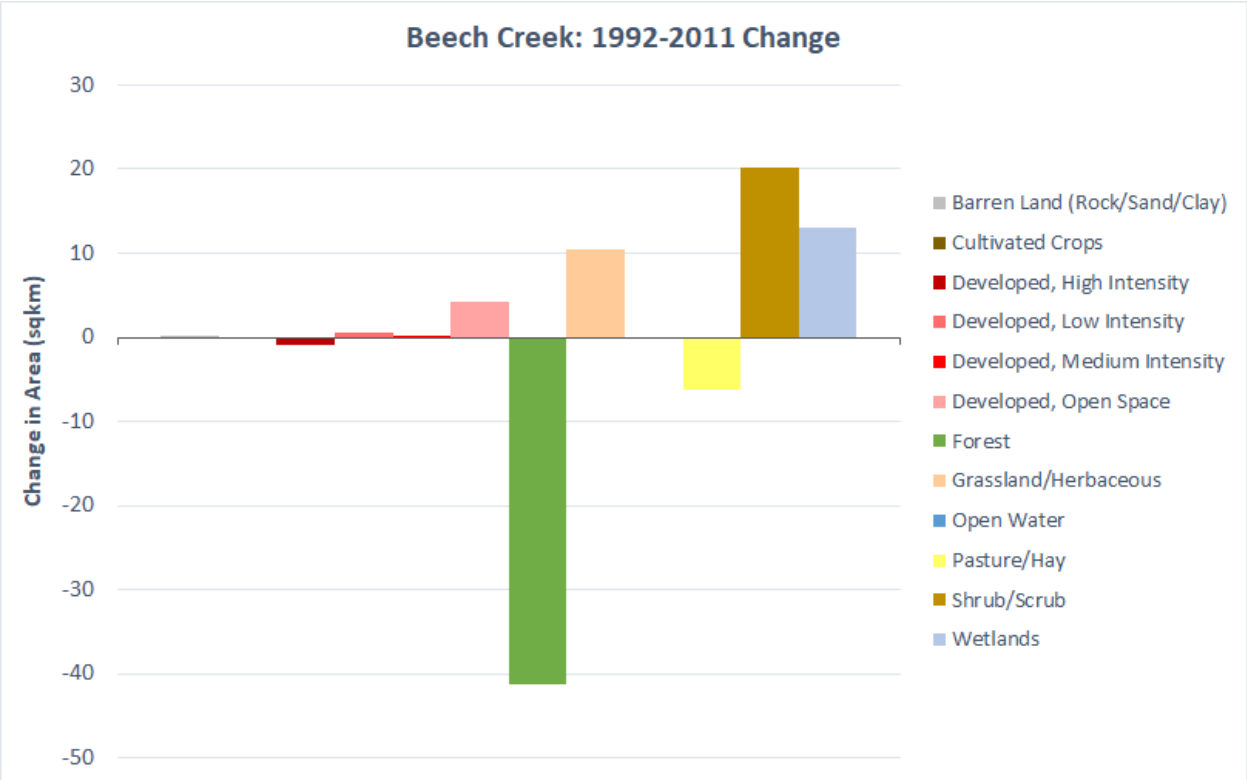

Figure 326. Land use change in area (sq km) from 1992-2011 for the Beech Creek watershed.

BIG CYPRESS CREEK

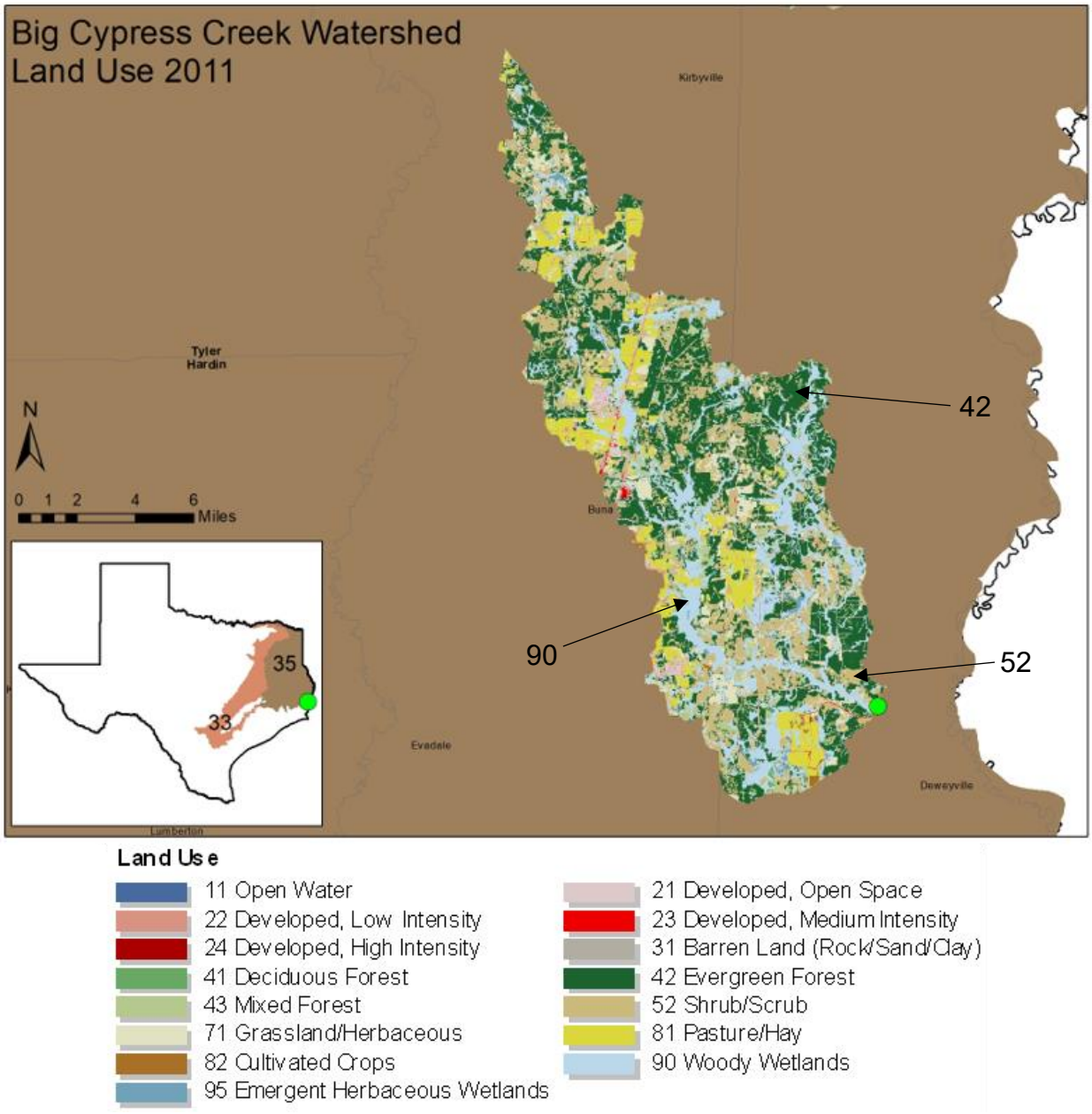

Figure 327. Map of Big Cypress Creek watershed location and 2011 land use; forest, shrub/scrub, and wetlands were the most common land uses.

Sampling Dates

Physical Habitat:	September 12, 1989; June 9, 2004; July 21, 2004
Water Quality:	19 sampling events
Fish:	September 12, 1989; June 9, 2004; July 21, 2004
Benthic Invertebrates:	September 12, 1989; June 9, 2004; July 21, 2004

Physical Characterization

Watershed and Land Use

Big Cypress Creek (also known as Cypress Creek) lies within the Sabine River Basin. Sample site 10342 is located downstream of SH 87 northwest of Deweyville in Newton County (Figure 327).

The Big Cypress Creek watershed at site 10342 is approximately 369.49 sq km. The entire watershed lies within Level IV Ecoregion 35f, the Flatwoods. The dominant land cover in the watershed is forest at 37.19% and is present throughout the watershed (Homer et al. 2015; Figure 327 and Figure 328). Secondary land covers include shrub at 20.7% and wetlands at 20.46%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 5.43% and total cover for cultivated crops is 0.21%.

From 1992-2011 there was a 102.93 sq km decrease in forest and a 25.86 sq km decrease in open space development. There was a 76.5 sq km increase in shrub and a 44.57 sq km increase in wetlands (Figure 329).

There are no permitted wastewater outfalls within the Big Cypress Creek watershed.

In Channel and Riparian Physical Habitat

Physical habitat for Big Cypress Creek was evaluated during three sampling events from 1989 to 2004. Big Cypress Creek is a perennial stream that drains to the Sabine River near Deweyville. Habitat Quality Index scores are available for two sample events and indicate an intermediate aquatic life use rating (17-19). Riparian areas were well vegetated throughout the reach with an average riparian buffer measured at greater than 20 meters for all sampling events. The riparian zone was generally dominated by trees followed by grasses then shrubs. The average percentage of tree canopy cover ranged from 93% to 99%. The dominant stream substrate was silt, and the average percent of substrate gravel size or larger was 0%. Average percent instream cover was 54% to 70% and instream cover types include roots, woody debris, and leaf packs. Big Cypress Creek ranged from 0.3-0.4 meters deep on average and 20-21 meters wide. Average stream bank slope ranged from 6-10 degrees. Stream flow at the site was 0.2 cfs in 1989 and 2.9 cfs in June 2004. Average stream bank erosion potential was 46%-63%. The deepest pool measured at Big Cypress Creek was 1.8 meters. The stream channel was noted as low gradient and braided in both 1989 and 2004. No riffles were observed at the site during any sampling event, and total number of stream bends ranged from two to three.

Water Quality

Water samples were collected at station 10342 over 19 sampling events from September 1989 through September 2004. Parameters measured included temperature, flow, transparency, specific conductance, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total nitrogen, phosphorus, total organic carbon, chloride, sulfate and chlorophyll-*a*. Continuous 24-hour data was also recorded at station 10342.

Biological Characterization

Fish

Thirty-six species (13 families) were collected over the course of the three sampling events. Centrarchidae was the richest family with 13 species. The most numerous fish in the 1989 and July 2004 samples was Western Mosquitofish while Pirate Perch was the most abundant species in June 2004. Three species were unique to the 1989 fish assemblage and included Blackstripe Topminnow, Cypress Minnow *Hybognathus hayi*, and Bantam Sunfish. Species that were new additions in 2004 were Bowfin, Flier, Blacktail Shiner, Grass Pickerel, Blackspotted Topminnow, Pallid Shiner, Redear Sunfish, Spotted Bass, Spotted Sucker, Bullhead Minnow, and White Crappie. The aquatic life use (based upon the fish assemblage) rated as exceptional for every collection.

Benthic Macroinvertebrates

A total of 914 individuals representing 15 orders of macroinvertebrates were collected during the three sample events at Big Cypress Creek (Appendix E). Diptera, Oligochaeta, and Ephemeroptera were the three most abundant orders collected representing 38.7%, 20.2%, and 15%, respectively, of the individuals collected. Isopoda (10.3%), Trichoptera (4%), Coleoptera (3.8%), Decapoda (2%), Nematoda (1.9%), and Pelecypoda (1.4%) were the only other orders which represented one percent or greater of the total individuals in the sample.

The functional organization of the Big Cypress Creek macroinvertebrate assemblage was dominated by collector-gatherers, filtering collectors, and predators which accounted for 52.5%, 19.7%, and 10.5%, respectively, of the total number of individuals collected. The scrapers (10.2%) and shredders (7.1%) were present, but each represented lower relative abundance.

The EPT varied from a minimum of one for the June 2004 sample to a maximum of five for the 1989 Surber sample, which falls between the 5th and the 25th percentiles for all EPT values for least disturbed streams in ecoregion aggregate 33/35. The relatively low EPT and the high average value for the biotic index (5.6), which falls between the 75th and 95th percentile for all biotic index values in the ecoregion aggregate, indicates a relatively tolerant macroinvertebrate assemblage in Big Cypress Creek.

Results for the Surber sample (39) BIBI falls in the range indicating a high aquatic life use for the Big Cypress Creek macroinvertebrate assemblage. The Ecoregions 33 and 35 BIBI score for the July 2004 sample fell in the intermediate aquatic life use category and the June 2004 sample fell in the limited aquatic life use category.

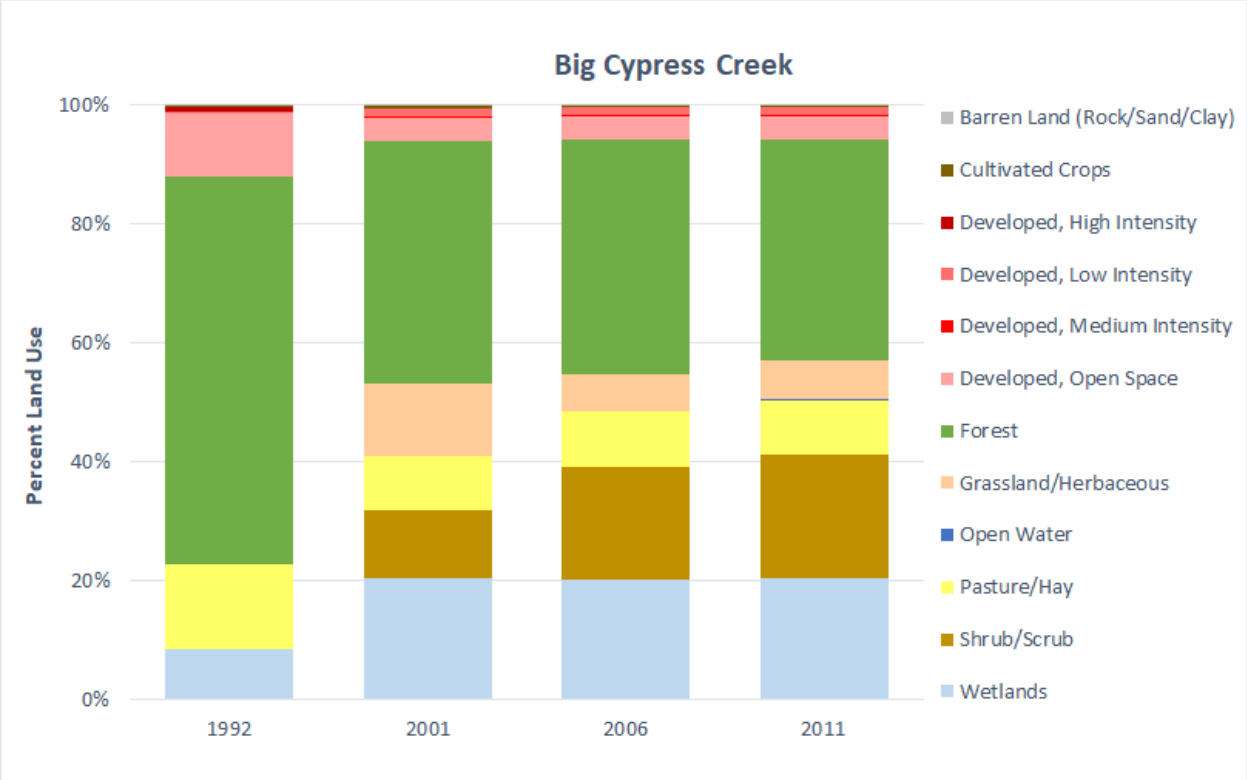

Figure 328. Percent land use in the Big Cypress Creek watershed from 1992-2011.

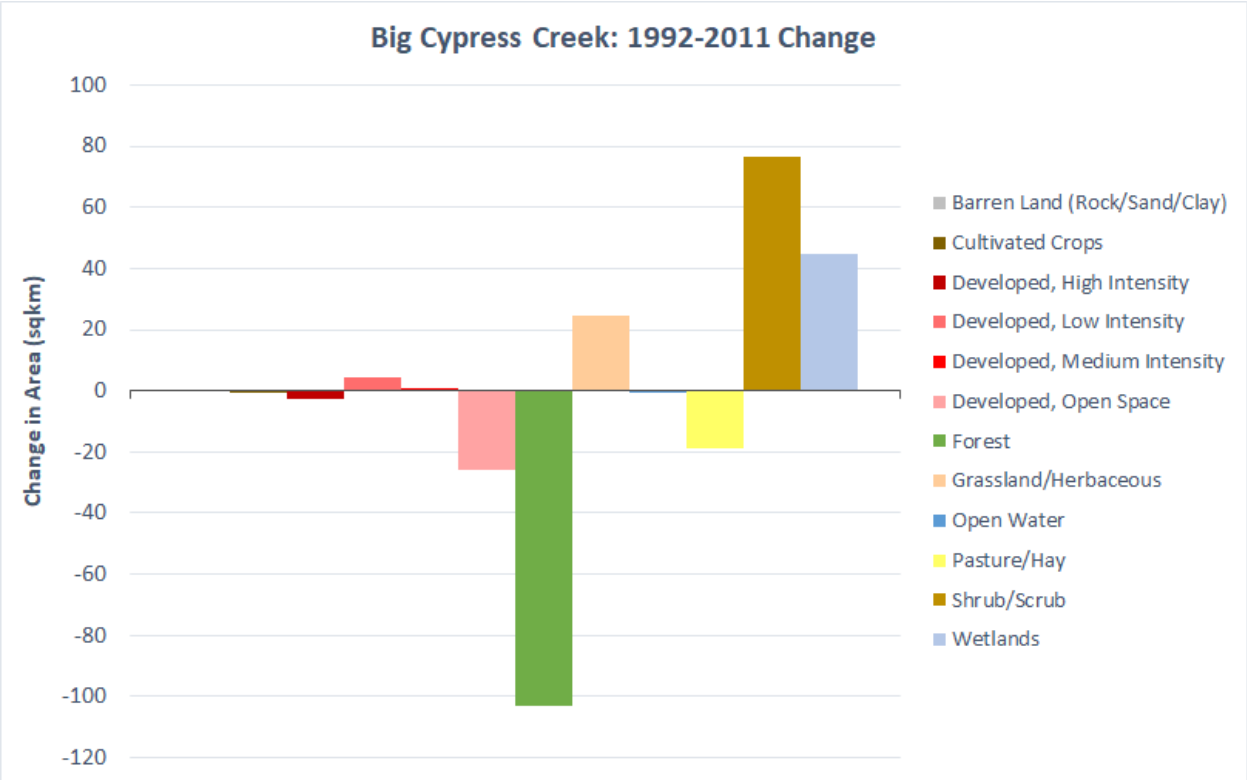

Figure 329. Land use change in area (sq km) from 1992-2011 for the Big Cypress Creek watershed.

BLACK BAYOU

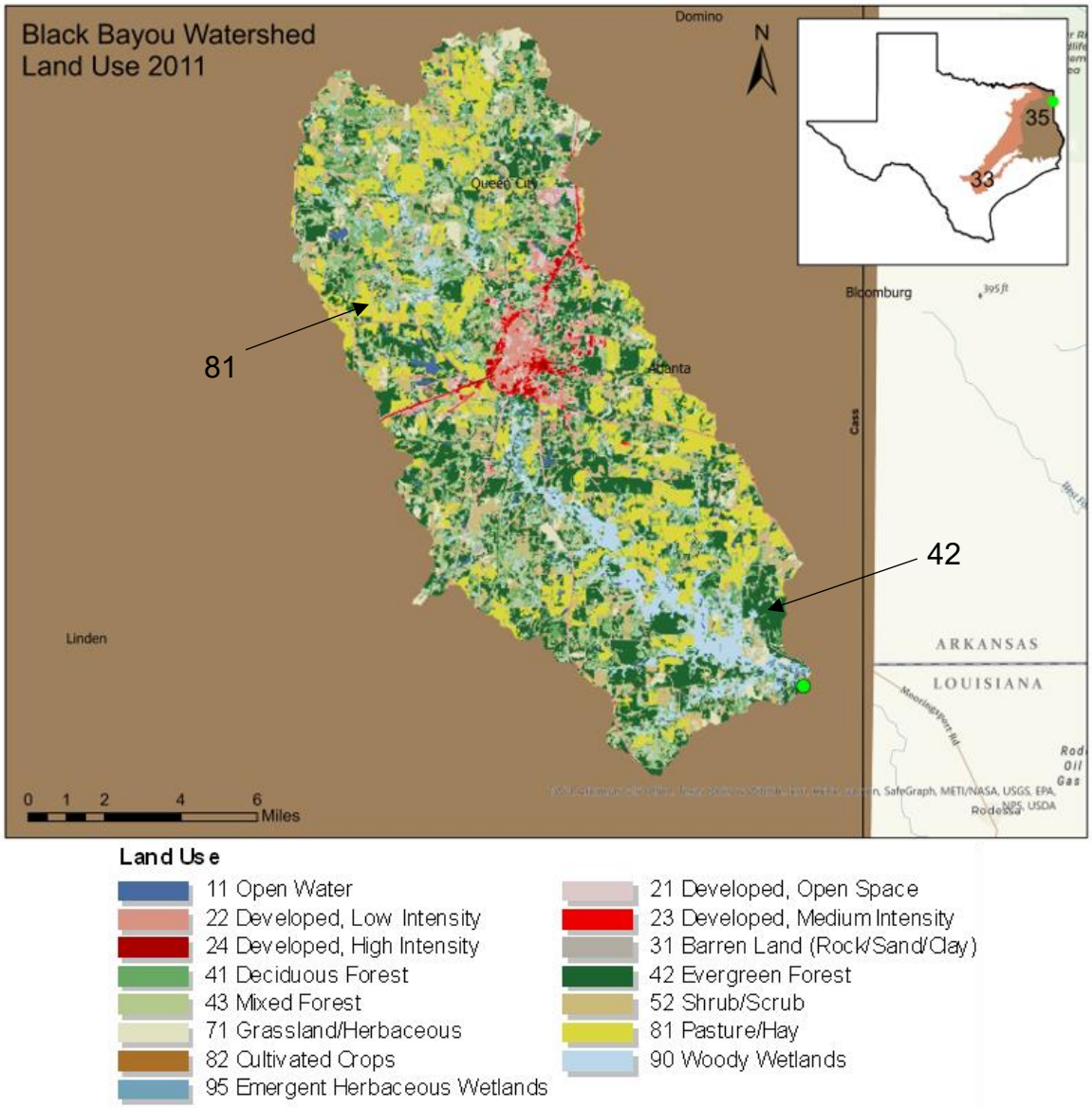

Figure 330. Map of Black Bayou watershed location and 2011 land use; forest and pasture/hay were the most common land uses.

Sampling Dates

Physical Habitat:	Station 10314: July 8, 2003; July 21, 2004; May 21, 2014; Station 16157: July 9, 2003; June 29, 2004
Water Quality:	343 sampling events (Stations 10314 and 16157)
Fish:	Station 10314: July 28, 1992; July 22, 1993; January 5, 1994; September 19, 1994; August 17, 1995; May 21, 2014
Benthic Invertebrates:	Station 10314: July 10, 1990; November 14, 1991; July 8, 2003; July 21, 2004; May 21, 2014; Station 16157: July 9, 2003; June 29, 2004

Physical Characterization

Watershed and Land Use

Black Bayou lies within the Cypress Creek Basin. Sample site 10314 is located at CR 4659, 6.44 km north of McLeod in Cass County (Figure 330).

The Black Bayou watershed at site 10314 is approximately 247.20 sq km. The entire watershed lies within Level IV Ecoregion 35a, the Tertiary Uplands. The dominant land cover in the watershed is forest at 46.58% and is present throughout the watershed (Homer et al. 2015; Figure 330 and Figure 331). Pasture/hay is the secondary land cover encompassing 17.40%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 10.17% and there is no cultivated crop cover present within the watershed.

From 1992-2011 there was a 44.59 sq km decrease in forest and a 17.47 sq km decrease in pasture/hay. There was a 30.38 sq km increase in shrub and a 10.56 sq km increase in open space development (Figure 332).

There is one industrial wastewater outfall (discharges ≥ 1 million gallons per day) within the Black Bayou watershed permitted to the City of Atlanta. This facility does not discharge directly into Black Bayou.

In Channel and Riparian Physical Habitat

Physical habitat for Black Bayou was evaluated at two sites during five sampling events from 2003 to 2014. Black Bayou is an intermittent stream with perennial pools that drains to Twelvemile Bayou north of Shreveport, LA. Habitat Quality Index scores are available for all five sample events and indicate an intermediate to high aquatic life use rating (15.5-23). Riparian areas were well vegetated throughout the reach with an average riparian buffer ranging from 19.7 meters wide to greater than 20 meters. The riparian zone was generally dominated by trees followed by grasses then shrubs. The average percentage of tree canopy cover ranged from 71% to 98%. The dominant stream substrate was silt followed by sand, and the average percent of substrate gravel size or larger was 0%. Average percent instream cover was 19% to 34% and instream cover types include extensive leaf packs, snags, cypress tree root mats, overhanging vegetation, and some algae and macrophytes. Black Bayou ranged from 0.3-0.5 meters deep on average and 10-25 meters wide. Average stream bank slope ranged from 7-16 degrees. Stream flow was measured at a minimum value of 0 cfs and a maximum of 29 cfs. Average stream bank erosion potential was 9%-12%. The deepest pool measured at Black Bayou was greater than 1.75 meters. No riffles were observed during any of the sampling events, and total number of stream bends ranged from one to six.

Water Quality

Water samples were collected at stations 10314 and 16157. Station 10314 was sampled 306 times from September 1968 through February 2020; station 16157 was sampled from November 1998 through July 2006 over 37 events. Parameters measured at both stations included

temperature, flow, transparency, specific conductance, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total nitrogen, phosphorus, total organic carbon, chloride, sulfate and chlorophyll-*a*. Continuous 24-hour data was recorded at both stations 10314 and 16157.

Biological Characterization

Fish

Thirty species (10 families) were collected over the course of the six sampling events. Centrarchidae was the richest family with 10 species. Twenty-one species were collected in the 1990s that were not part of the 2014 sample. These included Bowfin, Grass Pickerel, Brook Silverside *Labidesthes sicculus*, and two catfish, one darter, three topminnow, six sunfish, two sucker, and four minnow species. Bullhead Minnow was unique to the 2014 fish assemblage. The aquatic life use (based upon the fish assemblage) ranged from limited to high over the span of years evaluated. The most recent collection (2014) was the only one rating as intermediate. The consecutive collections of July 1993 and January 94 rated as limited but elevated to intermediate when the coefficient of variability was applied, while the other three received a high score.

Benthic Macroinvertebrates

Considered collectively, a total of 1,117 individuals representing 16 orders of macroinvertebrates were collected during the seven sample events at Black Bayou (Appendix E). Diptera was the most abundant order and accounted for 38.7% of the total numbers collected across all sites and dates. Amphipoda, Coleoptera, Odonata, Pelecypoda, Hemiptera, and Ephemeroptera were the next most abundant orders, accounting for 12%, 10.9%, 8.4%, 7.9%, 5.3%, and 4.9%, respectively, of the individuals collected. Other taxa, representing greater than 1% of the collections combined, include Isopoda, Hirudinea, Hydracarina, and Decapoda.

Considering both sites, and seven samples collectively, the functional organization of the Black Bayou macroinvertebrate assemblage was dominated by collector-gatherers, predators, and filtering collectors which accounted for 33.7%, 31.6%, and 17.9%, respectively, of the total number of individuals collected. The shredders (10.9%) and the scrapers (5.9%) were the least abundant functional groups. This functional organization was relatively constant across sample sites and dates except that the shredders were more abundant than filtering collectors on four dates, likely reflecting changes in the relative abundance of CPOM and suspended FPOM.

The EPT taxa were relatively depauperate with only four EPT taxa collected when all sites and dates are considered collectively. EPT values for individual samples ranged from zero to two. The average biotic index value for the collective Black Bayou benthic assemblage (6.4) falls between the 75th and the 95th percentile for all biotic index values in the ecoregion aggregate, indicating a relatively tolerant macroinvertebrate assemblage. The biotic index value for individual samples ranged from a low of 6 for the November 1991 sample to 6.8 for the June 2004 sample which exceeds the 95th percentile. This apparent high tolerance of the assemblage

likely reflects the harsh conditions as dictated by sluggish flow conditions which occasionally occur in Black Bayou combined with an inherently high organic load characteristic of the forested region.

Six of the seven Ecoregions 33 and 35 BIBIs for the Black Bayou RBP samples fell in the limited aquatic life use category, while the sample from July 2004 at Station 10314 fell in the intermediate aquatic life use category.

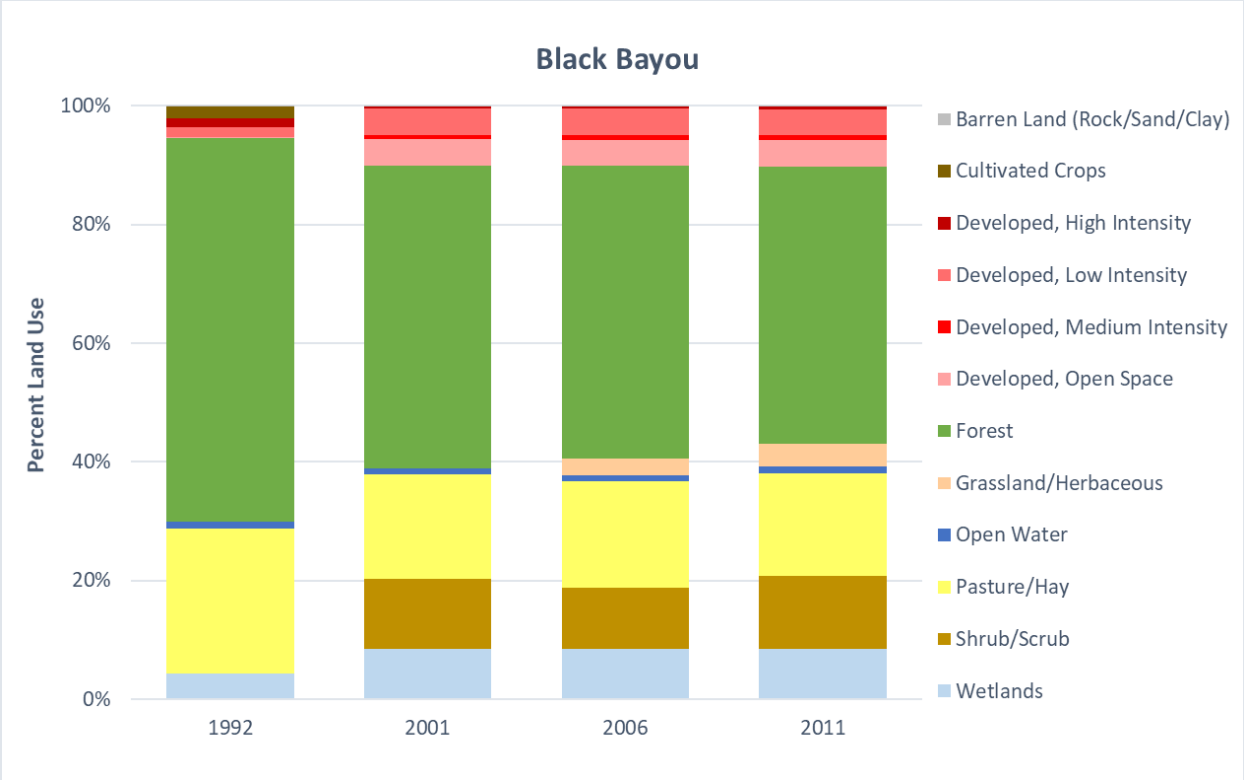

Figure 331. Percent land use in the Black Bayou watershed from 1992-2011.

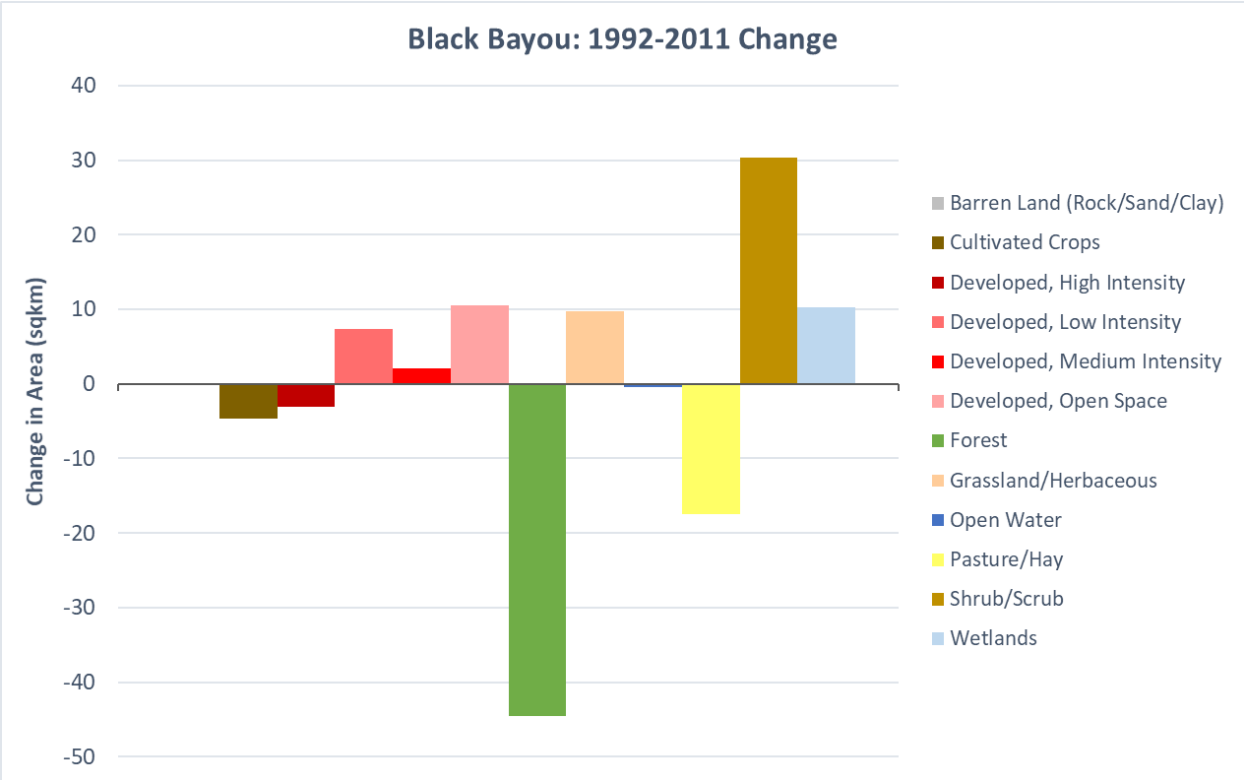

Figure 332. Land use change in area (sq km) from 1992-2011 for the Black Bayou watershed.

BLACK CYPRESS BAYOU

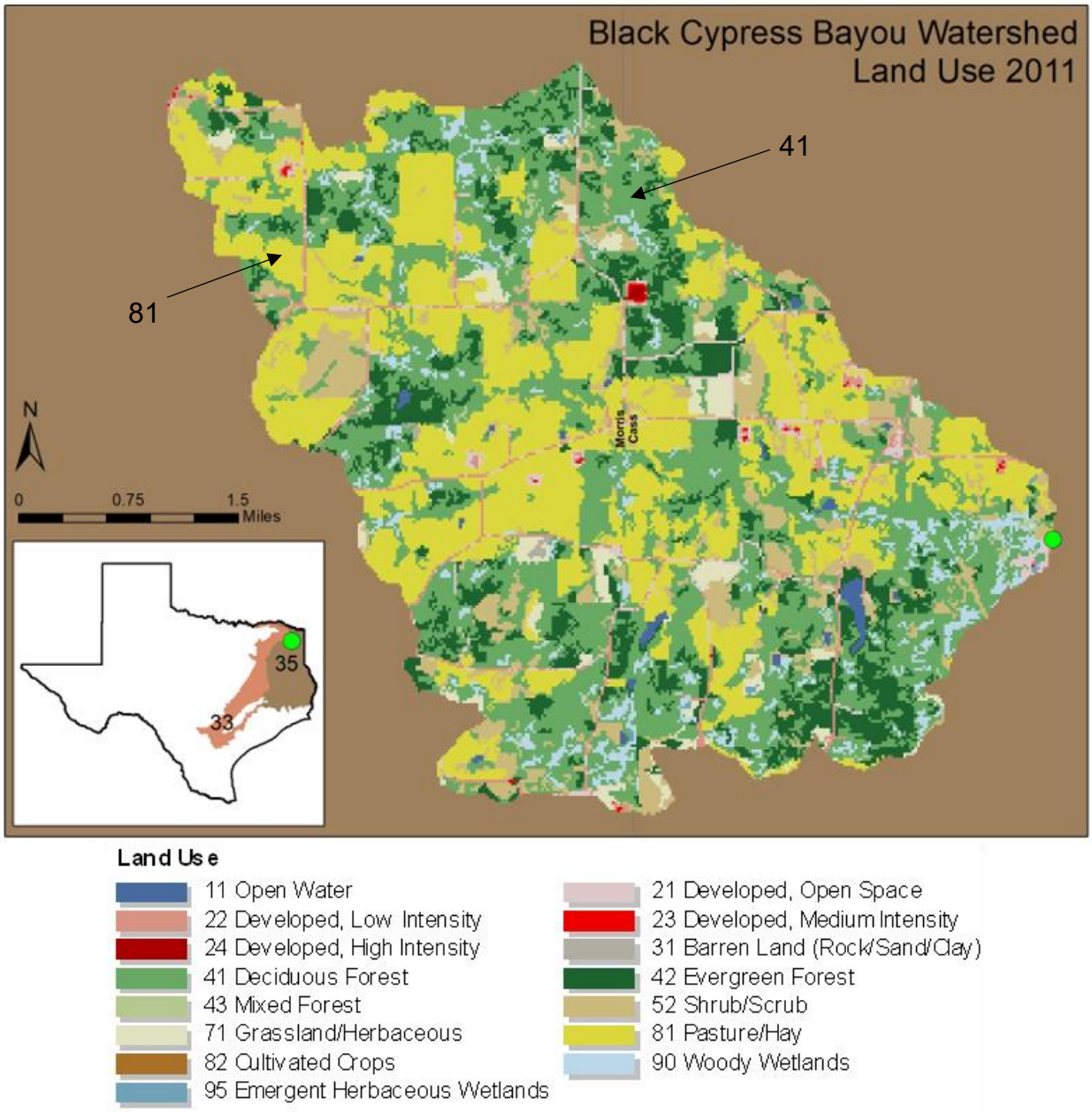

Figure 333. Map of Black Cypress Bayou watershed location and 2011 land use; forest and pasture/hay were the most common land uses.

Sampling Dates

Physical Habitat:	August 28, 1989
Water Quality:	63 sampling events
Fish:	August 30, 1989; July 27, 2000; August 21, 2000
Benthic Invertebrates:	August 30, 1989; July 27, 2000; August 21, 2000

Physical Characterization

Watershed and Land Use

Black Cypress Bayou lies within the Cypress Creek Basin. Sample site 10248 is located at FM 250, 6.44 km northeast of Hugh Springs in Cass County (Figure 333).

The Black Cypress Bayou watershed at site 10248 is approximately 46.96 sq km. The entire watershed lies within Level IV Ecoregion 35a, the Tertiary Uplands. The dominant land cover in the watershed is forest at 47.18% and is present throughout the watershed (Homer et al. 2015; Figure 333 and Figure 334). Pasture/hay is the secondary land cover encompassing 31.26%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 4.81% and there is no cultivated crop cover present within the watershed.

From 1992-2011 there was a 4.28 sq km decrease in pasture/hay and a 3.58 sq km decrease in forest. There was a 4.26 sq km increase in shrub and a 1.48 sq km increase in wetlands (Figure 335).

There are no permitted wastewater outfalls within the Black Cypress Bayou watershed.

In Channel and Riparian Physical Habitat

Physical habitat for Black Cypress Bayou was evaluated on August 28, 1989. Black Cypress Bayou is an intermittent stream with perennial pools that drains to Big Cypress Creek below Lake O' the Pines east of Jefferson. The riparian width was 61 meters. The riparian zone was dominated by trees, which made up an average of 70% of the total riparian species, followed by shrubs (15%) then grasses (10%). The average percentage of tree canopy cover was 81%. The dominant substrate was clay and decaying organic material with some areas of fine sand, and the average percent of substrate that was gravel size or larger was 2%. Average percent instream cover was 36% and instream cover types included woody debris, undercut banks and overhanging vegetation. Black Cypress Bayou had an average depth of 0.3 meters and a maximum depth of 0.8 meters. The average width was 5.8 meters and average stream bank slope was 56 degrees. Stream flow at the site was 0.9 cfs. Average stream bank erosion potential was 91%. Six riffles were observed at the site and there were ten total stream bends.

Water Quality

Water samples were collected at station 10248 over 63 sampling events from August 1987 through March 2015. Parameters measured included temperature, flow, transparency, specific conductance, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total nitrogen, phosphorus, total organic carbon, chloride, sulfate and chlorophyll-*a*. Continuous 24-hour data was also recorded at station 10248.

Biological Characterization

Fish

Thirty-one species (10 families) were collected over the course of the three sampling events. Cyprinidae and Centrarchidae yielded the greatest species richness with nine and eight, respectively. Western Mosquitofish was the most abundant species in the 1989 and July 2000 collections but was slightly outnumbered by Longear Sunfish in August 2000. Based upon the fish assemblage, all three collections rated as having a high aquatic life use. When the coefficient of variability is applied, the 1989 collection rises to exceptional.

Benthic Macroinvertebrates

Considered collectively, a total of 691 individuals representing 18 orders of macroinvertebrates were collected during the three sample events at Black Cypress Bayou (Appendix E). Diptera, Ephemeroptera, Coleoptera, Trichoptera, and Oligochaeta were the five most abundant taxa representing 25.5%, 20.5%, 19.4%, 12.9%, and 4.5%, respectively, of the individuals collected. Other taxa, representing greater than 1% of the three collections combined include Pelecypoda, Turbellaria, Gastropoda, Hemiptera, Odonata, Hydracarina, and Decapoda.

Considering all three samples collectively, the functional organization of the Black Cypress Bayou macroinvertebrate assemblage was dominated by collector-gatherers, scrapers, filtering collectors, and predators which accounted for 34.3%, 21.8%, 20.8%, and 19%, respectively, of the total number of individuals collected. The shredders (4.1%) were the least abundant functional group. This functional structure was relatively consistent across individual sites and dates.

A total of seven EPT taxa were collected when all sites and dates are considered collectively, and the EPT for individual samples varied from three to five. These values fall between the 5th and the 25th percentile, respectively, for all EPT values for least disturbed streams in ecoregion aggregate 33/35. The biotic index value for the collective Black Cypress Bayou benthic assemblage (6.2), which falls between the 75th and the 95th percentile for all biotic index values in the ecoregion aggregate, indicates a relatively tolerant macroinvertebrate assemblage. This apparent tolerance of the assemblage likely reflects the variably harsh conditions as dictated by sluggish flow conditions which occasionally occur in Black Cypress Bayou combined with an inherently high organic load characteristic of the forested region.

The East Bioregion Surber BIBI for the 1989 Surber sample fell in the exceptional aquatic life use category. Two of the three samples collected on Black Cypress Bayou were collected using RBP protocols. The Ecoregions 33 and 35 BIBIs for the two RBP samples both fell in the range indicating intermediate aquatic life use.

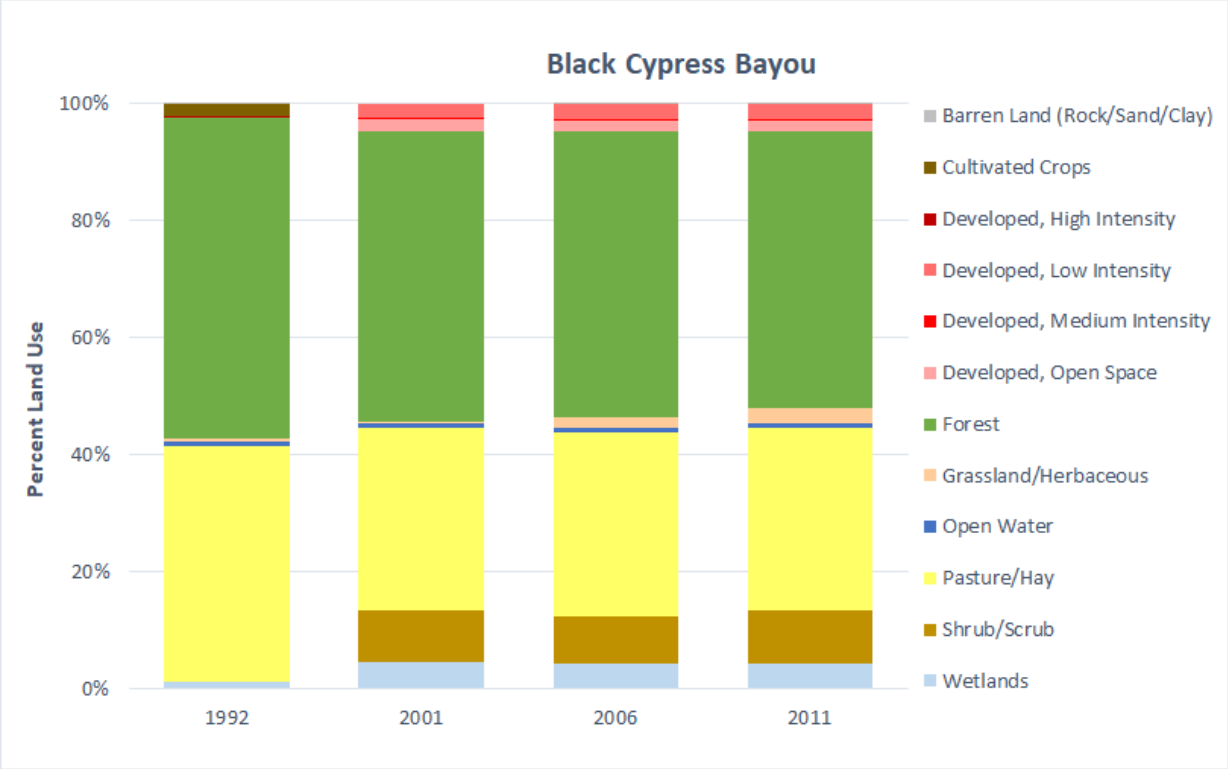

Figure 334. Percent land use in the Black Cypress Bayou watershed from 1992-2011.

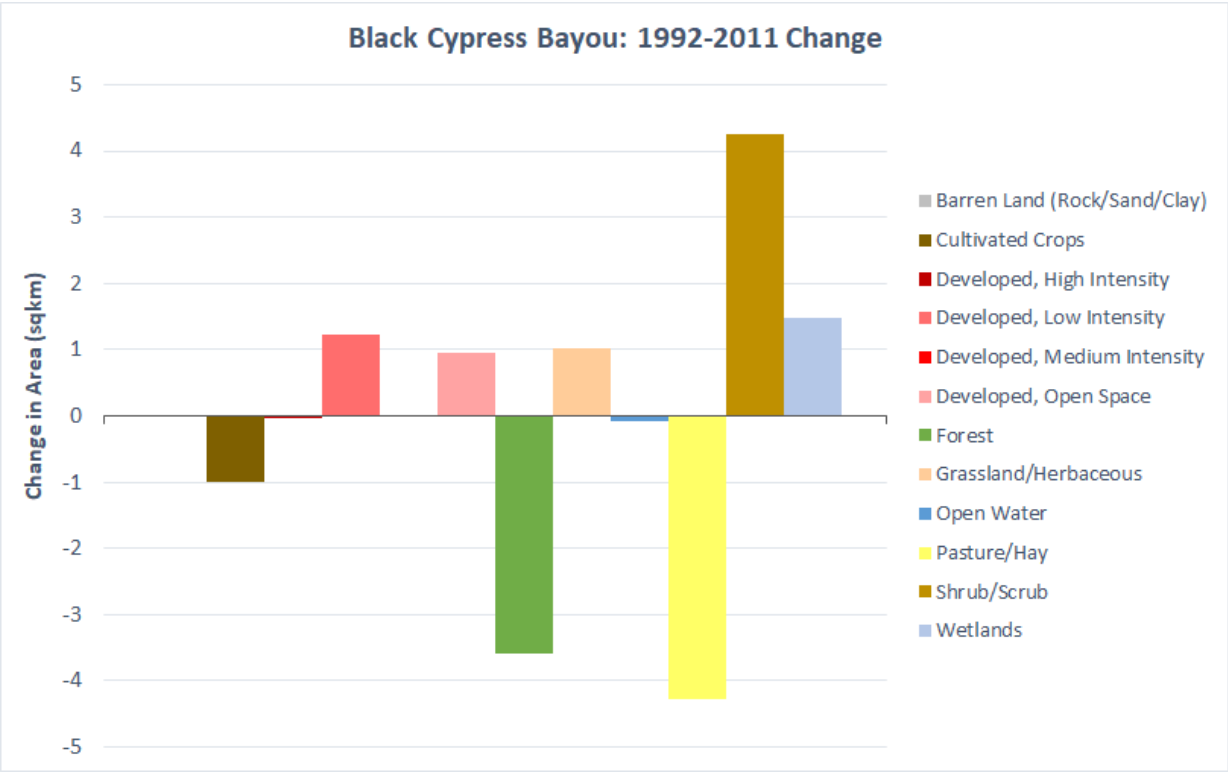

Figure 335. Land use change in area (sq km) from 1992-2011 for the Black Cypress Bayou watershed.

EAST FORK OF THE SAN JACINTO RIVER

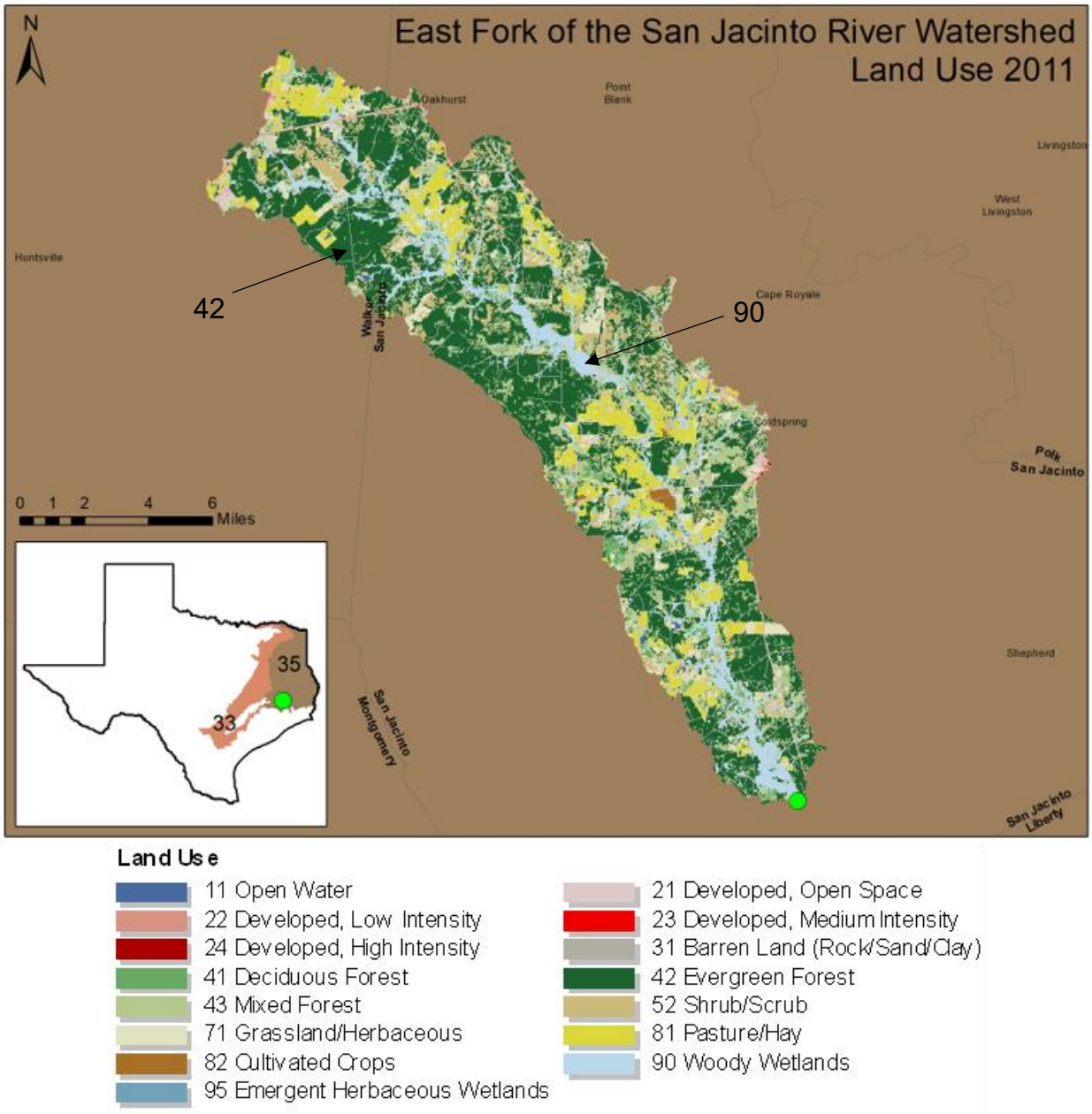

Figure 336. Map of East Fork of the San Jacinto River watershed location and 2011 land use; forest and wetland were the most common land uses.

Sampling Dates

Physical Habitat:	July 20, 1988; April 13, 2011; September 19, 2013
Water Quality:	36 sampling events
Fish:	July 20, 1988; April 14, 2011; July 13, 2011; September 19, 2013
Benthic Invertebrates:	July 20, 1988; April 13, 2011; July 12, 2011; June 19, 2013; September 19, 2013

Physical Characterization

Watershed and Land Use

The East Fork of the San Jacinto River lies within the San Jacinto River Basin. Sample site 11237 is located downstream of FM 945, 9.01 km north of Cleveland in San Jacinto County (Figure 336).

The East Fork of the San Jacinto River watershed at site 11237 is approximately 365.73 sq km. The sample location and extreme lower watershed lay within Level IV Ecoregion 35f, the Flatwoods, while the vast majority of the watershed lies within Level IV Ecoregion 35e, the Southern Tertiary Uplands. The dominant land cover in the watershed is forest at 57.59% and is present throughout the watershed (Homer et al. 2015; Figure 336 and Figure 337). Wetland is the secondary land cover encompassing 11.08%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 5.75% and total cover for cultivated crops is 0.3%.

From 1992-2011 there was a 65.44 sq km decrease in forest and a 22.4 sq km decrease in pasture/hay. There was a 34.46 sq km increase in wetlands, a 31.43 sq km increase in shrub, and a 24.3 sq km increase in grassland (Figure 338).

There are two domestic wastewater outfalls (discharges < 1 million gallons per day) within the East Fork of the San Jacinto River watershed. The facilities are permitted to the Sam Houston Area Council, Boy Scouts of America and Forest Glen Camps. Neither of these facilities discharge directly into the East Fork of the San Jacinto River.

In Channel and Riparian Physical Habitat

Physical habitat for the East Fork of the San Jacinto River was evaluated during three sampling events from 1988 to 2013. The East Fork of the San Jacinto River is a perennial stream that drains to Lake Houston. Habitat Quality Index scores are available for two sample events and indicate a high aquatic life use rating (22-23). Riparian areas were well vegetated throughout the reach with an average riparian buffer ranging from 16 meters wide to greater than 20 meters. The riparian zone was generally dominated by trees followed by shrubs then grasses. The average percentage of tree canopy cover ranged from 72% to 99%. The dominant stream substrate was sand, and the average percent of substrate gravel size or larger varied from 14% to 23%. Average percent instream cover was 13% to 30% and instream cover types include woody debris, undercut banks, and gravel. The East Fork of the San Jacinto River ranged from 0.3-0.5 meters deep on average and 7-8 meters wide. Average stream bank slope ranged from 21-41 degrees. Stream flow at the site was measured at a minimum value of 2 cfs and a maximum of 7.8 cfs. Average stream bank erosion potential was 3%-35%. The deepest pool measured at the East Fork of the San Jacinto River was 1.5 meters. Two riffles were observed at the site and total number of stream bends ranged from four to eight.

Water Quality

Water samples were collected at station 11237 over 36 sampling events from July 1988 through August 2019. Parameters measured included temperature, flow, transparency, specific conductance, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total nitrogen, phosphorus, total organic carbon, chloride, sulfate and chlorophyll-*a*. Continuous 24-hour data was also recorded at station 11237.

Biological Characterization

Fish

Thirty-one species (11 families) were collected over the course of the four sampling events. Centrarchidae and Cyprinidae were the two richest families, with eight and seven species respectively. Blacktail Shiner was the most abundant species in all but the April 2011 sample, where it was outnumbered by Redfin Shiner. Based upon the fish assemblage, all four collections from the East Fork of the San Jacinto River received a high aquatic life use rating. When the coefficient of variability is applied, the 1988 and 2013 collections rise to exceptional.

Benthic Macroinvertebrates

A total of 1,471 individuals representing 18 orders of macroinvertebrates were collected during the five sample events at East Fork San Jacinto River (Appendix E). The mayflies (Ephemeroptera) were the most abundant order, with taxa from 13 genera and eight families representing 31.7% of the individuals collected across all sample dates. Trichoptera and Coleoptera were the next most abundant orders, representing 21.9% and 18.4%, respectively, of the individuals collected. The most abundant families collected were Elmidae, Hydroptilidae, and Chironomidae, representing 15%, 10.3%, and 10.1%, respectively, of the total number of individuals collected.

The EPT ranged from a minimum of 12 to a maximum of 19 with a median value of 15, which falls between the 75th and 95th percentile of all EPT values for least disturbed streams sampled in the aggregated ecoregion. The biotic index ranged from a minimum of 3.9 to a maximum of 5.6. The median value of the biotic index, 4.7, falls between the 25th and 50th percentile of all biotic index values for least disturbed streams sampled in the aggregated ecoregion. The maximum EPT value (19) and the median and minimum values for the biotic index indicate that sensitive species are relatively common in East Fork San Jacinto River.

Considered collectively across all sample dates, the functional organization of the East Fork San Jacinto River macroinvertebrate assemblage was dominated by collector gatherers, scrapers, and filtering collectors, which accounted for 36%, 31%, and 18.7%, respectively, of the total number of individuals collected. The predators (10.9%) and shredders (3.4%) functional groups represented a smaller proportion of individuals. Percent dominant functional group (FFG) is a macroinvertebrate community structure metric where low to moderate values reflect a balanced community, and higher values indicate a stressed community. Values for % Dominant FFG for East Fork San Jacinto River ranged from 35.4% to 45.8%. The median value of 42.8 % falls between the 25^{th} and 50^{th} percentile of all values for least disturbed streams sampled in the

aggregated ecoregion. These metrics indicate that East Fork San Jacinto River has a well-balanced community structure.

The East Bioregion Surber BIBI for the 1988 Surber sample fell in the exceptional aquatic life use category. Results for the Ecoregions 33 and 35 BIBI for the four RBP samples collected at East Fork San Jacinto River reflect a moderate degree of variability, ranging from 27 (intermediate) to 36 (exceptional).

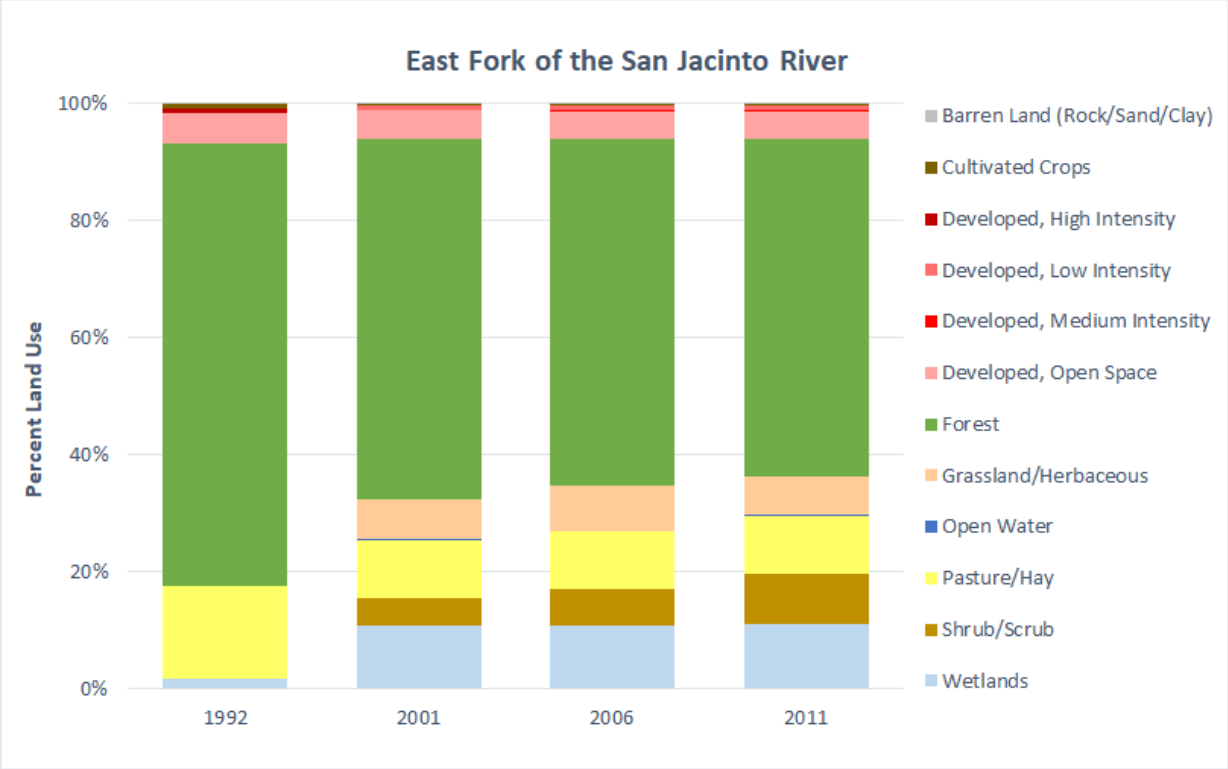

Figure 337. Percent land use in the East Fork of the San Jacinto River watershed from 1992-2011.

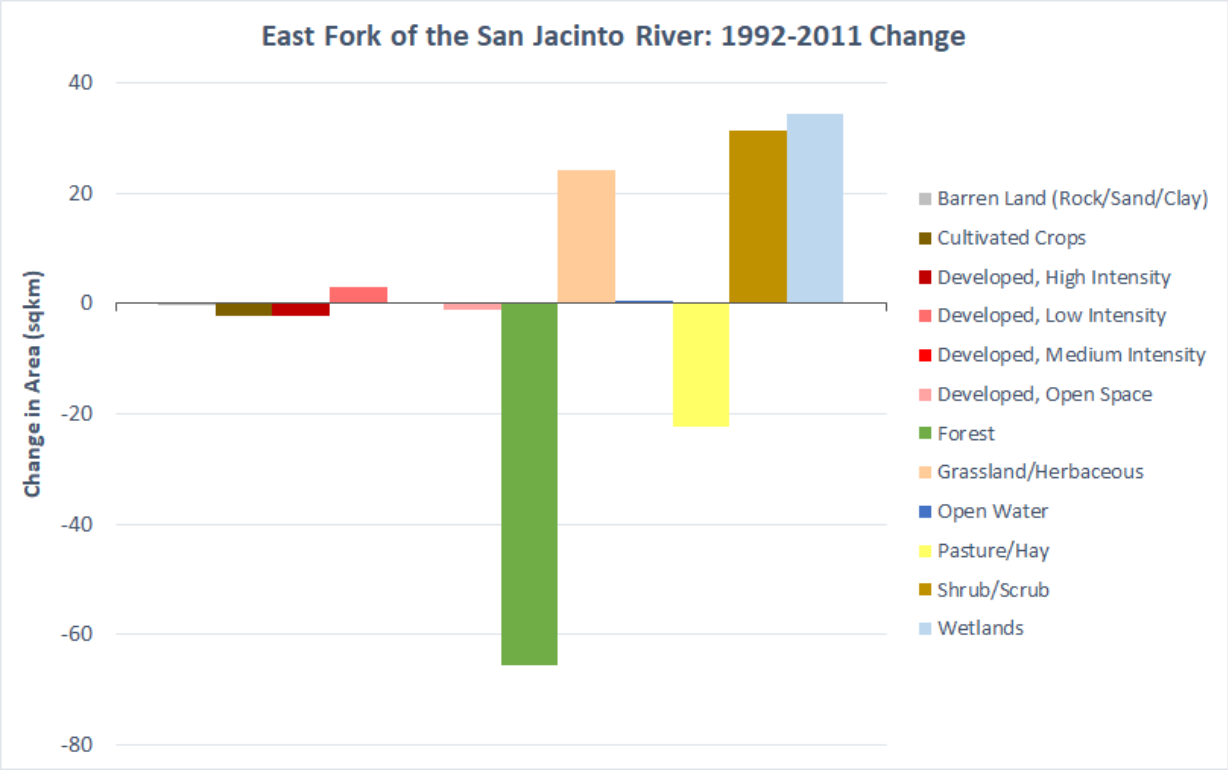

Figure 338. Land use change in area (sq km) from 1992-2011 for the East Fork of the San Jacinto River watershed.

FRAZIER CREEK

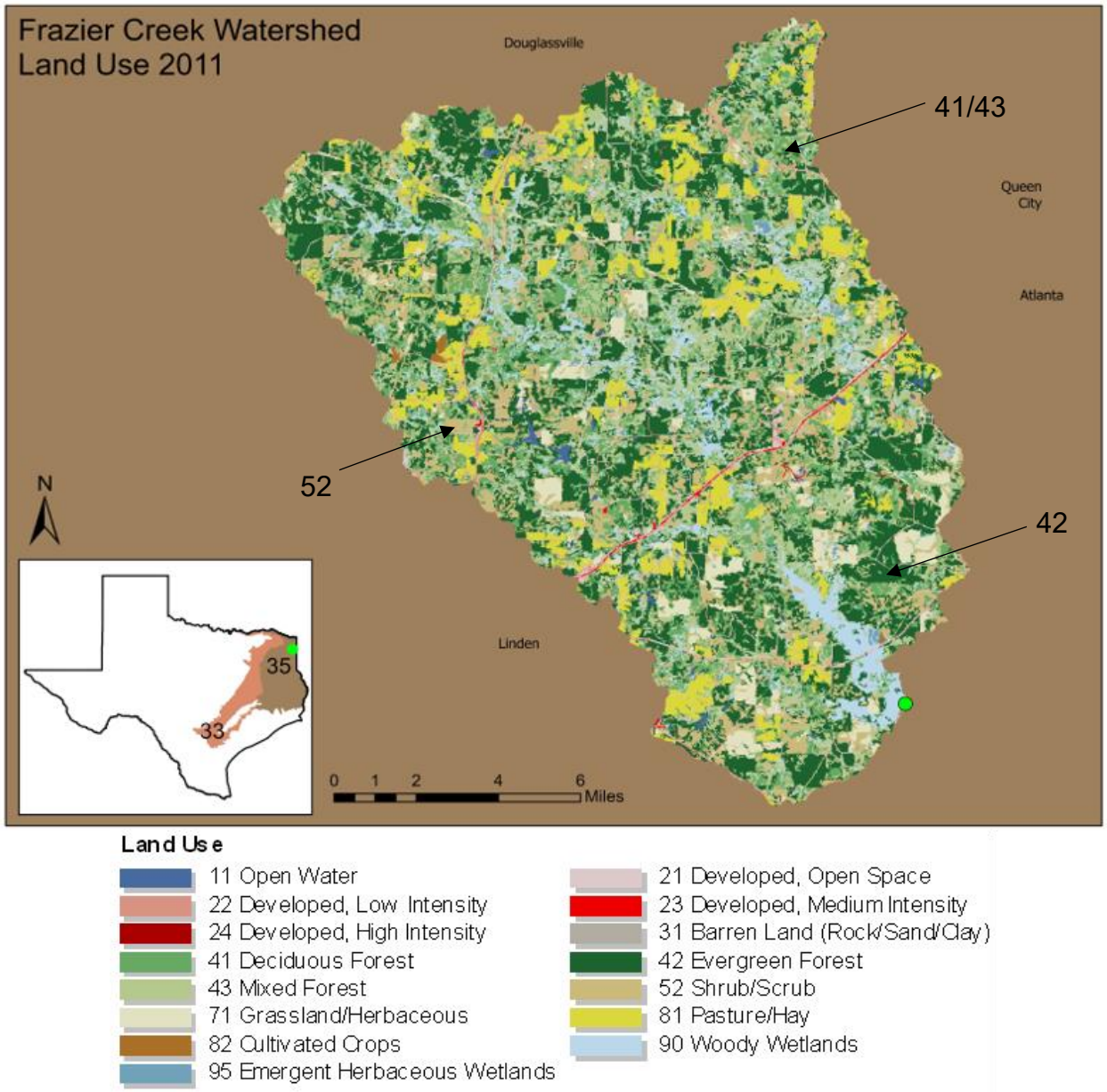

Figure 339. Map of Frazier Creek watershed location and 2011 land use; forest and shrub/scrub were the most common land uses.

Sampling Dates

Physical Habitat:	Station 10259: August 29, 1989; August 8, 2000; June 18, 2001; August 31, 2016; Station 17619: June 3, 2003; August 5, 2003
Water Quality:	85 sampling events (Stations 17619 and 10259)
Fish:	August 29, 1989; August 8, 2000; June 18, 2001; August 31, 2016
Benthic Invertebrates:	Station 10259: August 29, 1989; August 8, 2000; June 18, 2001, August 31, 2016; Station 17619: June 3, 2003; August 5, 2003

Physical Characterization

Watershed and Land Use

Frazier Creek lies within the Cypress Creek Basin. Sample site 17619 is located at FM 248, approximately 5 km north-northeast of Kildare in Cass County (Figure 339).

The Frazier Creek watershed at site 17619 is approximately 340.50 sq km. The entire watershed lies within the Level IV Ecoregion 35a, the Tertiary Uplands. The dominant land cover in the watershed is forest at 60.69% and is present throughout the watershed (Homer et al. 2015; Figure 339 and Figure 340). Shrub/scrub is the secondary land cover encompassing 12.71%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 4.65% and the total cover for cultivated crops 0.13%.

From 1992-2011 there was a 64.34 sq km decrease in forest and 12.06 sq km decrease in pasture/hay. There was a 43.27 sq km increase in shrub and a 16.05 sq km increase in grassland (Figure 341).

There is one domestic wastewater outfall (discharges < 1 million gallons per day) permitted to the Texas Department of Transportation which discharges into Frazier Creek.

In Channel and Riparian Physical Habitat

Physical habitat for Frazier Creek was evaluated at two sites during six sampling events from 1989 to 2016. Frazier Creek is an intermittent stream with perennial pools that drains to James Bayou north of Caddo Lake. Habitat Quality Index scores are available for four sample events and indicate an intermediate to high aquatic life use rating (15-20.5). Riparian areas were well vegetated throughout the reach with an average riparian buffer ranging from 15 meters wide to greater than 20 meters. The riparian zone was generally dominated by trees followed by grasses then shrubs. The average percentage of tree canopy cover ranged from 8% to 95%. The dominant substrate type varies from clay to sand, with sand identified as dominant in four of the six events. The average percent of substrate gravel size or larger varied from 0% to 1%. Average percent instream cover was 5% to 31% and instream cover types include overhanging vegetation, undercut banks, leaf packs, woody debris, and root mats. Frazier Creek ranged from 0.2-0.6 meters deep on average and 3-9 meters wide. Average stream bank slope ranged from 32-68 degrees. Stream flow at the sites was measured at a minimum value of 0 cfs and a maximum of 26 cfs. Average stream bank erosion potential was 37%-60%. The deepest pool measured at Frazier Creek was 1.6 meters. Number of riffles observed at the site varied from zero to six, and total number of stream bends ranged from one to seven.

Water Quality

Water samples were collected at stations 10259 and 17619. Station 10259 was sampled 77 times from November 1988 through October 2019; station 17619 was sampled from October 2002 through August 2003 over 8 events. Parameters measured at both stations included temperature, flow, transparency, specific conductance, dissolved oxygen, pH, alkalinity, ammonia, total

Kjeldahl nitrogen, total nitrogen, phosphorus, total organic carbon, chloride, sulfate and chlorophyll-a. Continuous 24-hour data was recorded at both stations.

Continuous flow data is available from USGS gage 07346140, located at station 10259 (Figure 342). Discharge was recorded from January 1985 through September 1991. In that time the median flow was 21 cfs, and flows ranged from 0 cfs to 3690 cfs. Flows increase sharply with rain events throughout the year; however only 0.5 percent of daily mean flows are greater than 1000 cfs. Data have been log transformed to better visualize flow patterns.

Biological Characterization

Fish

Thirty-five species (11 families) were collected over the course of the four sampling events. Centrarchidae yielded the most species (11) of any family. Frazier Creek received a high aquatic life use rating for three of the four fish collections evaluated during this study. The 2000 collection rated as exceptional. With the application of the coefficient of variability, the 1989 sample also achieves an exceptional rating. When comparing the oldest to the most recent collection, several metrics dropped in score between 1989 and 2016. The number of sunfish species declined from five to four (resulting in the metric score dropping from 5 to 3) and number of intolerant species went from three to one. Overall catch per unit effort also declined. Regarding sunfish, two species missing from the 2016 survey were Redear Sunfish and Redspotted Sunfish. Their absence from the 2016 collection is not particularly indicative of changes in the stream or watershed but is more likely due to their relatively low abundance. Only one individual of each of these sunfish species were collected in 1989. Warmouth (a species tolerant to organic enrichment and low dissolved oxygen concentrations) was added to the species list in 2016. The large reduction in number of intolerant species may reflect some disturbance or alteration. The greater than doubling of the percentage of tolerant individuals captured (even though the numbers did not result in a change to the metric score) may also support this supposition. None of the three intolerant species reported in 1989 were collected in 2016 even though 12 individuals were collected of the most abundant of the three species (Brook Silverside) in 1989. The 2016 collection was not without intolerant species but only included one individual Tadpole Madtom. This species was not collected in 1989. Decline in catch per unit effort could also be in response to changes in the watershed or stream.

Benthic Macroinvertebrates

Considered collectively, a total of 1,313 individuals representing 19 orders of macroinvertebrates were collected during the six sample events at Frazier Creek (Appendix E). Ephemeroptera was the most abundant order, representing 22.9% of the total number of individuals collected. The other orders that each accounted for greater than 10% of the total number of individuals collected were Coleoptera (17.1%), Trichoptera (16.1%), Diptera (13%), and Decapoda (10.4%). Other taxa, representing greater than 1% of the six collections combined include Hemiptera, Odonata, Hirudinea, Amphipoda, and Pelecypoda.

Considering both sites, and six samples collectively, the functional organization of the Frazier Creek macroinvertebrate assemblage was dominated by collector-gatherers, predators, filtering collectors, and scrapers which accounted for 34.4%, 27.1%, 22%, and 12.6%, respectively, of the total number of individuals collected. The shredders (3.9%) were the least abundant functional group. This functional structure was relatively consistent across individual sites and dates.

A total of 17 EPT taxa were collected when all sites and dates are considered collectively. The EPT for individual samples varied from three to seven. These values fall between the 5th and 50th percentile for all EPT values for least disturbed streams in ecoregion aggregate 33/35. The biotic index value for the collective Frazier Creek benthic assemblage (5.4), which falls between the 50th and the 75th percentile for all biotic index values in the ecoregion aggregate, indicates a moderately tolerant macroinvertebrate assemblage.

The sample BIBI score for the August 1989 Surber sample collected at US 59 (41) falls in the range indicating an exceptional aquatic life use. The Ecoregions 33 and 35 BIBI scores for the RBP samples indicated intermediate aquatic life use category for all five samples. These results indicate a slight decrease in biotic integrity over the 27-year period between August 1989 and August 2016.

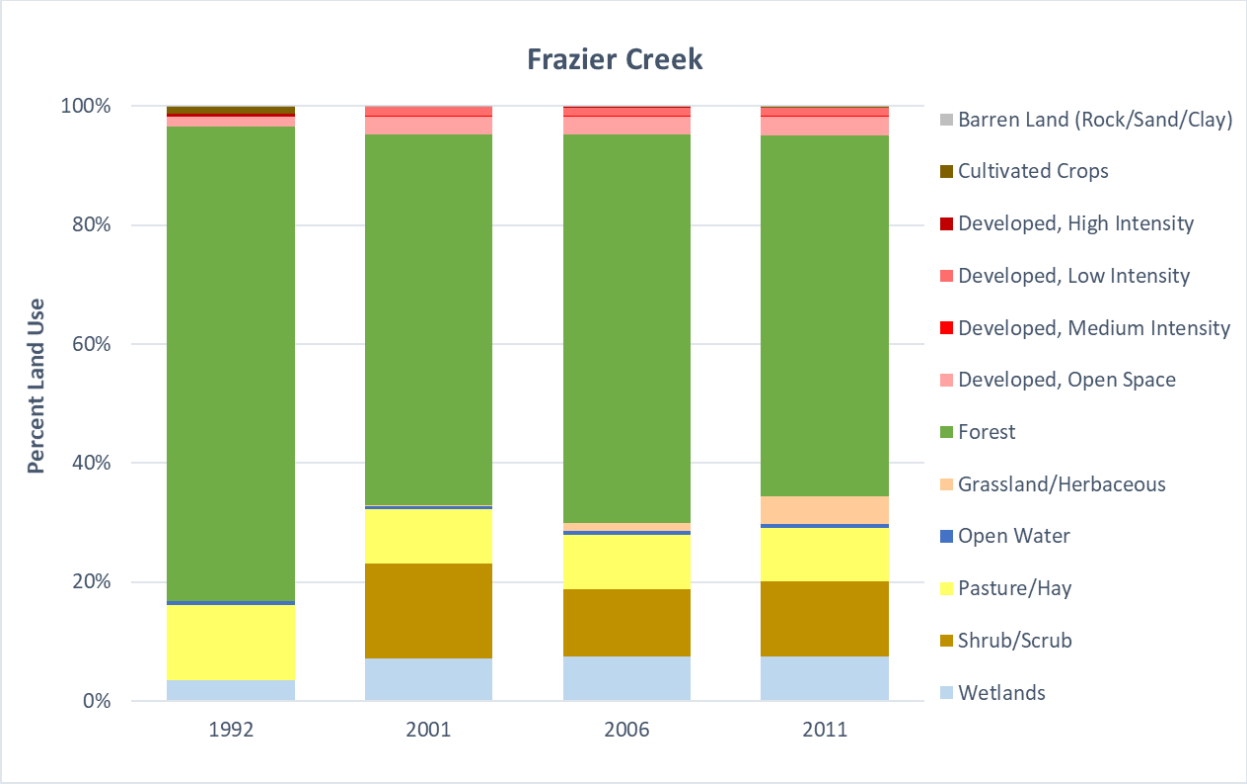

Figure 340. Percent land use in the Frazier Creek watershed from 1992-2011.

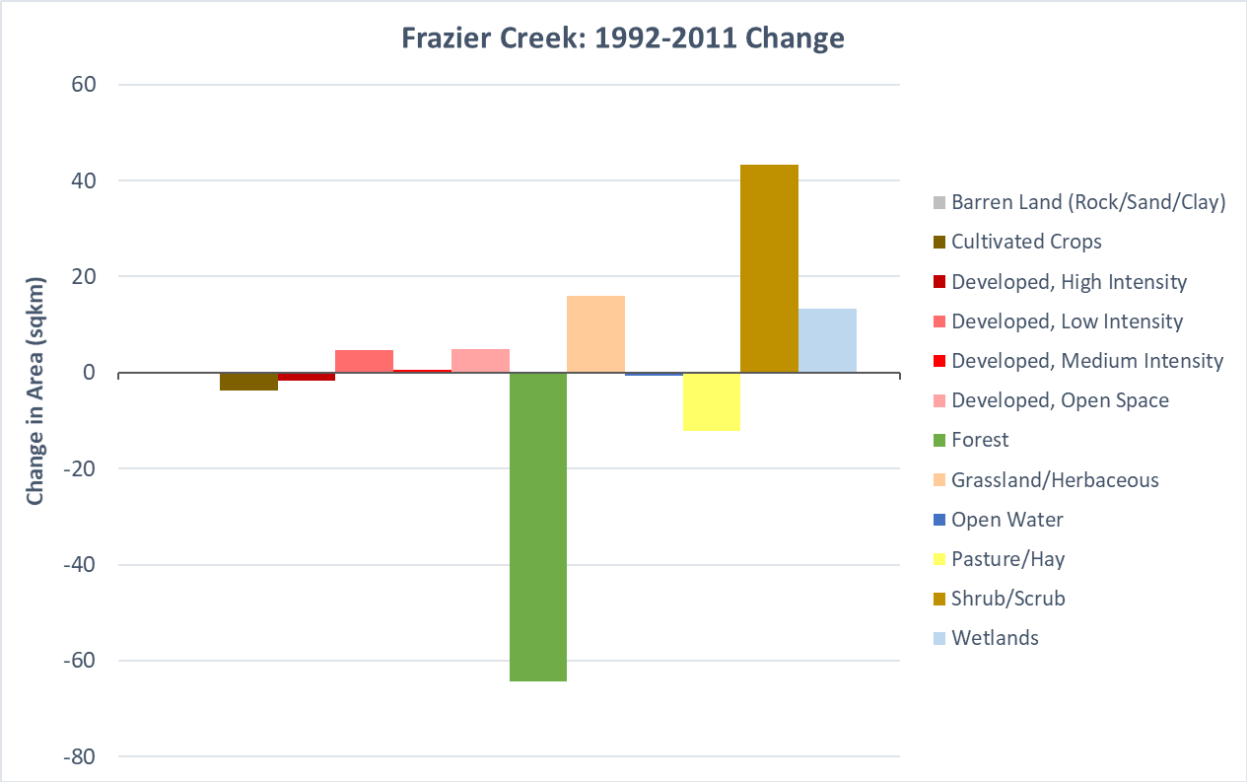

Figure 341. Land use change in area (sq km) from 1992-2011 for the Frazier Creek watershed.

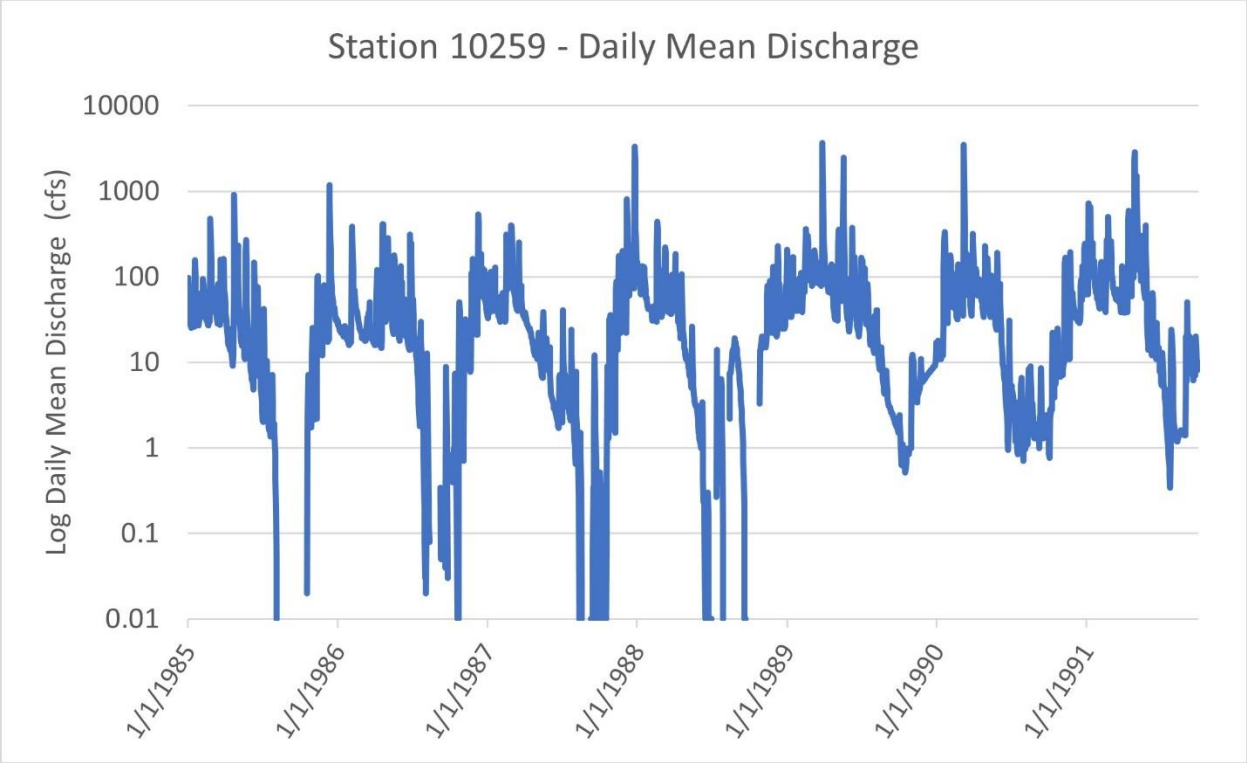

Figure 342. Log transformed daily mean discharge for Frazier Creek at station 10259.

IRONS BAYOU

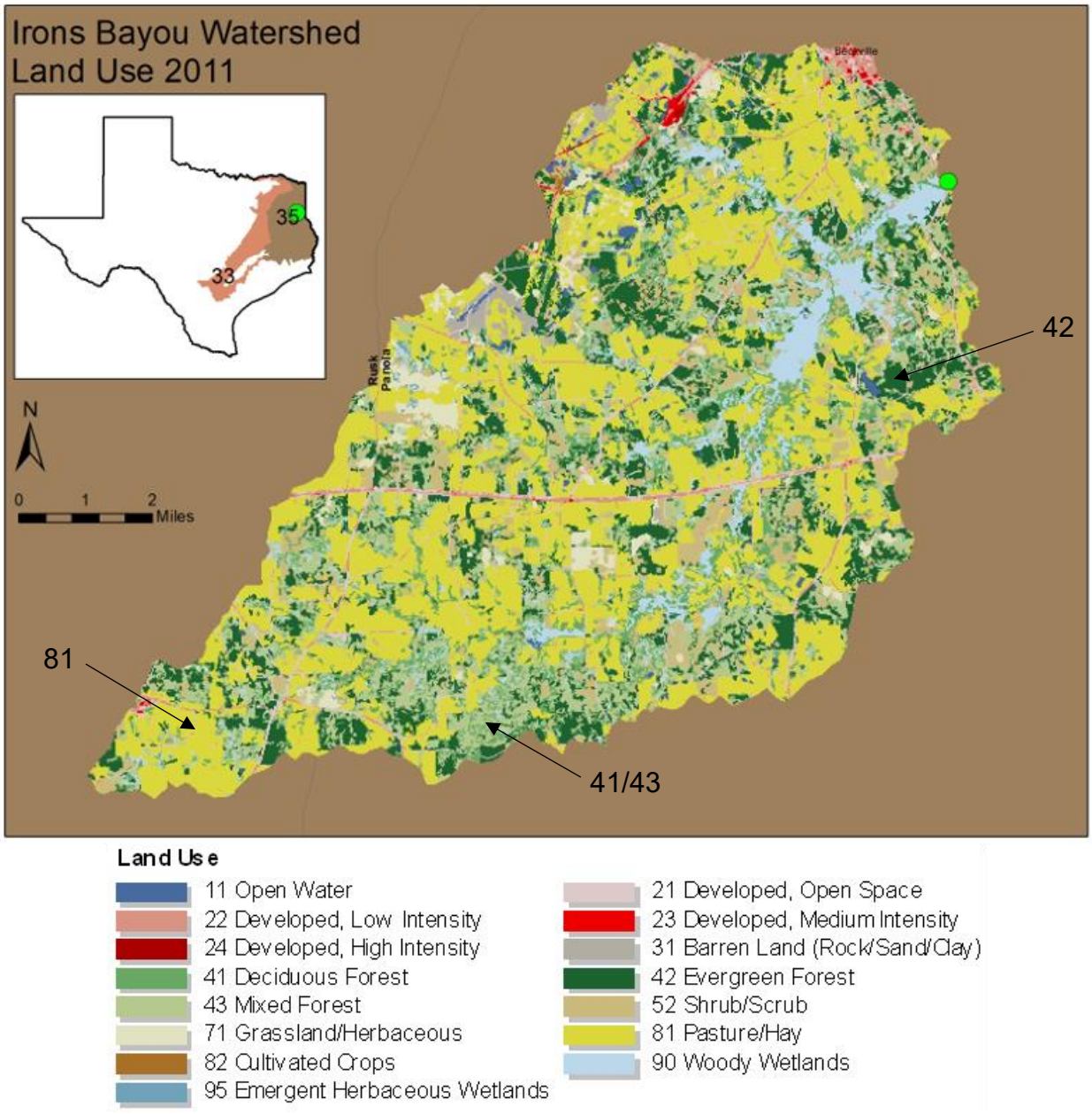

Figure 343. Map of Irons Bayou watershed location and 2011 land use; forest and pasture/hay were the most common land uses.

Sampling Dates

Physical Habitat:	August 31, 1989; August 10, 2004
Water Quality:	16 sampling events
Fish:	August 30, 1989; August 10, 2004
Benthic Invertebrates:	August 31, 1989; August 10, 2004

Physical Characterization

Watershed and Land Use

Irons Bayou lies within the Sabine River Basin. Sample site 10389 is located at SH 149 southeast of Beckville in Panola County (Figure 343).

The Irons Bayou watershed at site 10389 is approximately 220.22 sq km. The entire watershed lies within Level IV Ecoregion 35a, the Tertiary Uplands. The dominant land cover in the watershed is forest at 39.12% and is present throughout the watershed (Homer et al. 2015; Figure 343 and Figure 344). Pasture/hay is the secondary land cover encompassing 36.2%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 5.7% and total cover for cultivated crops is 0.06%.

From 1992-2011 there was a 19.16 sq km decrease in pasture/hay and a 9.25 sq km decrease in forest. There was a 19.9 sq km increase in shrub and a 6.38 sq km increase in open space development (Figure 345).

There are two domestic wastewater outfalls (discharges < 1 million gallons per day) within the Irons Bayou watershed. The facilities are permitted to the City of Beckville and Luminant Mining Co, LLC, a coal mining company. Neither of these facilities discharge directly into Irons Bayou.

In Channel and Riparian Physical Habitat

Physical habitat for Irons Bayou was evaluated on August 31, 1989 and again on August 10, 2004. The 2004 Habitat Quality Index score of 19 indicates an intermediate aquatic life use rating. Irons Bayou is an intermittent stream that drains to the Sabine River north of Carthage. Riparian areas were well vegetated throughout the reach with an average riparian buffer measured at greater than 20 meters for both sampling events. The riparian zone was dominated by trees followed by grasses then shrubs. The average percentage of tree canopy cover was 75%. The dominant substrate was clay and silt, and the average percent of substrate that was gravel size or larger was 0%. Average percent instream cover was 46% and instream cover types include snags, root mats, undercut banks, and woody debris. Irons Bayou ranges from 0.4-0.5 meters deep on average and 6-7 meters wide. Average stream bank slope was 43 degrees. Stream flow at the site was measured at a minimum value of 0.6 cfs and a maximum of 1.6 cfs. Average stream bank erosion potential was 74%. The deepest pool measured at Irons Bayou was 1 meter deep. A maximum of two riffles were observed at the site and there were six to seven total stream bends.

Water Quality

Water samples were collected at station 10389 over 16 sampling events from August 1989 through September 2011. Parameters measured included temperature, flow, transparency, specific conductance, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total

nitrogen, phosphorus, total organic carbon, chloride, sulfate and chlorophyll-*a*. Continuous 24-hour data was also recorded at station 10389.

Biological Characterization

Fish

Twenty-six species (10 families) were collected between the two sampling events. A notable difference between the two collections was the rather large decline in native cyprinid species richness in 2004. Six native cyprinid species were collected in 1998, but only two in 2004. In addition to the four cyprinid species (Red Shiner, Blacktail Shiner, Weed Shiner, and Bullhead Minnow), Bluntnose Darter *Etheostoma chlorosomum*, Orangebelly Darter *E. radiosum*, and Tadpole Madtom were also absent from the 2004 sample. Species unique to the 2014 fish assemblage included Western Mosquitofish, Brook Silverside, Spotted Gar *Lepisosteus oculatus*, Spotted Bass, and Spotted Sucker. Ribbon Shiner was the most abundant fish species in both collections. Despite the fish assemblage changes, Irons Bayou received an exceptional aquatic life use rating in 1989 and a high rating in 2004; however, when the coefficient of variability was applied to the 2004 sample it also rated as exceptional.

Benthic Macroinvertebrates

A total of 2,091 individuals representing 17 orders of macroinvertebrates were collected in the two samples from Irons Bayou (Appendix E). Diptera and Trichoptera were the most abundant orders, representing 28.5% and 25.2% respectively of the total number of individuals collected. Amphipoda (13.9%) and Coleoptera (13.6%) were the only other orders which accounted for greater than 10% of the total number of individuals collected. Other taxa representing greater than 1% of the two collections combined, include Megaloptera (6.1%), Ephemeroptera (5.4%), Oligochaeta (3%), and Pelecypoda (2.6%).

The functional organization of the Irons Bayou macroinvertebrate assemblage was dominated by filtering collectors, collector gatherers, and predators which accounted for 31%, 29%, and 19%, respectively, of the total number of individuals collected. The shredders (11%) and scrapers (10%) were well represented at lower relative abundance.

A total of 12 EPT taxa were collected in the two Irons Bayou samples. This value falls between the 50th and 75th percentile for all EPT values for least disturbed streams in ecoregion aggregate 33/35. The biotic index value for the benthic assemblage (5.6) equals the 75th percentile for all biotic index values in the ecoregion indicating a moderately tolerant macroinvertebrate assemblage in Irons Bayou.

The East Bioregion Surber BIBI score for the 1989 Surber sample falls in the range indicating an exceptional aquatic life use. The exceptional BIBI score is a result of maximum scores for the metrics total number of taxa, number of Diptera taxa, number of intolerant taxa, percent EPT, percent tolerant, and percent gatherers, and a low relative dominance of the three most abundant

taxa in the Surber sample. The Ecoregions 33 and 35 BIBI score for the August 2004 RBP sample fell in the range indicating an intermediate aquatic life use.

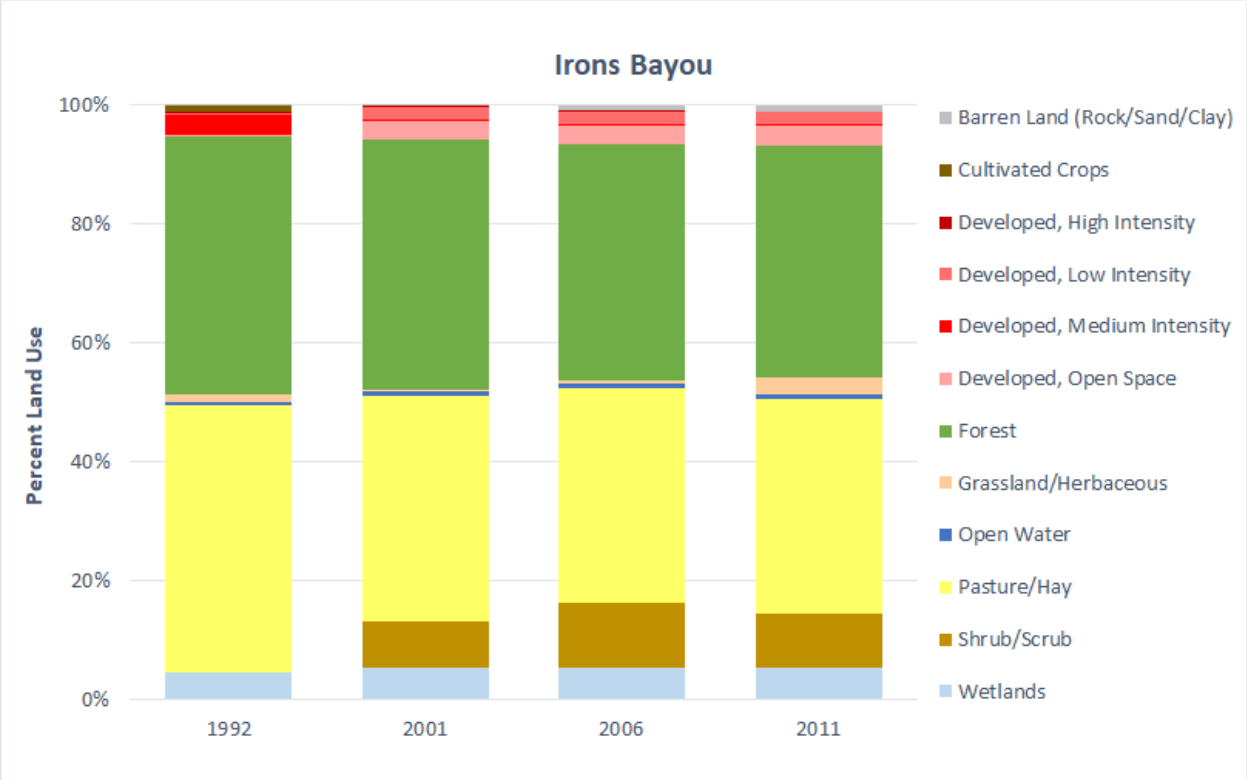

Figure 344. Percent land use in the Irons Bayou watershed from 1992-2011.

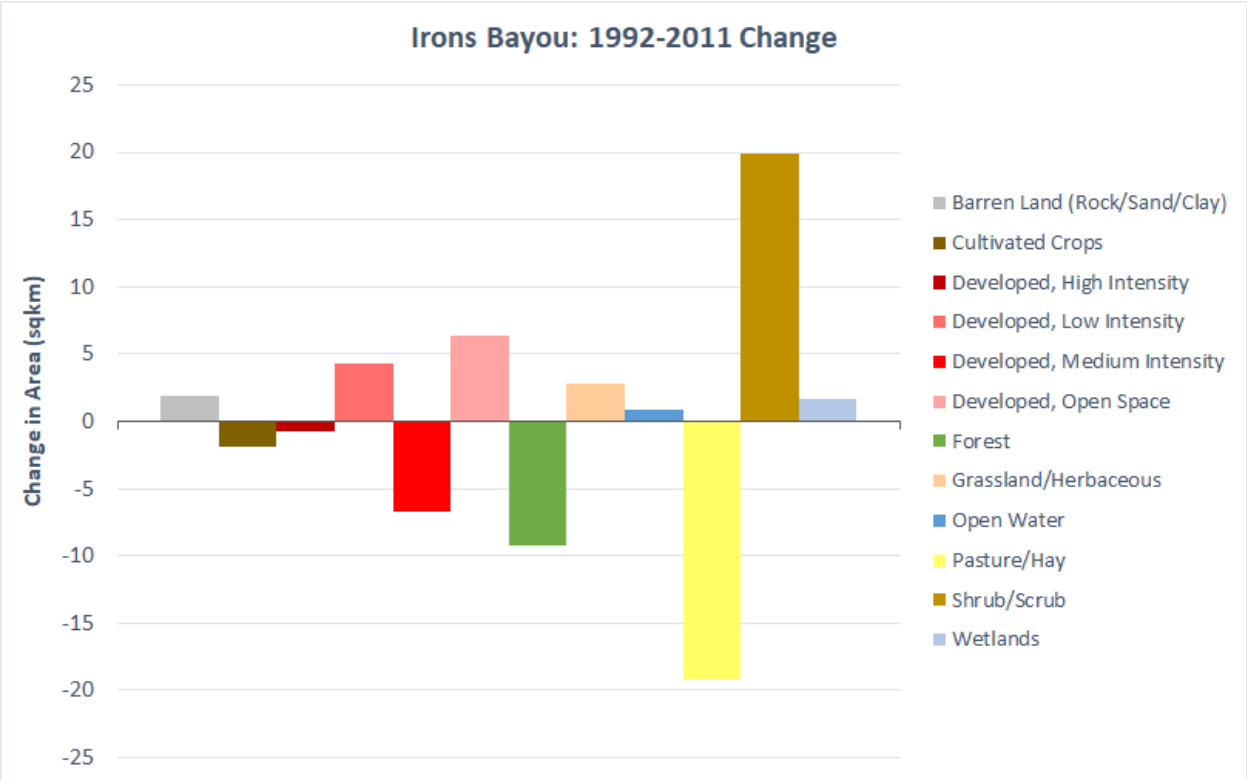

Figure 345. Land use change in area (sq km) from 1992-2011 for the Irons Bayou watershed.

JAMES (JIMS) BAYOU

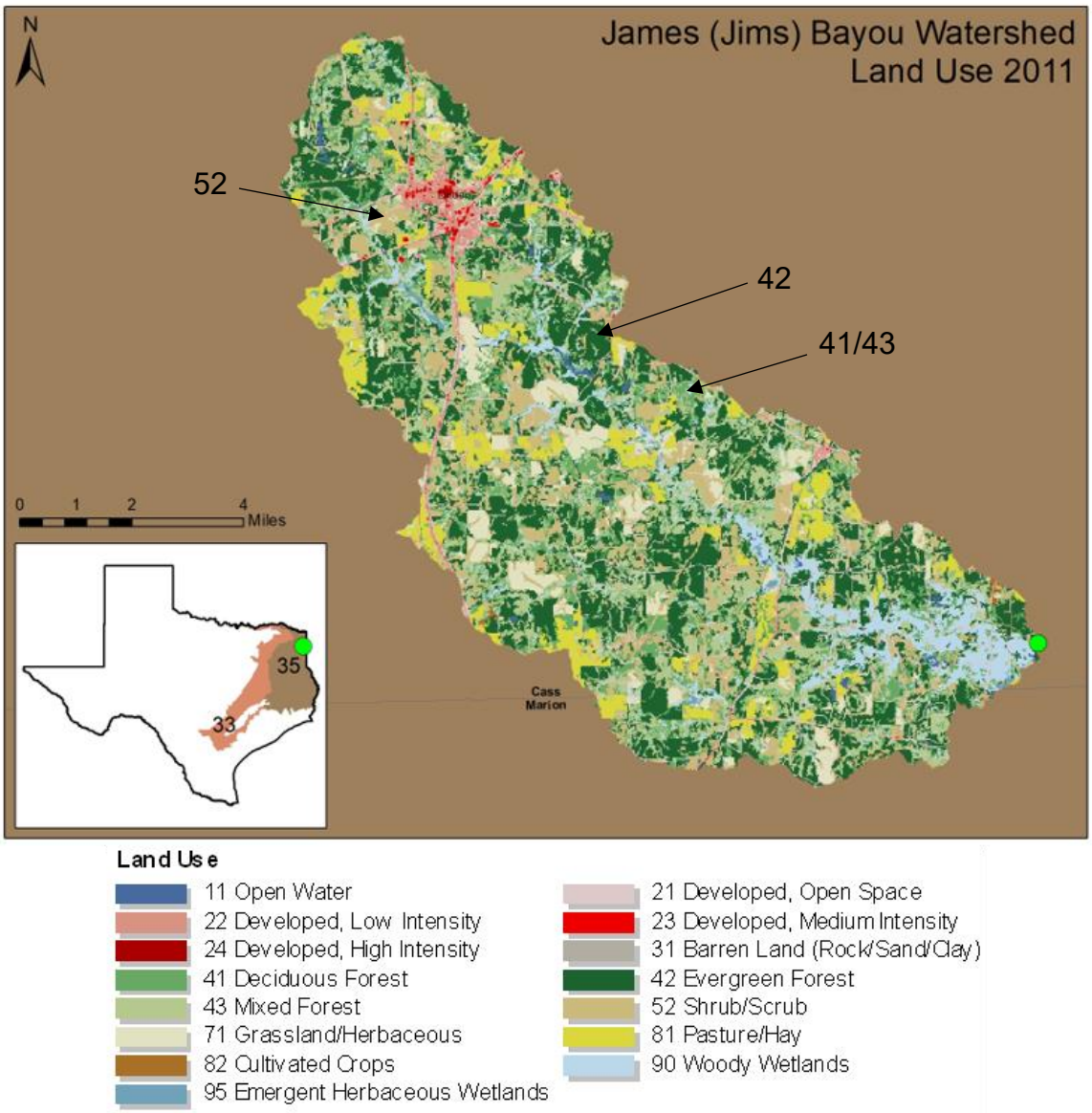

Figure 346. Map of James Bayou watershed location and 2011 land use; forest and shrub/scrub were the most common land uses.

Sampling Dates

Physical Habitat:	Station 10321: August 8, 2000; June 19, 2001; June 12, 2002, August 13, 2002; June 3, 2003; August 5, 2003; July 16, 2004; August 17, 2004; June 14, 2005; June 21, 2006; August 8, 2006; Station 14976: June 21, 2006; August 8, 2006; June 16, 2016; August 2, 2016
Water Quality:	216 sampling events (Stations 10321 and 14976)
Fish:	CR 1775 (Station 10321) - August 19, 1997; August 8, 2000; June 19, 2001; June 12, 2002, August 13, 2002; June 3, 2003; August 5, 2003;

	July 16, 2004; August 17, 2004; June 14, 2005; June 21, 2006; August 8, 2006; CR 1779 - August 24, 1999; SH 43 (Station 14976) - June 21, 2006; August 8, 2006; June 16, 2016; August 2, 2016
Benthic Invertebrates:	Station 10321: August 8, 2000; June 19, 2001; June 12, 2002, August 13, 2002; June 3, 2003; August 5, 2003; July 16, 2004; August 17, 2004; June 14, 2005; June 21, 2006; August 8, 2006; Station 14976: June 21, 2006; August 8, 2006; June 16, 2016; August 2, 2016

Physical Characterization

Watershed and Land Use

James (Jims) Bayou lies within the Cypress Creek Basin. Sample site 14976 is located at SH 43, 19.31 km northeast of Jefferson in Cass County (Figure 346).

The James Bayou watershed at site 14976 is approximately 210.83 sq km. The entire watershed lies within Level IV Ecoregion 35a, the Tertiary Uplands. The dominant land cover in the watershed is forest at 57% and is present throughout the watershed (Homer et al. 2015; Figure 346 and Figure 347). Shrub is the secondary land cover encompassing 14.3%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 7.58% and total cover for cultivated crops is 0.08%.

From 1992-2011 there was a 50.02 sq km decrease in forest and a 7.46 sq km decrease in pasture/hay. There was a 30.15 sq km increase in shrub and an 11.42 sq km increase in grassland (Figure 348).

There are two domestic wastewater outfalls (discharges < 1 million gallons per day) within the James Bayou watershed, both permitted to the city of Linden. Neither of these facilities discharge directly into James Bayou.

In Channel and Riparian Physical Habitat

Physical habitat for James Bayou was evaluated at two sites during fifteen sampling events from 2000 to 2016. James Bayou is an intermittent stream with perennial pools that drains to Caddo Lake after crossing the Louisiana border. Habitat Quality Index scores are available for 14 sample events and indicate an intermediate to high aquatic life use rating (15-21.5). Riparian areas were generally well vegetated throughout the reach with an average riparian buffer ranging from 10 meters wide to greater than 20 meters. The riparian zone was generally dominated by trees followed by grasses then shrubs. The average percentage of tree canopy cover ranged from 60% to 100%. The dominant substrate type varies from clay to sand for the 15 sampling events, but clay was identified as dominant in 13 of 15 events. The average percent of substrate gravel size or larger varied from 0% to 13%. Average percent instream cover was 8% to 26% and instream cover types include overhanging vegetation, snags, woody debris, and root mats. James Bayou ranged from 0.1-0.7 meters deep on average and 3-12 meters wide. Average stream bank slope ranged from 10-45 degrees. Stream flow at the two sites was measured at a minimum value

of 0 cfs and a maximum of 34.5 cfs. Average stream bank erosion potential was 7%-91%. The deepest pool measured at James Bayou was 1.2 meters. Number of riffles observed at the sites varied from zero to one, and total number of stream bends ranged from two to seven.

Water Quality

Water samples were collected at stations 10321 and 14976. Station 10321 was sampled 154 times from October 1982 through July 2018; station 14976 was sampled from October 2005 through October 2019 over 62 events. Parameters measured included temperature, flow, transparency, specific conductance, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total nitrogen, phosphorus, total organic carbon, chloride, sulfate and chlorophyll-*a*. Continuous 24-hour data was recorded at both stations.

Biological Characterization

Fish

Fish collections from three sample stations (within about 16 km of each other) were used in the evaluation of this river reach. Most of the collections (12 of 17) were conducted at the most upstream station (CR 1775). The fish assemblage from seven of these collections rated as having an exceptional aquatic life use, three rated high (one elevates to exceptional with the application of the coefficient of variability), and two intermediate (both from 2006). No collections have been made at this station since 2006 making it difficult to know whether the aquatic life use has continued to decline or whether this sample was an anomaly. Overall, 44 species (14 families) were collected over the course of the 12 sampling events. Twenty species were unique to this site and included Black Bullhead, Tadpole Madtom, Gizzard Shad, Western Creek Chubsucker *Erimyzon claviformis*, Chain Pickerel *Esox niger*, Golden Topminnow *Fundulus chrysotus*, Orangespotted Sunfish, Dollar Sunfish, Bantam Sunfish, White Crappie, Black Crappie, Spotted Sucker, Striped Shiner *Luxilus chrysocephalus*, Golden Shiner, Emerald Shiner, Blackspot Shiner, Weed Shiner, Bullhead Minnow, Bigscale Logperch, and Dusky Darter.

Four fish samples were collected from SH 43, the most downstream station between 2006 and 2016. Twenty-two species (13 families) were collected over the course of the sampling events, including two species only found at this station - Freshwater Drum *Aplodinotus grunniens* and Channel Catfish. The aquatic life use ratings from 2006 rated as intermediate and limited, the 2016 ratings were intermediate and high. No fish data collected prior to 2006 was located for this sample station making it difficult to determine whether these lower ratings support the decline noted upstream or whether this station had declined conditions as early as 1997 (when sampling began at CR 1775).

One collection was made in 1999 at a location midway between the upper and lower stations (CR 1779). This station yielded 22 species (11 families), including one species unique to this site - Ironcolor Shiner *Notropis chalybaeus*. The fish assemblage rated high indicating that conditions, at least that far downstream, were still relatively good in 1999, but was lower than the

exceptional ratings consistently being seen upstream. It is only one sample, but when used in context of the ratings seen at SH 43, conditions appear to decline as one moves downstream.

Pirate Perch and Grass Pickerel were collected during each sampling event. Centrarchidae yielded the greatest species richness of all the families represented at each station; however, number of species within this family declined from 14 to 7 as one moved downstream.

Benthic Macroinvertebrates

Considered collectively, a total of 2,678 individuals representing 21 orders of macroinvertebrates were collected in the 15 sample events at James Bayou (Appendix E). Diptera was the most abundant order, representing 18% of the total number of individuals collected. Other orders that each accounted for greater than 10% of the total number of individuals collected were Ephemeroptera (16.1%), Hemiptera (15.7%), Coleoptera (15.1%), and Decapoda (11.4%). Other taxa, representing greater than 1% of the 15 collections combined, include Odonata, Trichoptera, Pelecypoda, Plecoptera, Amphipoda, Oligochaeta, and Gastropoda.

Considering all 15 samples collectively, the functional organization of the James Bayou macroinvertebrate assemblage was dominated by predators and collector-gatherers, which accounted for 41.8% and 36.7%, respectively, of the total number of individuals collected. The filtering collectors (11.9%), scrapers (7.7%), and shredders (1.9%) were present, but in lower relative abundance. This functional structure was relatively consistent across individual sample dates.

A total of 19 EPT taxa were collected when all dates are considered collectively. The EPT for individual samples varied from a minimum of zero to a maximum of 11. These values fall between the minimum and the 75th percentile for all EPT values for least disturbed streams in ecoregion aggregate 33/35. The variability of the EPT is likely related to variable flow conditions and the sensitivity of the EPT taxa to low flow conditions.

The biotic index value for the collective James Bayou benthic assemblage (5.3) falls between the 50th and the 75th percentile for all biotic index values in the ecoregion aggregate indicating a moderately tolerant macroinvertebrate assemblage. The maximum biotic index value for individual samples was 7.3, which exceeds the 95th percentile for the ecoregion aggregate. The lowest biotic index value among the 15 samples (4.1) falls between the 5th and the 25th percentiles for the ecoregion aggregate.

The RBP IBI scores for the 15 samples ranged from limited to exceptional aquatic life use. These results likely indicate the response of the assemblage to less favorable flow conditions. The Ecoregions 33 and 35 BIBIs for each of the RBP samples fell in the following aquatic life use categories:

- Exceptional (Station 10321: June 2003)
- High (Station 10321: June 2002, August 2002, July 2004)

- Intermediate (Station 10321: August 2000, June 2001, August 2003, June 2005, June 2006, August 2006; Station 14976: June 2016, August 2016)
- Limited (Station 10321: August 2004; Station 14976: June 2006, August 2006)

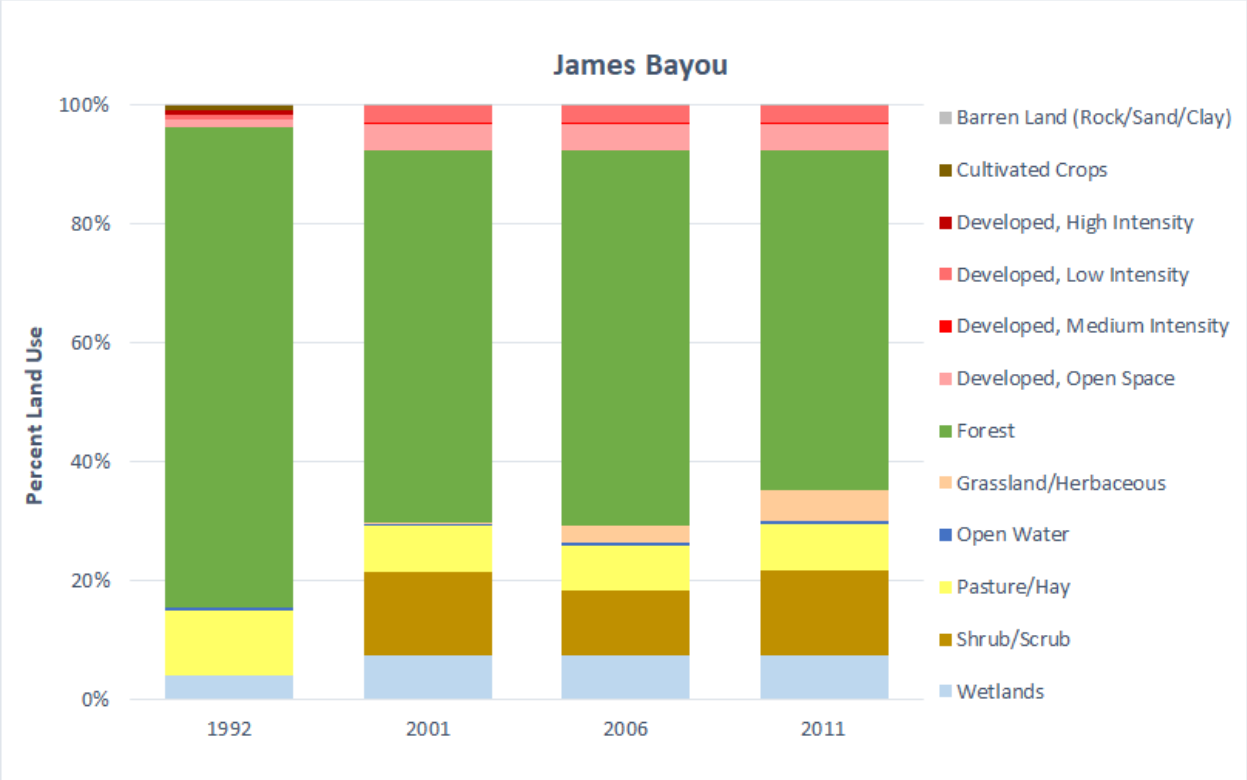

Figure 347. Percent land use in the James Bayou watershed from 1992-2011.

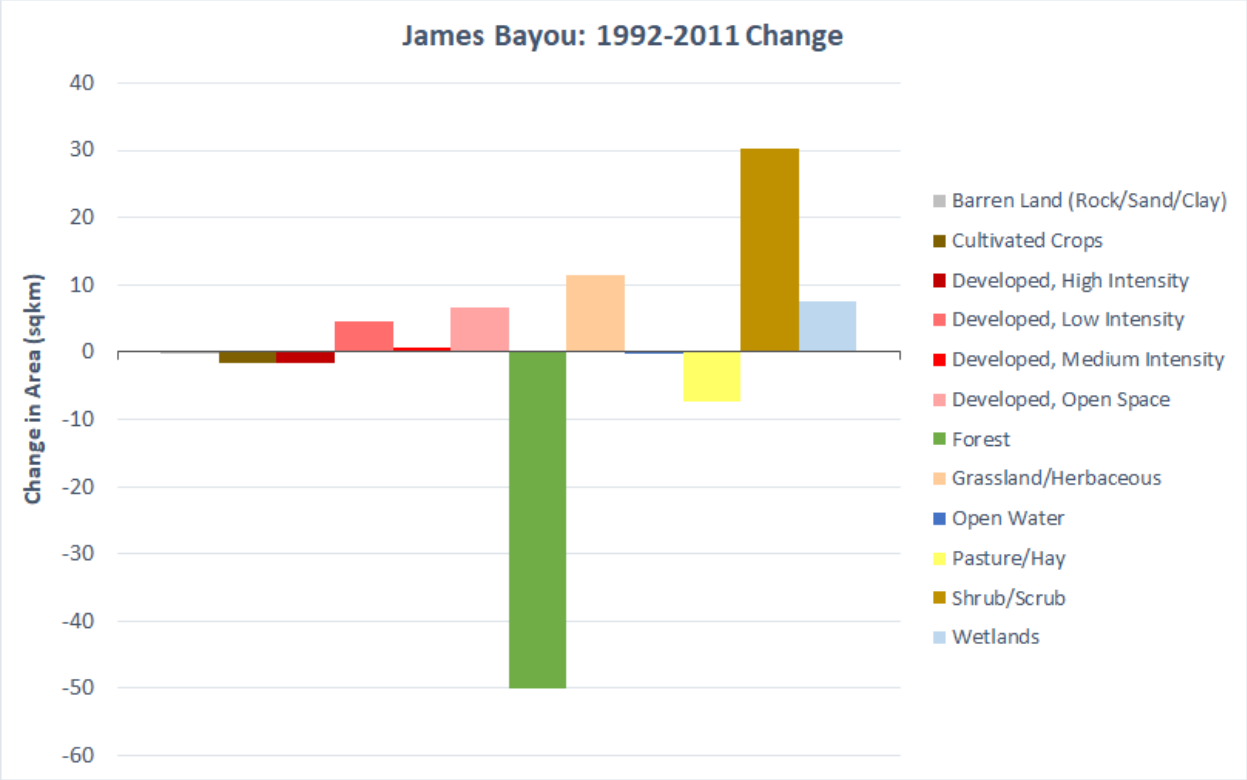

Figure 348. Land use change in area (sq km) from 1992-2011 for the James Bayou watershed.

LAKE CREEK

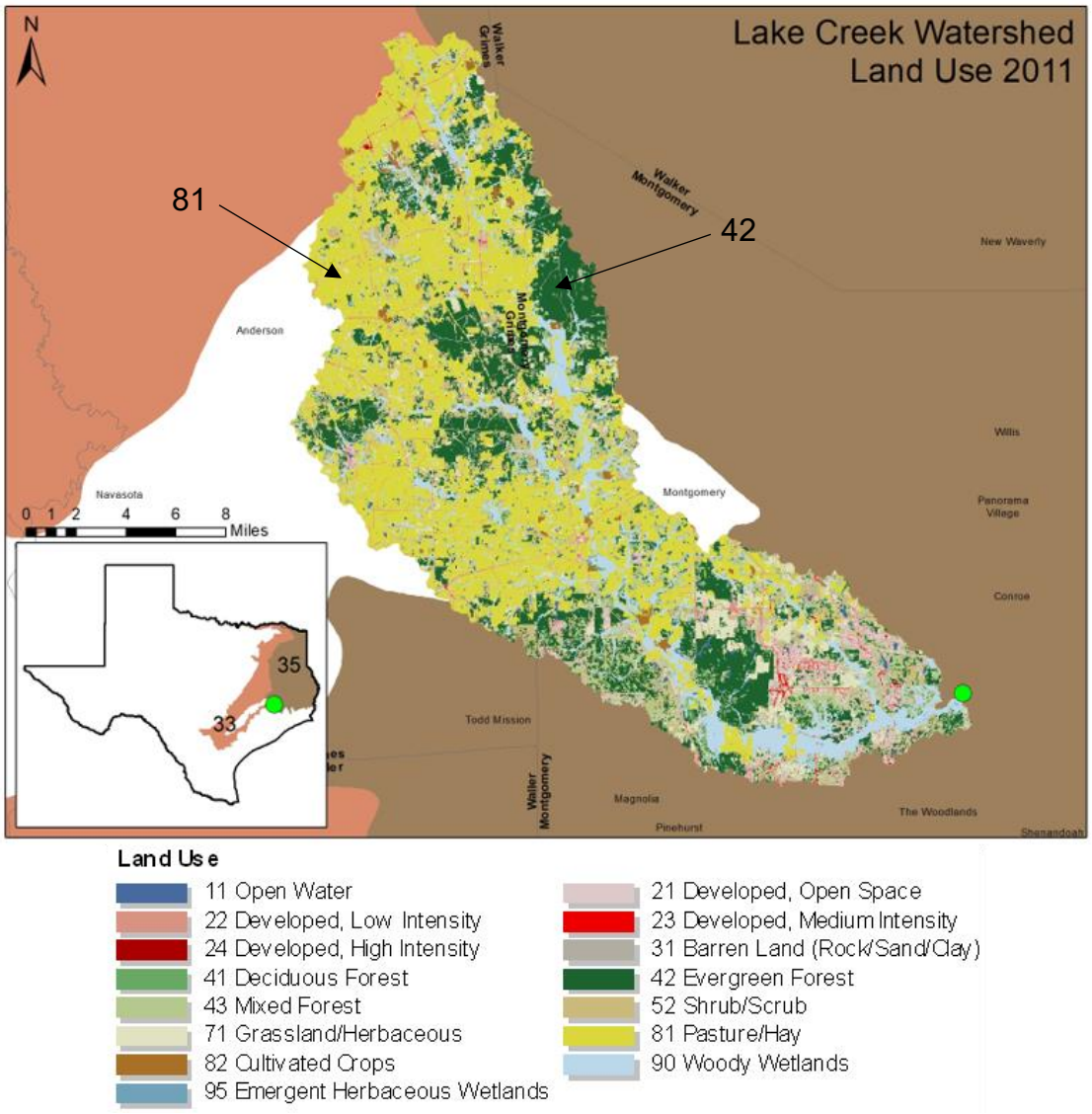

Figure 349. Map of Lake Creek watershed location and 2011 land use; pasture/hay and forest were the most common land uses.

Sampling Dates

Physical Habitat:	Station 11366: July 20, 1988; Station 11367: May 10, 2011; July 22, 2011; Station 17331: April 14, 2011; June 19, 2013; September 19, 2013
Water Quality:	139 sampling events (Stations 11366, 11367 and 17331)
Fish:	July 21, 1988; October 1, 1991; April 1, 1992; April 14, 2011; July 13, 2011; June 19, 2013; September 19, 2013

Benthic Invertebrates: Station 11366: July 20, 1988; Station 11367: May 10, 2011; July 22, 2011; Station 17331: April 14, 2011; July 13, 2011; June 19, 2013; September 19, 2013

Physical Characterization

Watershed and Land Use

Lake Creek lies within the San Jacinto River Basin. Sample site 11366 is located 2.99 km upstream of the West Fork of the San Jacinto River, north of The Woodlands in Montgomery County (Figure 349).

The Lake Creek watershed at site 11366 is approximately 850.14 sq km. The lower portion of the watershed and sections of the upper watershed lay within Level IV Ecoregion 35e, the Southern Tertiary Uplands. The remaining portion of the middle and upper watershed lay within Level IV Ecoregion 32b, the Southern Blackland/Fayette Prairie. The dominant land cover in the watershed is pasture/hay at 37.24% and is most concentrated within the portions of the watershed that lay within Ecoregion 32 (Homer et al. 2015; Figure 349 and Figure 350). The secondary land cover is forest at 28.39%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 8% and total cover for cultivated crops is 0.79%.

From 1992-2011 there was a 105.91 sq km decrease in forest and an 85.47 sq km decrease in pasture/hay. There was a 64.61 sq km increase in shrub and a 52.4 sq km increase in grassland (Figure 351).

There are 15 domestic wastewater outfalls (discharges < 1 million gallons per day) and one industrial wastewater outfall (discharges ≥ 1 million gallons per day) within the Lake Creek watershed. The domestic facilities are permitted to a golf course, industrial administrative offices, municipal utility districts, water and sewer utility companies, a private residence, and Richards ISD. The one industrial wastewater facility is permitted to Tenaska Roan's Prairie Partners, LLC (Tenaska Frontier Generating Station) which is an electric generating facility. Five of the domestic wastewater outfalls discharge directly into Lake Creek.

In Channel and Riparian Physical Habitat

Physical habitat for Lake Creek was evaluated at three sites during six sampling events from 1988 to 2013. Lake Creek is a perennial stream that drains to the West Fork of the San Jacinto River below Lake Conroe. Habitat Quality Index scores are available for four sample events and indicate an intermediate to high aquatic life use rating (19-22). Riparian areas were well vegetated throughout the reach with an average riparian buffer ranging from 18 meters wide to greater than 20 meters. The riparian zone was generally dominated by trees followed by shrubs then grasses. The average percentage of tree canopy cover ranged from 13% to 96%. The dominant stream substrate was sand, and the average percent of substrate gravel size or larger varied from 0% to 18%. Average percent instream cover was 12% to 89% and instream cover types include overhanging vegetation, woody debris, and gravel. Lake Creek ranged from 0.3-0.5

meters deep on average and 6-10 meters wide. Average stream bank slope ranged from 31-40 degrees. Stream flow at the site was measured at a minimum value of 0.4 cfs and a maximum of 7 cfs. Average stream bank erosion potential was 8%-38%. The deepest pool measured at Lake Creek was 2 meters. Number of riffles observed at the site varied from one to four, and total number of stream bends ranged from four to eight.

Water Quality

Water samples were collected at stations 11366, 11367 and 17331. Station 11366 was sampled 17 times between July 1988 and July 1999. Station 11367 was sampled 114 times from October 1981 through May 2020. Lastly, 8 sampling events occurred at station 17331 from October 2002 through August 2003. Parameters measured included temperature, flow, transparency, specific conductance, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total nitrogen (except at station 17331), phosphorus (except at station 17331), total organic carbon, chloride, sulfate and chlorophyll-a. Continuous 24-hour data was recorded at stations 11366, 11367 and 17331.

Continuous flow data is available from USGS gage 08067900 (Figure 352). Discharge was recorded from September 2002 through January 2005; median flow was 37.75 cfs and flows ranged from 3.03 cfs to 15,700 cfs. Flows increase sharply with rain events throughout the year and 8.3 percent of daily mean flows were greater than 1000 cfs. Extremely high flows of up to 15,700 cfs were recorded on November 6 and 7, 2002. These high flows were related to heavy rainfall totals between 4 and 10 inches in southeast Texas. Data have been log transformed to better visualize flow patterns.

Biological Characterization

Fish

Thirty-four species (13 families) were collected over the course of the seven sampling events. Centrarchidae and Cyprinidae tied for having the most species with eight. Blacktail Shiner was collected in each sample and was the most abundant species in each collection except the one in 1991 where Bullhead Minnow outnumbered it. Other species represented in each sample were Blackstripe Topminnow, Western Mosquitofish, Bluegill, and Longear Sunfish. Every fish collection, except the 1988 one (which rated as exceptional), yielded a high aquatic life use rating. Trends noted over time include a general decline in cyprinid and benthic invertivore species richness and an increase in sunfish species richness. Cyprinid species that were only collected between 1988 and 1992 were Emerald and Ribbon shiners; however, both were rare (one and two individuals, respectively). Freckled Madtom *Noturus nocturnus*, Slough Darter, and Bigscale Logperch (all benthic invertivore species) were also only collected during the early time period. Sunfish species that were added during the latter time period were Green Sunfish and Redear Sunfish. Other fish species unique to the early collections include: Freshwater Drum, Alligator Gar *Atractosteus spatula*, River Carpsucker, Channel Catfish, and Flathead Catfish. Each of these species were represented by only one individual and/or in one collection.

Benthic Macroinvertebrates

A total of 2,110 individuals representing 23 orders of macroinvertebrates were collected in the seven sample events at Lake Creek between 1988 and 2013 (Appendix E). Ephemeroptera was the most abundant order, representing 36% of the total number of individuals collected. Other orders that each accounted for 10% or greater of the total number of individuals collected were Amphipoda (12%), Coleoptera (10.3%), and Diptera (10.1%). Trichoptera and Pelecypoda were the only other taxa representing greater than 5% of the individuals in the seven collections combined.

Considering all seven samples collectively, the functional organization of the Lake Creek macroinvertebrate assemblage was dominated by collector-gatherers, scrapers, and predators, which accounted for 49.7%, 17.3%, and 12.8%, respectively, of the total number of individuals collected. Filtering collectors (11.8%) and shredders (8.4%) were present, but in lower relative abundance. This functional structure was relatively consistent across individual sample dates.

A total of 21 EPT taxa were collected when all sites and dates are considered collectively. The EPT for individual samples varied from a minimum of two for both samples collected in 2011 at site 11367 to a maximum of 16 for the Surber sample collected July 20, 1988 at site 11366. These EPT values range from just above the 5th percentile to above the 75th percentile for all EPT values for least disturbed streams in ecoregion aggregate 33/35. The variability of the EPT is likely related to variable flow conditions and the sensitivity of the EPT taxa to low flow conditions.

The biotic index value for the collective Lake Creek benthic assemblage (6) falls between the 75th and 95th percentile for all biotic index values in the ecoregion aggregate, indicating a tolerant macroinvertebrate assemblage. Three of the four highest biotic index values were obtained for samples collected in 2011 and coincide with the lowest EPT values, likely reflecting low flow conditions in 2011.

The BIBI score for the 1988 Surber sample collected at site 11366 falls in the range which indicates an exceptional aquatic life use. The Ecoregions 33 and 35 BIBI scores for the six RBP samples collected in 2011 and 2013 ranged from limited to high aquatic life use with an average that falls in the intermediate aquatic life use category. The RBP samples that scored in the high ALU category were collected in April 2011 and June 2013 which coincides with the second and third highest EPT values and the second and third lowest biotic index values. The sample dates also coincide with periods of relatively normal flow and good dissolved oxygen levels. Conversely, the May 2011 sample (which was collected during lower than normal flow conditions (0.8 cfs) and low dissolved oxygen) had the lowest RBP IBI score (21) and associated limited aquatic life use, the highest biotic index value, and lowest EPT. These results reflect the response of the assemblage to varying flow conditions.

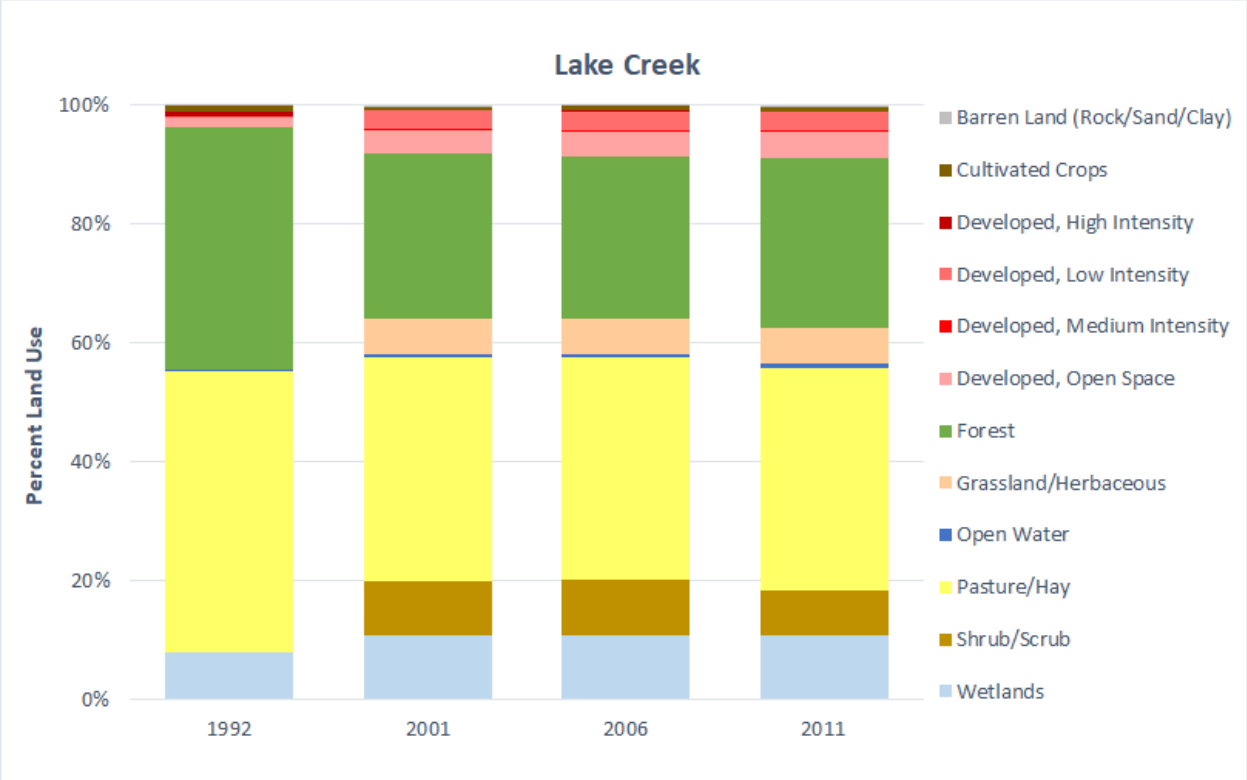

Figure 350. Percent land use in the Lake Creek watershed from 1992-2011.

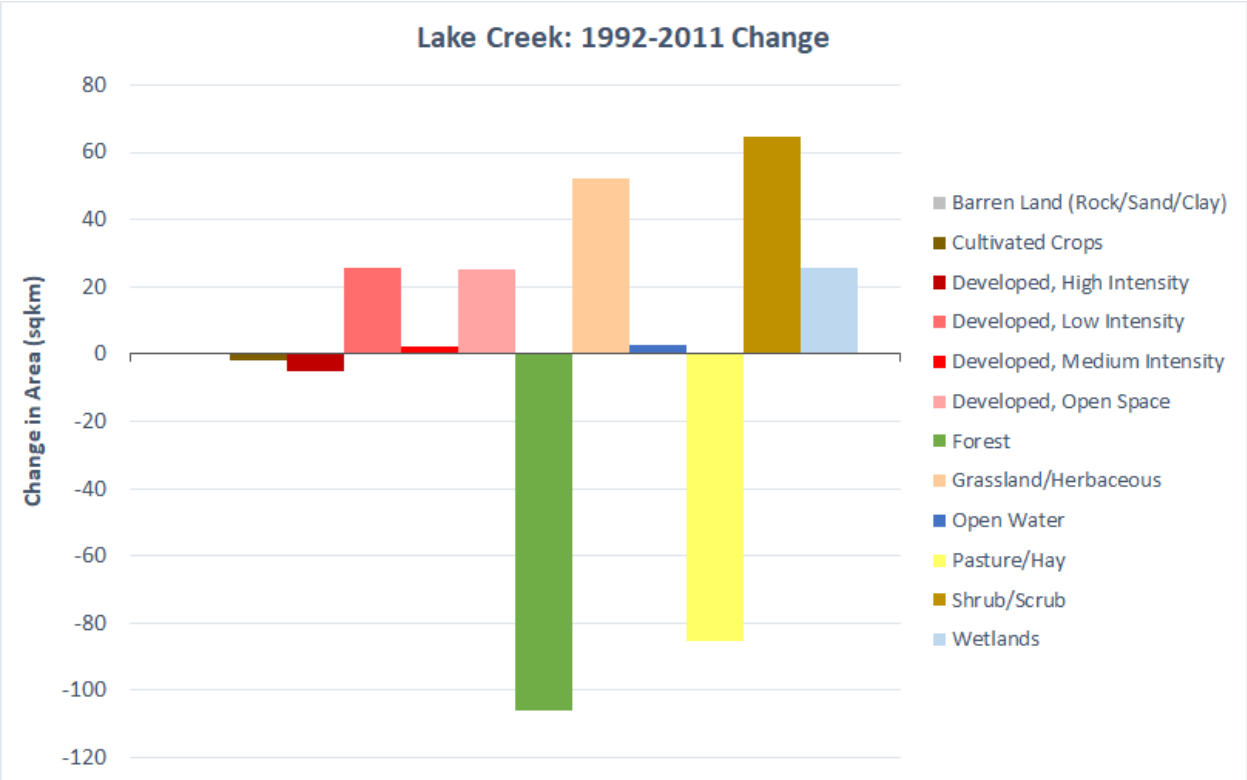

Figure 351. Land use change in area (sq km) from 1992-2011 for the Lake Creek watershed.

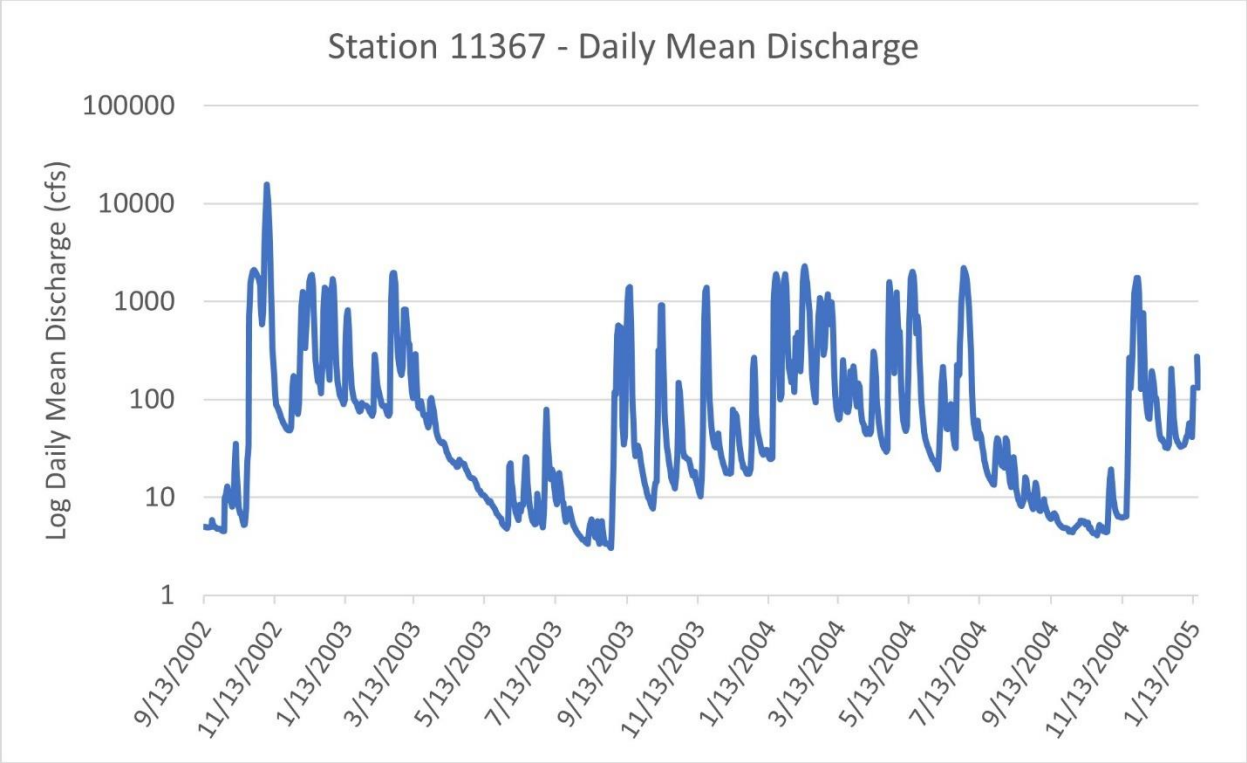

Figure 352. Log transformed daily mean discharge for Lake Creek at station 11367.

LITTLE CYPRESS BAYOU

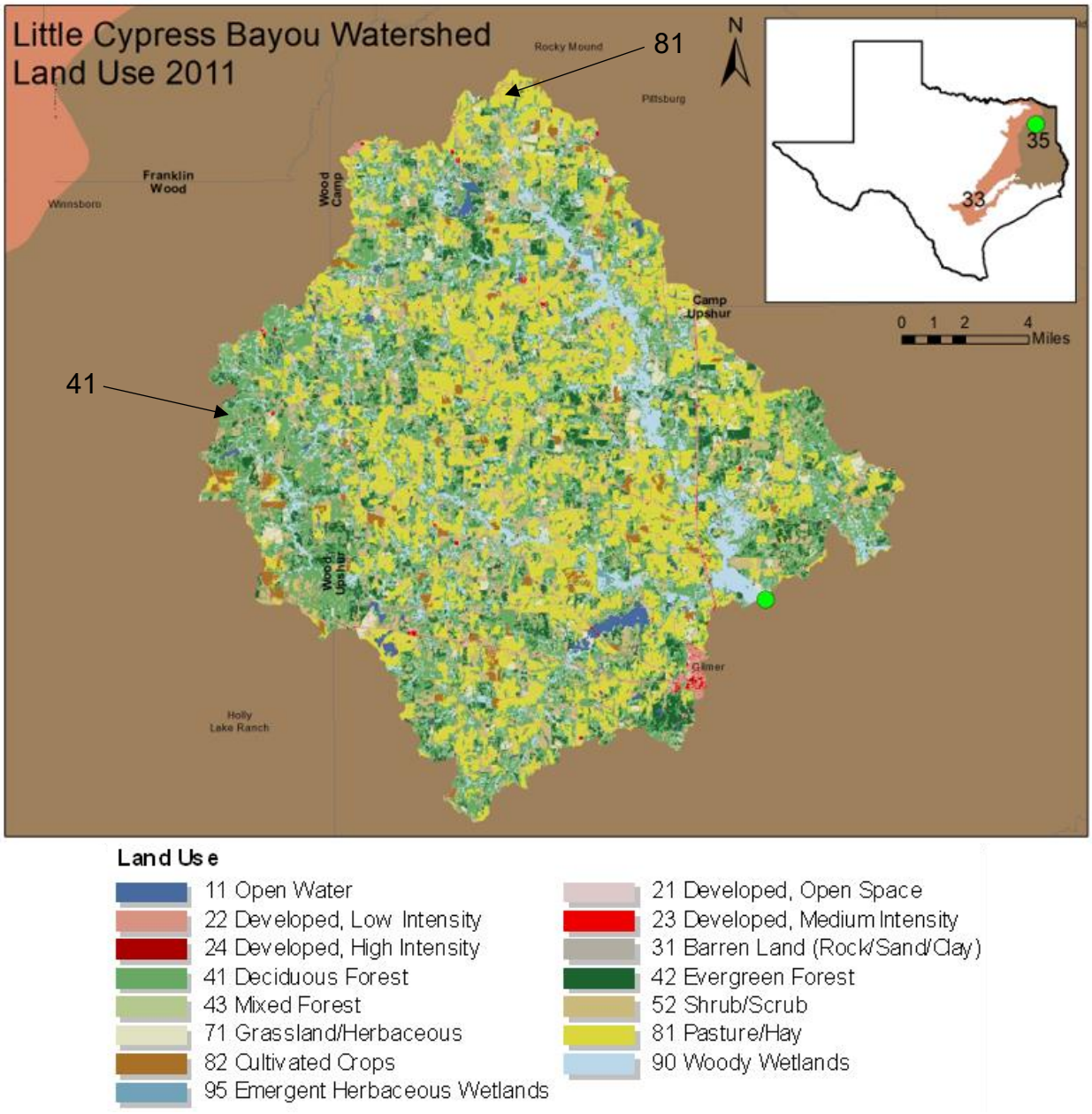

Figure 353. Map of Little Cypress Bayou watershed location and 2011 land use; forest and pasture/hay were the most common land uses.

Sampling Dates

Physical Habitat:	August 30, 1989; July 16, 2004; August 11, 2004; August 17, 2004
Water Quality:	22 sampling events
Fish:	August 31, 1989; July 16, 2004; August 11, 2004; August 17, 2004
Benthic Invertebrates:	August 30, 1989; July 16, 2004; August 11, 2004; August 17, 2004

Physical Characterization

Watershed and Land Use

Little Cypress Bayou lies within the Cypress Creek Basin. Sample site 10335 is located at SH 155 northeast of Gilmer in Upshur County (Figure 353).

The Little Cypress Bayou watershed at site 10335 is approximately 730.49 sq km. The entire watershed lies within Level IV Ecoregion 35a, the Tertiary Uplands. The dominant land cover in the watershed is forest at 40% and is present throughout the watershed (Homer et al. 2015; Figure 353 and Figure 354). Pasture/hay is the secondary land cover encompassing 27.89%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 6.18% and total cover for cultivated crops is 1.72%.

From 1992-2011 there was a 98.7 sq km decrease in forest and a 68.29 sq km decrease in pasture/hay. There was a 74.73 sq km increase in shrub and a 36.68 sq km increase in wetlands (Figure 355).

There are two domestic wastewater outfalls (discharges < 1 million gallons per day) and one industrial wastewater outfall (discharges ≥ 1 million gallons per day) within the Little Cypress Bayou watershed. One domestic facility is permitted to Union Hill ISD and the other to Harmony ISD. The industrial wastewater facility is permitted to Luminant Mining Co, LLC, a coal mining company. None of these facilities discharge directly into Little Cypress Bayou.

In Channel and Riparian Physical Habitat

Physical habitat for Little Cypress Bayou was evaluated during four sampling events from 1989 to 2004. Little Cypress Bayou is a perennial stream that drains to Big Cypress Creek below Lake O' the Pines east of Jefferson. Habitat Quality Index scores are available for three sample events and indicate an intermediate to high aquatic life use rating (17.5-21). Riparian areas were well vegetated throughout the reach with an average riparian buffer measured at greater than 20 meters for all sampling events. The riparian zone was generally dominated by trees followed by grasses then shrubs. The average percentage of tree canopy cover ranged from 56% to 98%. The dominant stream substrate was sand, and the average percent of substrate gravel size or larger varied from 0% to 2%. Average percent instream cover was 28% to 38% and instream cover types include overhanging vegetation, woody debris, and root mats. Little Cypress Bayou ranged from 0.2-0.6 meters deep on average and 5-8 meters wide. Average stream bank slope ranged from 25-35 degrees. Stream flow at the site was measured at a minimum value of 1 cfs and a maximum of 14.7 cfs. Average stream bank erosion potential was 53%-79%. The deepest pool measured at Little Cypress Bayou was 1.3 meters. Number of riffles observed at the site varied from zero to four, and total number of stream bends ranged from three to eight.

Water Quality

Water samples were collected at station 10335 over 22 sampling events from August 1989 through July 2005. Parameters measured included temperature, flow, transparency, specific

conductance, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total nitrogen, phosphorus, total organic carbon, chloride, sulfate and chlorophyll-*a*. Twenty-four-hour data were collected at this station.

Biological Characterization

Fish

Forty-six species (11 families) were collected over the course of the four sampling events. The most species rich family was Percidae with 11 species. Ribbon Shiner was the most abundant species in each collection. The aquatic life use (based upon the fish assemblage) increased from high to exceptional between 1989 and 2004. The metrics contributing to this increase were number of intolerant species and the proportion of individuals exhibiting a disease or other anomaly. Three intolerant fish species (Tadpole Madtom, Dusky Darter, and Cypress Darter *Etheostoma proeliare*) were collected in 1989 (metric score of 3). These same three species, plus five more (Brook Silverside, Goldstripe Darter *E. parvipinne*, Bigscale Logperch, Blackside Darter *Percina maculata*, and Freckled Madtom), were collected in 2004 (metric score of 5). No disease or anomalies were detected in 2014 (metric score of 5), in contrast to 1.3% of the individuals harboring some sort of anomaly in 1989 (metric score of 1).

Benthic Macroinvertebrates

Considering all four samples collected at Little Cypress Bayou in 1989 and 2004, a total of 1,880 individuals representing 14 orders of macroinvertebrates were collected (Appendix E). Trichoptera, Coleoptera, and Diptera were the most abundant orders, representing 31.7%, 15.4%, and 12.4%, respectively, of the total number of individuals collected. Other orders that each accounted for 5% or greater of the total number of individuals collected were Ephemeroptera (11.4%), Isopoda (9.2%), Pelecypoda (6.5%), and Oligochaeta (5.5%).

Considering all four samples collectively, the functional organization of the Little Cypress Bayou macroinvertebrate assemblage was dominated by filtering collectors and collector gatherers which accounted for 38.8% and 29.3%, respectively, of the total number of individuals collected. Scrapers (12.6%), predators (12.1%), and shredders (7.2%) were present, but in lower relative abundance. This functional structure was relatively consistent across individual sample dates with the exception of the August 2004 collection when collector gatherers and predators were the dominant functional groups.

A total of 14 EPT taxa were collected when all sites and dates are considered collectively. The EPT for individual samples varied from four for the August 11, 2004 sample to 11 for the Surber sample collected in August 1989. These EPT values fall between the 25th percentile and the 75th percentile for all EPT values for least disturbed streams in ecoregion aggregate 33/35.

The biotic index value for the collective Little Cypress Bayou benthic assemblage (6) falls between the 75th and the 95th percentile for all biotic index values in the ecoregion aggregate, indicating a moderately tolerant macroinvertebrate assemblage. The highest biotic index value

for the four samples was for the August 1989 sample (6.2). The three samples collected in 2004 had lower biotic index values (average 4.7), perhaps reflecting less harsh conditions in 2004.

The BIBI score for the August 1989 Surber sample falls in the range which indicates an exceptional aquatic life use. The Ecoregions 33 and 35 BIBI scores for the July 16, 2004 and August 17, 2004 RBP samples fall in the range indicating a high aquatic life use, while the August 11, 2004 RBP sample falls in the intermediate aquatic life use category. These results indicate relative constancy of biotic integrity over the 15-year interval between 1989 and 2004.

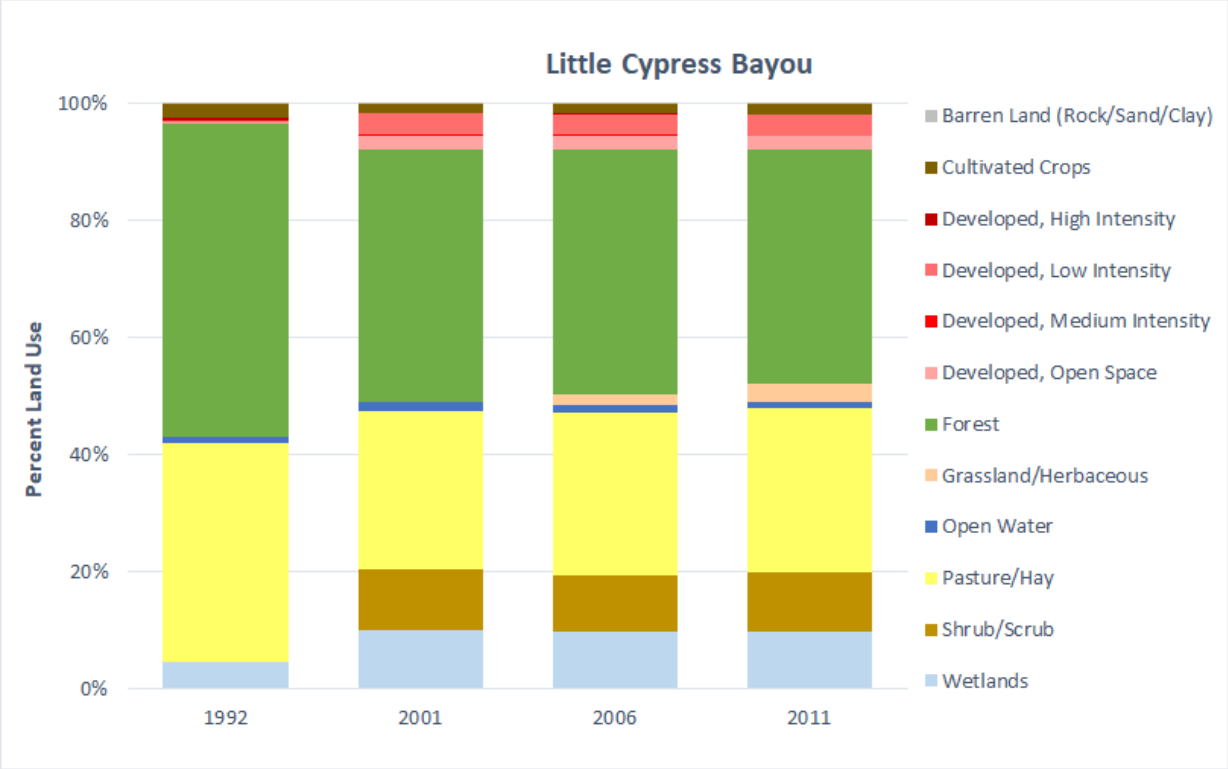

Figure 354. Percent land use in the Little Cypress Bayou watershed from 1992-2011.

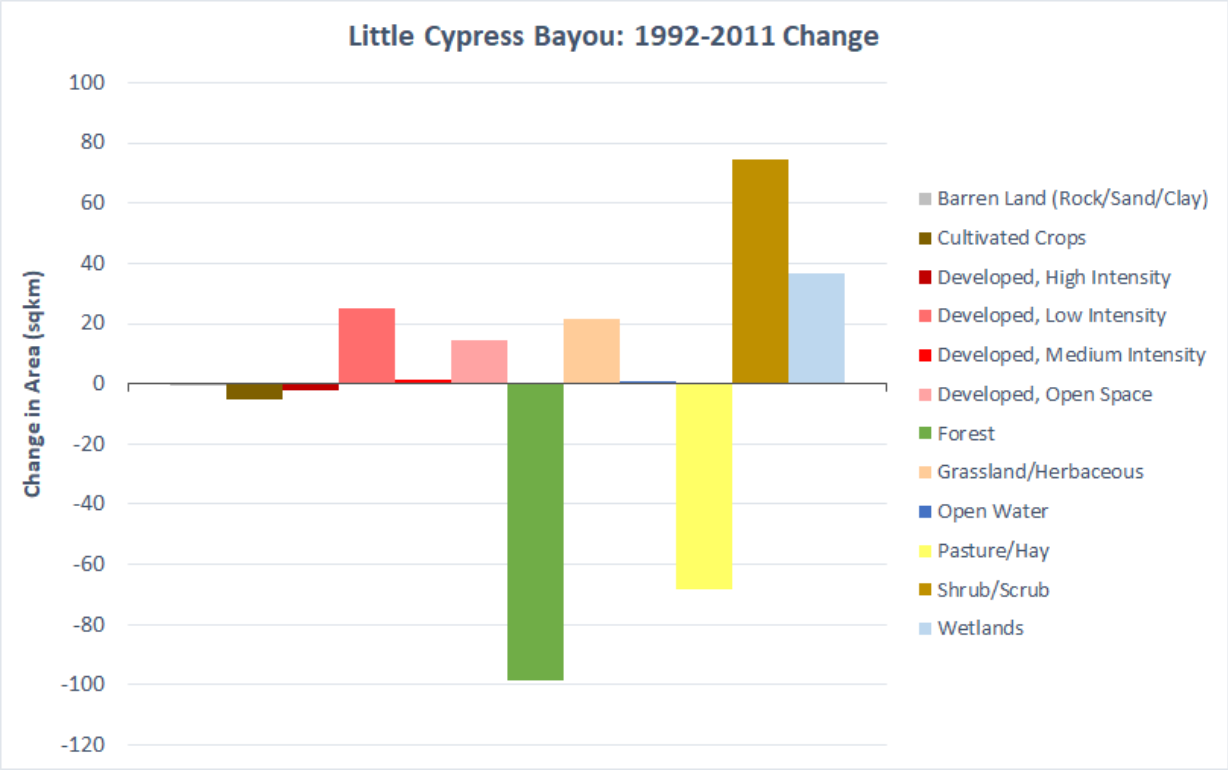

Figure 355. Land use change in area (sq km) from 1992-2011 for the Little Cypress Bayou watershed.

LITTLE PINE ISLAND BAYOU

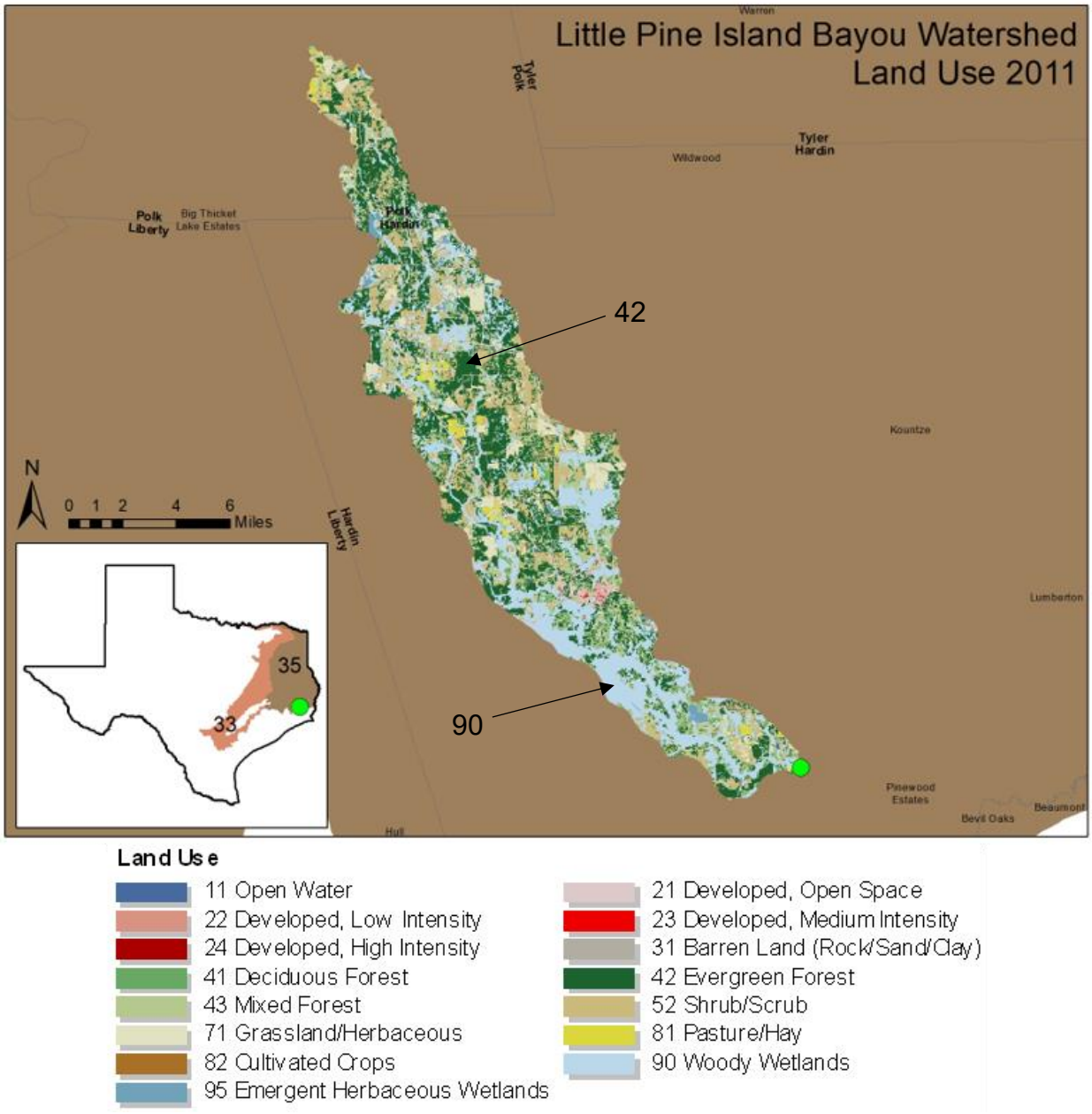

Figure 356. Map of Little Pine Island Bayou watershed location and 2011 land use; forest and wetland were the most common land uses.

Sampling Dates

Physical Habitat:	May 14, 2008; September 23, 2010
Water Quality:	116 sampling events
Fish:	May 14, 2008; September 23, 2010
Benthic Invertebrates:	May 14, 2008; September 23, 2010

Physical Characterization

Watershed and Land Use

Little Pine Island Bayou lies within the Neches River Basin. Sample site 15346 is located at SH 326, 5.68 km north of Sour Lake in Hardin County (Figure 356).

The Little Pine Island Bayou watershed at site 15346 is approximately 319.25 sq km. The entire watershed lies within Level IV Ecoregion 35f, the Flatwoods. The dominant land cover in the watershed is forest at 42.6% and is present throughout the watershed (Homer et al. 2015; Figure 356 and Figure 357). Wetlands is the secondary land cover encompassing 27.25%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 4.42% and total cover for cultivated crops is 0.01%.

From 1992-2011 there was a 157.18 sq km decrease in forest and an 11.36 sq km decrease in pasture/hay. There was an 85.12 sq km increase in wetlands and a 54.37 sq km increase in shrub (Figure 358).

There are no permitted wastewater outfalls within the Little Pine Island Bayou watershed.

In Channel and Riparian Physical Habitat

Physical habitat for Little Pine Island Bayou was evaluated during two sampling events from 2008 to 2010. Little Pine Island Bayou is a perennial stream that drains to Pine Island Bayou northwest of Beaumont. Habitat Quality Index scores are available for both sample events and indicate a high aquatic life use rating (19.5-21.5). Riparian areas were well vegetated throughout the reach with an average riparian buffer measured at greater than 20 meters. The riparian zone was generally dominated by trees followed by shrubs then grasses. The average percentage of tree canopy cover ranged from 91% to 94%. The dominant stream substrate was silt and clay, and the average percent of substrate gravel size or larger was 0%. Average percent instream cover was 49% to 60% and instream cover types include overhanging vegetation, leaf packs, snags, woody debris, and root mats. Little Pine Island Bayou ranged from 0.1-0.2 meters deep on average and 4 meters wide. Average stream bank slope ranged from 22-23 degrees. Stream flow at the site was measured at a minimum value of 0.4 cfs and a maximum of 1.1 cfs. Average stream bank erosion potential was 21%-48%. The deepest pool measured at Little Pine Island Bayou was 0.6 meters. Number of riffles observed at the site varied from one to four, and total number of stream bends ranged from two to four.

Water Quality

Water samples were collected at station 15346 over 116 sampling events from January 1997 through October 2019. Parameters measured included temperature, flow, transparency, specific conductance, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total nitrogen, phosphorus, total organic carbon, chloride, sulfate and chlorophyll-*a*. Twenty-four-hour data were collected at this station.

Biological Characterization

Fish

Twenty-one species (eight families) were collected between the two sampling events. Cyprinidae and Centrarchidae were the most species rich families with six and five, respectively. Western Mosquitofish was the most abundant species. The aquatic life use scored as high and intermediate, based upon the 2008 and 2010 fish collections, respectively. When the coefficient of variability was applied, the ratings elevated to exceptional and high. The 2010 collection rated lower because of reduced overall species richness, subsequent lower numbers of benthic invertivore and intolerant species, and a much lower percentage of piscivorous individuals. Two species identified as being both benthic invertivores and intolerant, Tadpole Madtom and Dusky Darter, were collected in 2008, although in relatively low numbers. Neither species were collected in 2010; however, Cypress Darter (also a benthic invertivore and intolerant species) was collected in fairly abundant numbers. Slough Darter, another benthic invertivore species, was only collected in 2008. The main reason for the lower metric score for piscivores was the difference in number of Warmouth collected. Species unique to the 2008 collection were Blacktail Shiner, Ribbon Shiner, Bluegill, and Largemouth Bass. Golden Shiner and Emerald Shiner were only collected in 2010. The shift in presence and absence of these species is not especially indicative of major changes in water quality or habitat.

Benthic Macroinvertebrates

Considering both RBP samples collected at Little Pine Island Bayou, a total of 422 individuals representing 14 orders of macroinvertebrates were collected (Appendix E). Amphipoda, Diptera, and Ephemeroptera were the most abundant orders, representing 38.4%, 14.9%, and 12%, respectively, of the total number of individuals collected. Decapoda, Trichoptera, and Isopoda were present, but relatively less common in the collections with each order accounting for between 1% and 5% of the total number of individuals collected.

Considering both samples collectively, the functional organization of the Little Pine Island Bayou macroinvertebrate assemblage is dominated by collector gatherers and shredders which accounted for 40.8% and 22.1%, respectively, of the total number of individuals collected. Predators (12.7%), scrapers (10.7%), and filtering collectors (12.3%) were present, but in lower relative abundance. This functional organization was relatively consistent across dates, except that the scrapers were more abundant than the shredders in the September 2010 sample.

A total of seven EPT taxa were collected when both samples are considered collectively. The EPT for individual samples varied from three for the May 2008 sample to five for the sample collected in September 2010. These EPT values fall between the 5th percentile and the 50th percentile for all EPT values for least disturbed streams in ecoregion aggregate 33/35.

The biotic index value for the collective Little Cypress Bayou benthic assemblage (4.7) falls between the 25th and the 50th percentile for all biotic index values in the ecoregion aggregate,

indicating a moderately tolerant macroinvertebrate assemblage. The biotic index value was 5 for the May 2008 sample and 5.5 for the sample collected in September 2010.

The Ecoregions 33 and 35 BIBI score for both the May 2008 sample and the September 2010 sample fell in the range indicating an intermediate aquatic life use.

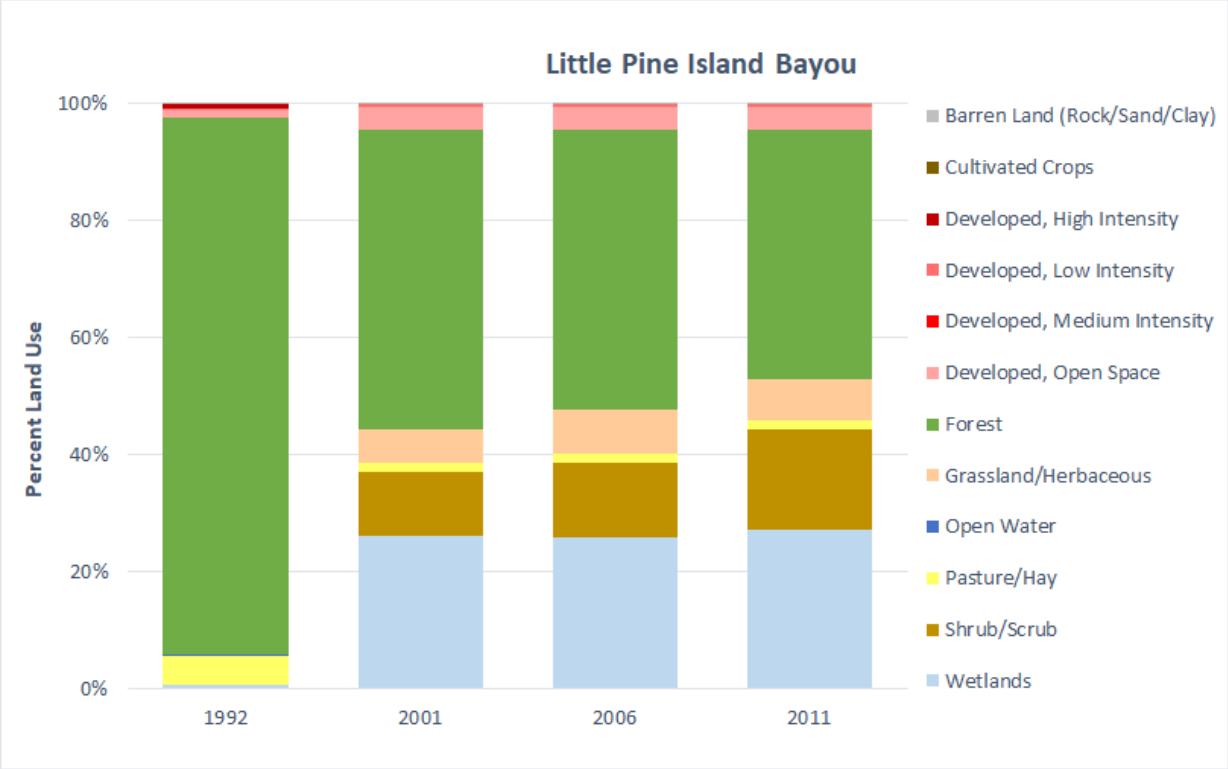

Figure 357. Percent land use in the Little Pine Island Bayou watershed from 1992-2011.

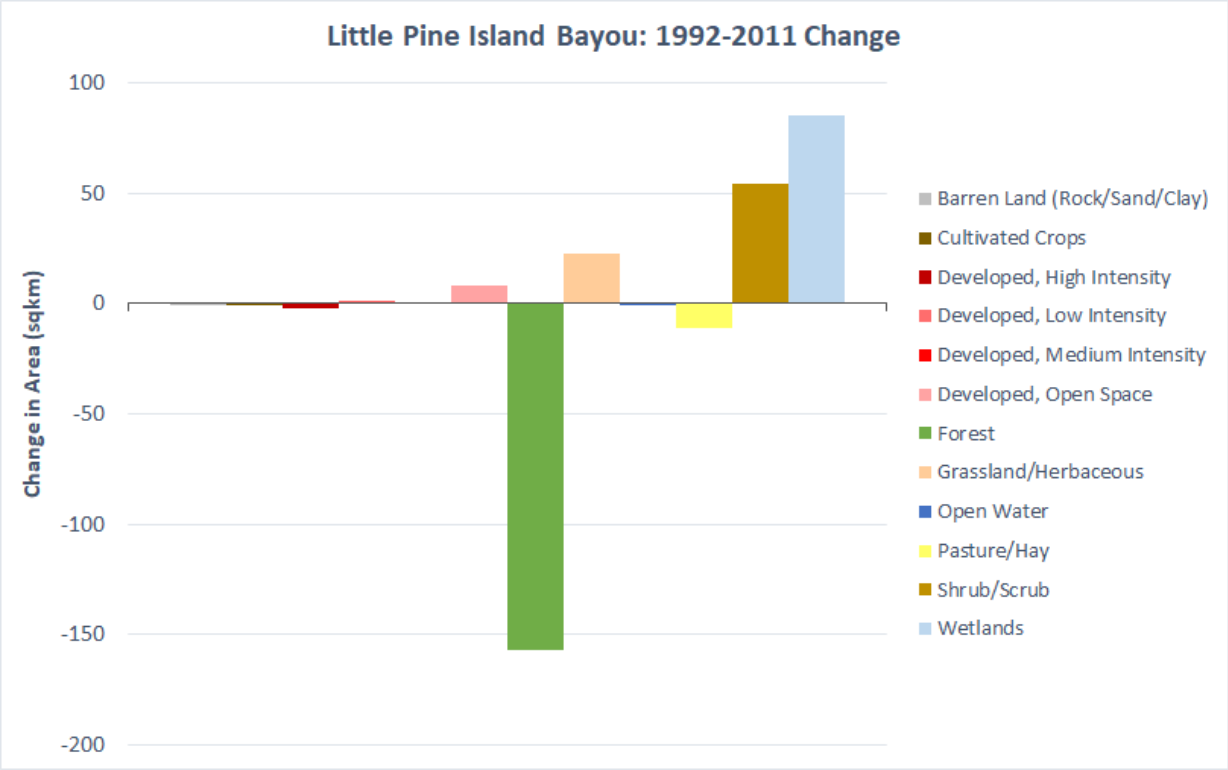

Figure 358. Land use change in area (sq km) from 1992-2011 for the Little Pine Island Bayou watershed.

PEACH CREEK

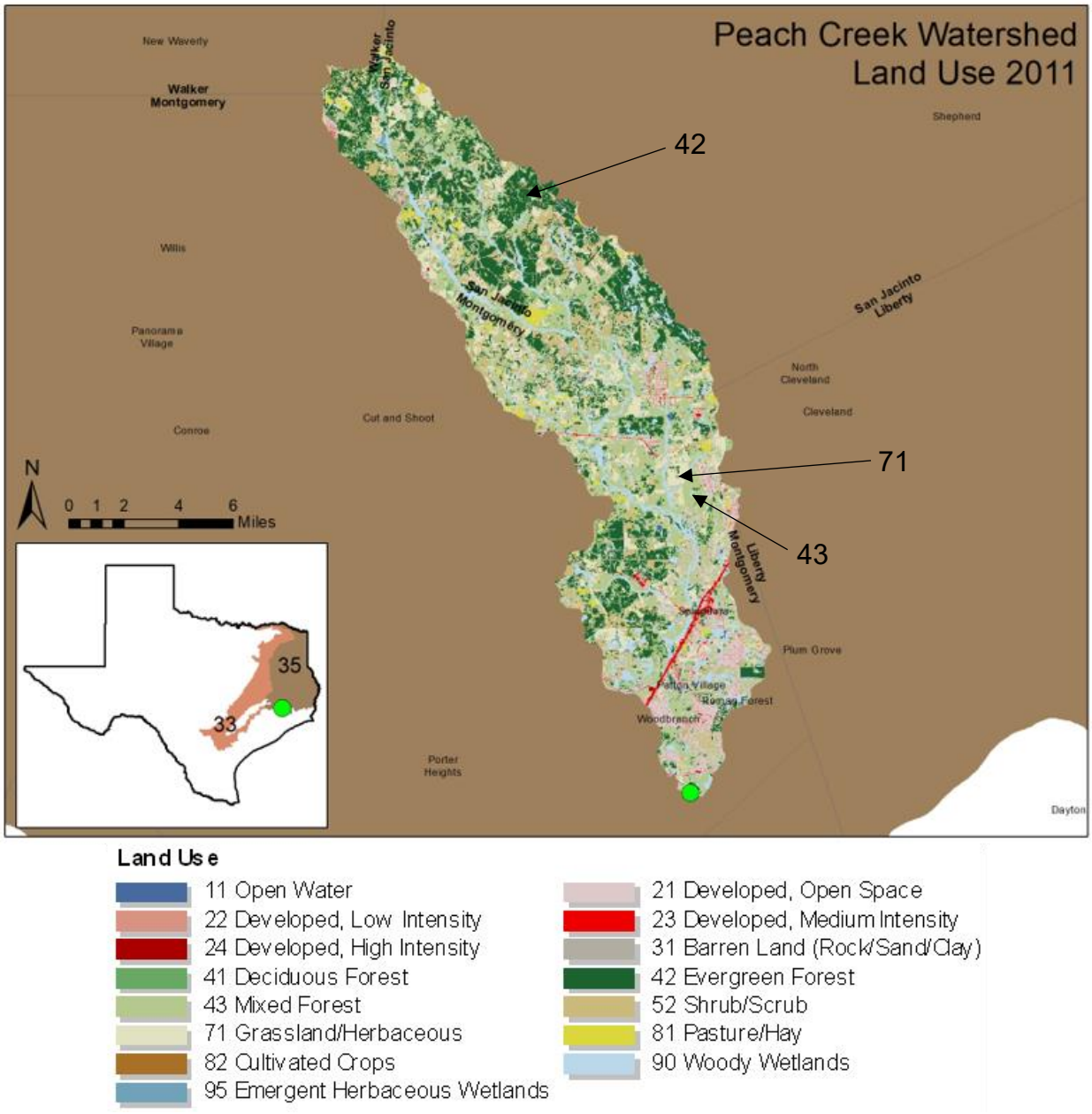

Figure 359. Map of Peach Creek watershed location and 2011 land use; forest and grassland/herbaceous were the most common land uses.

Sampling Dates

Physical Habitat: June 19, 2002; September 12, 2002; April 1, 2004; May 5, 2005; May 15, 2006; June 13, 2007; June 25, 2008; June 17, 2009; April 6, 2010; May 5, 2011; May 9, 2012; April 9, 2013; August 14, 2013; June 26, 2014; August 26, 2014; July 20, 2016; April 26, 2017; May 2, 2018; July 18, 2018

Water Quality:	78 sampling events
Fish:	June 17, 1998; June 19, 2002; September 12, 2002; May 22, 2003; August 7, 2003; April 12, 2004; August 17, 2004; May 5, 2005; July 22, 2005; May 15, 2006; August 24, 2006; June 17, 2007; September 26, 2007; June 25, 2008; June 17, 2009; August 18, 2009; April 6, 2010; August 17, 2010; May 11, 2011; July 12, 2011; August 7, 2012; April 9, 2013; August 14, 2013; July 14, 2015; July 20, 2016; April 27, 2017
Benthic Invertebrates:	June 19, 2002; September 12, 2002; May 22, 2003; August 7, 2003; April 1, 2004; August 17, 2004; May 5, 2005; July 22, 2005; May 15, 2006; August 24, 2006; June 13, 2007; September 26, 2007; June 25, 2008; June 17, 2009; August 18, 2009; April 5, 2010; August 17, 2010; May 4, 2011; July 12, 2011; May 9, 2012; August 7, 2012; April 8, 2013; August 13, 2013; June 24, 2014; August 28, 2014; July 14, 2015; July 20, 2016; April 26, 2017

Physical Characterization

Watershed and Land Use

Peach Creek lies within the San Jacinto River Basin. Sample site 17746 is located in Lake Houston State Park, 1.09 km downstream of FM 1485 in Montgomery County (Figure 359).

The Peach Creek watershed at site 17746 is approximately 399.89 sq km. The lower half of the watershed lies within Level IV Ecoregion 35f, the Flatwoods. The upper half of the watershed lies within Level IV Ecoregion 35e, the Southern Tertiary Uplands. The dominant land cover in the watershed is forest at 50.83% and is present throughout the watershed (Homer et al. 2015; Figure 359 and Figure 360). Grassland is the secondary land cover encompassing 12.3%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 12.33% and total cover for cultivated crops is 0.01%.

From 1992-2011 there was a 111.26 sq km decrease in forest and a 34.67 sq km decrease in pasture/hay. There was a 49.19 sq km increase in grassland and a 45.81 sq km increase in shrub (Figure 361).

There are nine domestic wastewater outfalls (discharges < 1 million gallons per day) and one industrial wastewater outfall (discharges ≥ 1 million gallons per day) within the Peach Creek watershed. One domestic facility is permitted to Splendora ISD, one permitted to Crystal Springs Water Utility Company, three permitted to the cities of Patton Village, Splendora, and Woodbranch Village, and four others permitted to municipal utility districts. The industrial wastewater facility is permitted to Bradbury Development Limited, a residential development company. Three of the domestic facilities discharge directly into Peach Creek.

In Channel and Riparian Physical Habitat

Physical habitat for Peach Creek was evaluated at one site during 19 sampling events from 2002 to 2018. Peach Creek is a perennial stream that drains to Caney Creek before the confluence with Lake Houston. Habitat Quality Index scores are available for 18 sample events and indicate an intermediate to high aquatic life use rating (16-22). Riparian areas were well vegetated throughout the reach with an average riparian buffer ranging from 16 meters wide to greater than 20 meters. The riparian zone was generally dominated by trees followed by shrubs then grasses. The average percentage of tree canopy cover ranged from 15% to 92%. The dominant stream substrate was sand, and the average percent of substrate gravel size or larger varied from 6% to 45%. Average percent instream cover was 6% to 28% and instream cover types include overhanging vegetation, leaf packs, macrophytes, undercut banks, snags, woody debris, root mats, and gravel. Peach Creek ranged from 0.1-0.3 meters deep on average and 6-20 meters wide. Average stream bank slope ranged from 30-60 degrees. Stream flow at the site was measured at a minimum value of 2.5 cfs and a maximum of 44 cfs. Average stream bank erosion potential was 6%-64%. The deepest pool measured at Peach Creek was 1.5 meters. Number of riffles observed at the site varied from zero to five, and total number of stream bends ranged from one to seven.

Water Quality

Water samples were collected at station 17746 over 78 sampling events from June 2002 through October 2019. Parameters measured included temperature, flow, transparency, specific conductance, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total nitrogen, phosphorus, total organic carbon, chloride, sulfate and chlorophyll-*a*. Twenty-four-hour data were collected at this station.

Biological Characterization

Fish

A total of 44 species (13 families) were collected over the 27 fish sampling events. Species richness ranged from 11 to 23 and averaged 17 species per sampling event. The richest family was Cyprinidae with 13 species represented. Blacktail Shiner, Longear Sunfish, and Blacktail Redhorse *Moxostoma poecilurum* were collected during every event. Blacktail Shiner was the most abundant fish in all but one collection where Longear Sunfish slightly outnumbered it. Four species were only collected once and in each case were represented by one individual. These species were Cypress Darter, Southern Brook Lamprey *Ichthyomyzon gagei*, Blue Catfish *Ictalurus furcatus*, and Golden Shiner.

Of the 27 fish collections, four rated as having an exceptional aquatic life use (May 2005, June 2008, August 2009, and July 12, 2011), 21 high, and two intermediate (April 2004 and June 2009). When the coefficient of variability is applied four assemblages rating as high rise to exceptional (May 2005, August 2006, September 2007, and August 2010) and one of the intermediate ratings rise to high (April 2004).

Benthic Macroinvertebrates

Considering the 28 RBP samples collectively, a total of 6096 individuals representing 101 taxa from 16 orders of macroinvertebrates were collected from Peach Creek (Appendix E). The Ephemeroptera, Trichoptera, Coleoptera, Odonata, and Diptera were the most commonly collected orders, collectively accounting for 92.2 percent of the total number of individuals collected. The Hemiptera, Decapoda, and Veneroida were the only other orders which comprised at least one percent of the collections.

The Ecoregions 33 and 35 BIBIs for the RBP samples fell in the either the exceptional aquatic life use category (September 2002, April 2004, May 2005, July 2005, May 2006, August 2006, June 2007, September 2007, June 2008, August 2009) or the high aquatic life use category (June 2002, May 2003, August 2003, August 2004, June 2009, April 2010, August 2010, May 2011, July 2011, May 2012, August 2012, April 2013, August 2013, June 2014, August 2014, July 2015, July 2016, April 2017).

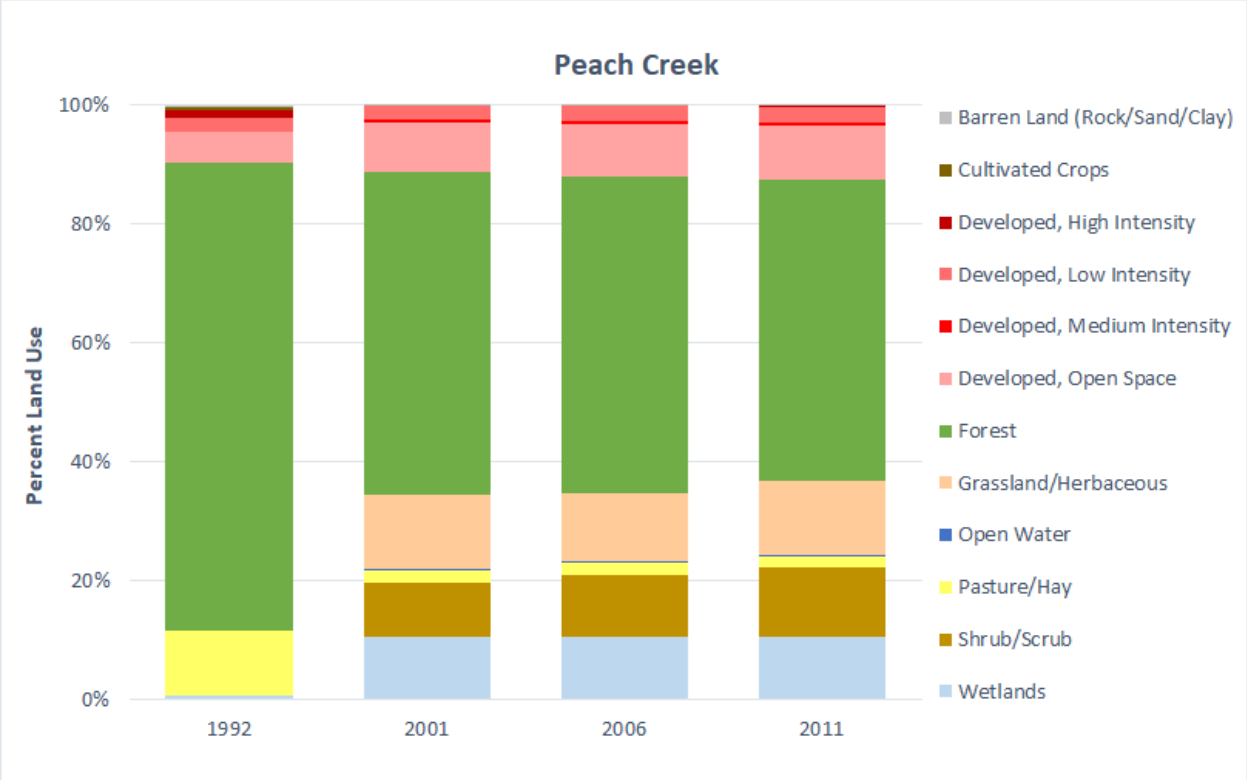

Figure 360. Percent land use in the Peach Creek watershed from 1992-2011.

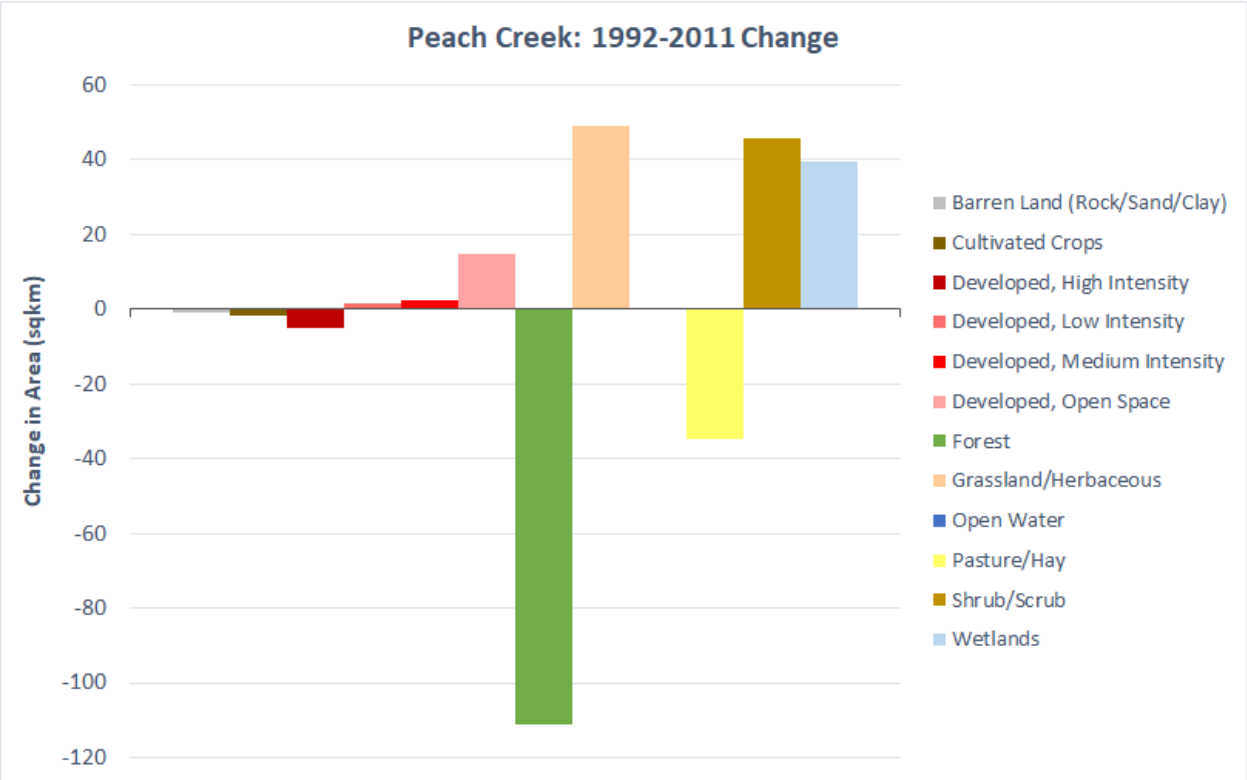

Figure 361. Land use change in area (sq km) from 1992-2011 for the Peach Creek watershed.

PINEY CREEK

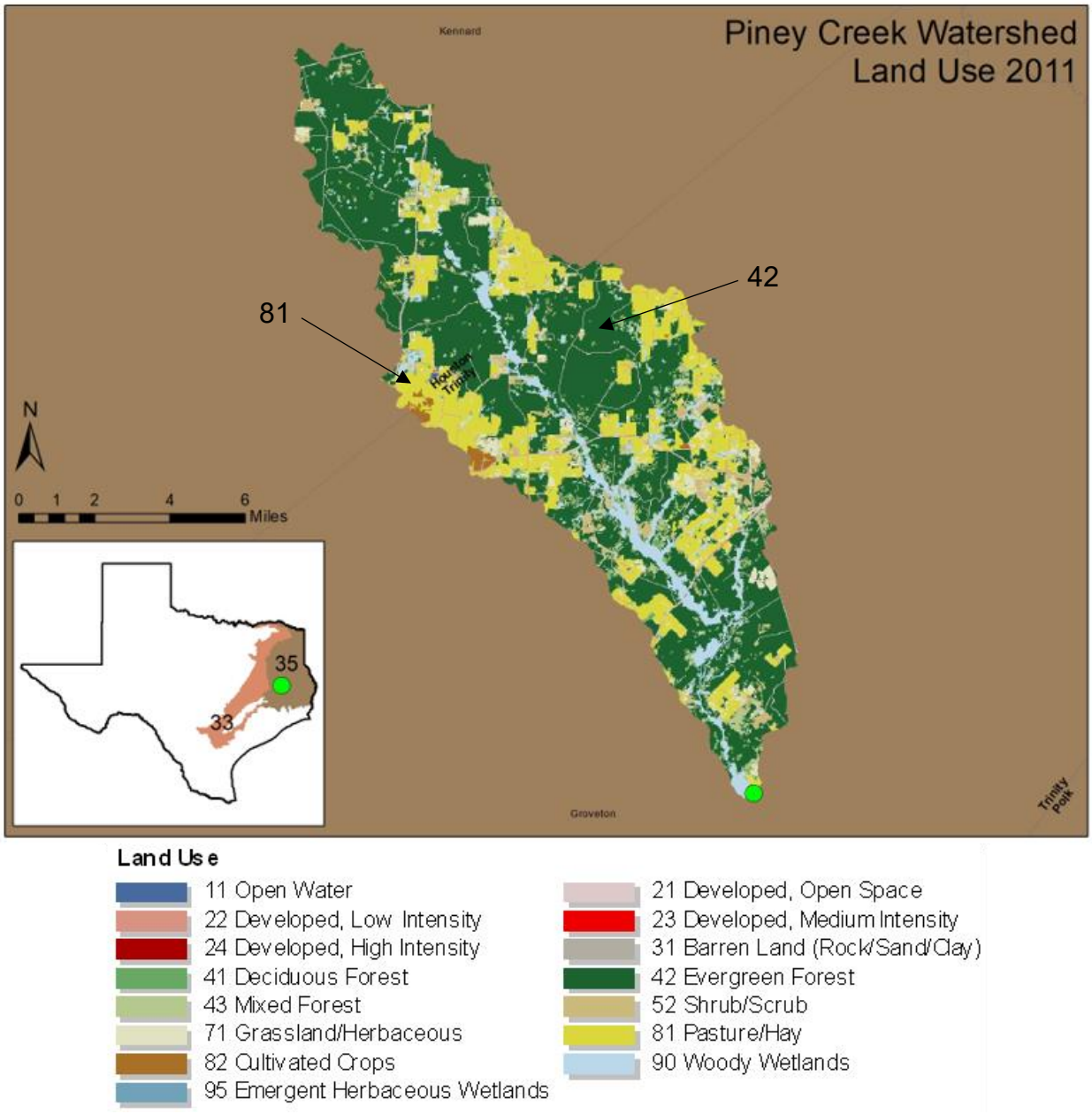

Figure 362. Map of Piney Creek watershed location and 2011 land use; forest and pasture/hay were the most common land uses.

Sampling Dates

Physical Habitat:	September 14, 1989; June 14, 2017; July 18, 2018
Water Quality:	22 sampling events
Fish:	September 14, 1989; June 14, 2017; July 26, 2017
Benthic Invertebrates:	September 14, 1989; June 14, 2017; July 26, 2017

Physical Characterization

Watershed and Land Use

Piney Creek lies within the Neches River Basin. Sample site 10530 is located at FM 2262, 6.9 km east northeast of Groveton in Trinity County (Figure 362).

The Piney Creek watershed at site 10530 is approximately 251.71 sq km. The entire watershed lies within Level IV Ecoregion 35e, the Southern Tertiary Uplands. The dominant land cover in the watershed is forest at 59.25% and is present throughout the watershed (Homer et al. 2015; Figure 362 and Figure 363). Pasture/hay is the secondary land cover encompassing 18.29%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 3.66% and total cover for cultivated crops is 0.58%.

From 1992-2011 there was a 31.62 sq km decrease in forest and a 10.98 sq km decrease in pasture/hay. There was a 16.87 sq km increase in shrub and a 10.69 sq km increase in wetlands (Figure 364).

There are no permitted wastewater outfalls within the Piney Creek watershed.

In Channel and Riparian Physical Habitat

Physical habitat for Piney Creek was evaluated during three sampling events from 1989 to 2018. Piney Creek is a perennial stream that drains to the Neches River below Lake Palestine. Habitat Quality Index scores are available for two sample events and indicate a high aquatic life use rating (21-22.5). Riparian areas were well vegetated throughout the reach with an average riparian buffer ranging from 16 meters wide to greater than 20 meters. The riparian zone was generally dominated by trees followed by grasses then shrubs. The average percentage of tree canopy cover ranged from 85% to 93%. The dominant stream substrate was sand, and the average percent of substrate gravel size or larger varied from 14% to 32%. Average percent instream cover was 26% to 36% and instream cover types include overhanging vegetation, macrophytes, woody debris, and gravel. Piney Creek ranged from 0.1-0.3 meters deep on average and 4-6 meters wide. Average stream bank slope ranged from 26-42 degrees. Stream flow at the site was measured at a minimum value of 0.2 cfs and a maximum of 2 cfs. Average stream bank erosion potential was 43%-62%. The deepest pool measured at Piney Creek was 1.4 meters. Number of riffles observed at the site varied from one to four, and total number of stream bends ranged from four to seven.

Water Quality

Water samples were collected at station 10530 over 22 sampling events from September 1989 through September 2019. Parameters measured included temperature, flow, specific conductance, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total nitrogen, phosphorus, total organic carbon, chloride, sulfate and chlorophyll-*a*. A use attainability analysis study was conducted by TCEQ's Water Quality Standards team and sampling took place at three sites from 2018 through 2019.

Biological Characterization

Fish

Twenty-nine species (nine families) were collected over the course of the three sampling events. Centrarchidae and Cyprinidae were the most species rich families yielding nine and eight species, respectively. Western Mosquitofish was the most abundant species in 1989, whereas Redbreast Sunfish was in 2017. The 1989 fish assemblage received an aquatic life use rating of high. The 2017 collections showed a decline with ratings of limited and intermediate; however, when the coefficient of variability was applied each elevated to the next aquatic life use. Those metrics showing the greatest decline are number of native cyprinid species, number of benthic invertivore species, and percentage of individuals as non-native species. Seven native cyprinid species were collected in 1989 whereas only three were collected in 2017 (including one not found in 1989 - Redfin Shiner). Minnow species not collected in the recent collections include: Mississippi Silvery Minnow *Hybognathus nuchalis*, Golden Shiner, Blackspot Shiner, Weed Shiner, and Bullhead Minnow. Benthic invertivore species declined from four to two, with Slough Darter and Spotted Sucker not being present in the 2017 samples. No non-native species were detected in 1988; however, by 2017 27.5% of the individuals collected were non-native (Redbreast Sunfish). Six other species in addition to Redbreast Sunfish were unique to the 2017 samples. In most instances these species were represented by one individual (Blue Catfish, Redfin Shiner, Black Bullhead, and Flier), except for Warmouth (five individuals) and Redspotted Sunfish which was the second most abundant member of the fish assemblage.

Benthic Macroinvertebrates

A total of 1,790 individuals representing 13 orders of macroinvertebrates were collected in the three samples from Piney Creek (Appendix E). Trichoptera, Diptera, Coleoptera, and Ephemeroptera were the most abundant orders, representing 42.5%, 20.7%, 13.2%, and 9.7%, respectively, of the total number of individuals collected. Oligochaeta (7.8%) and Pelecypoda (3.4%) were the only other orders which accounted for greater than 1% of the total number of individuals collected.

The functional organization of the Piney Creek macroinvertebrate assemblage was dominated by filtering collectors which accounted for 46.7% of the total number of individuals collected. The collector gatherers (23.7%), scrapers (15.7%), predators (11.5%) and shredders (2.4%) functional groups were represented at lower relative abundance.

The EPT ranged from a minimum of four to a maximum of 10 with a median value of six, which falls between the 25th and 50th percentile of all EPT values for least disturbed streams sampled in the aggregated ecoregion. The biotic index ranged from a minimum of 4.6 to a maximum of 5.9. The median value of the biotic index, 5.2, falls between the 50th and 75th percentile of all biotic index values for least disturbed streams sampled in the aggregated ecoregion, indicating a moderately tolerant macroinvertebrate assemblage.

The BIBI score for the 1989 Surber sample falls in the range indicating an exceptional aquatic life use. The exceptional BIBI score is a result of maximum scores for the metrics total number of taxa, number of Diptera taxa, number of intolerant taxa, percent EPT, percent tolerant, and percent gatherers, and a low relative dominance of the three most abundant taxa in the Surber sample. Results for the Ecoregions 33 and 35 BIBI for the two RBP samples collected in 2017 were relatively consistent and indicated intermediate aquatic life use for both samples.

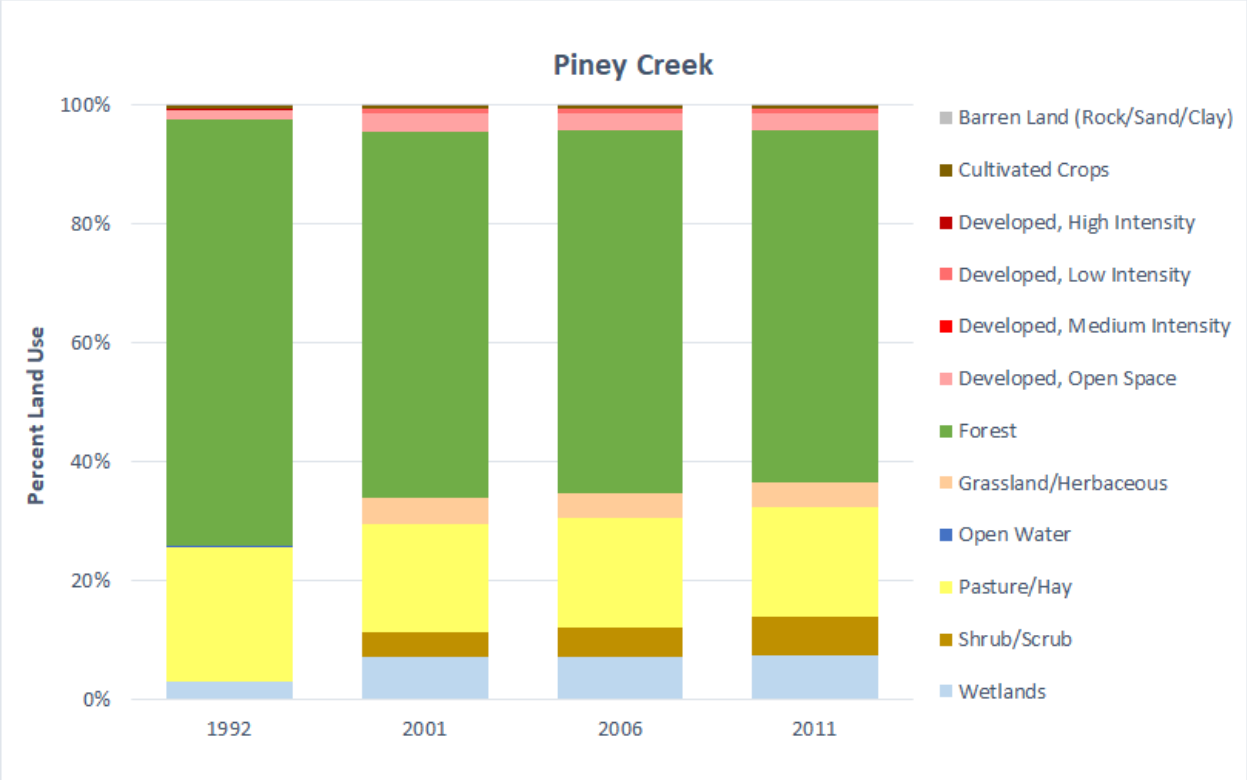

Figure 363. Percent land use in the Piney Creek watershed from 1992-2011.

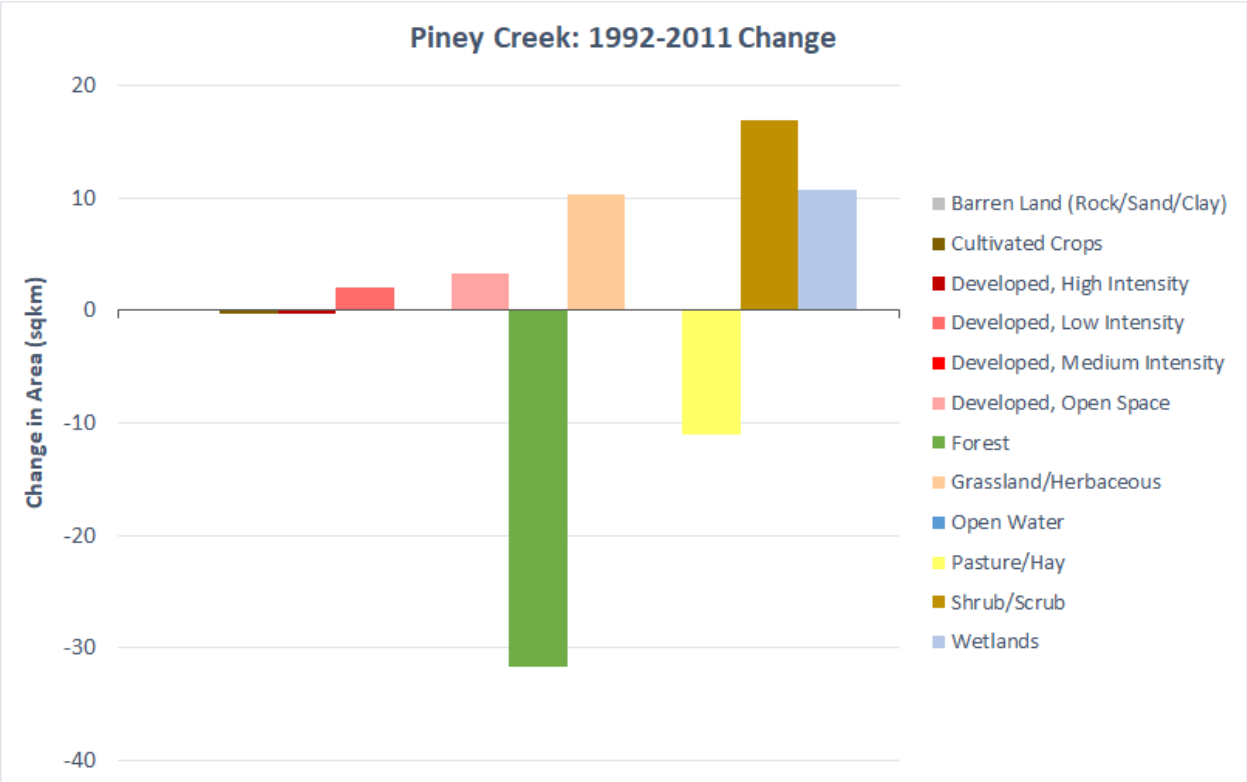

Figure 364. Land use change in area (sq km) from 1992-2011 for the Piney Creek watershed.

SAN PEDRO CREEK

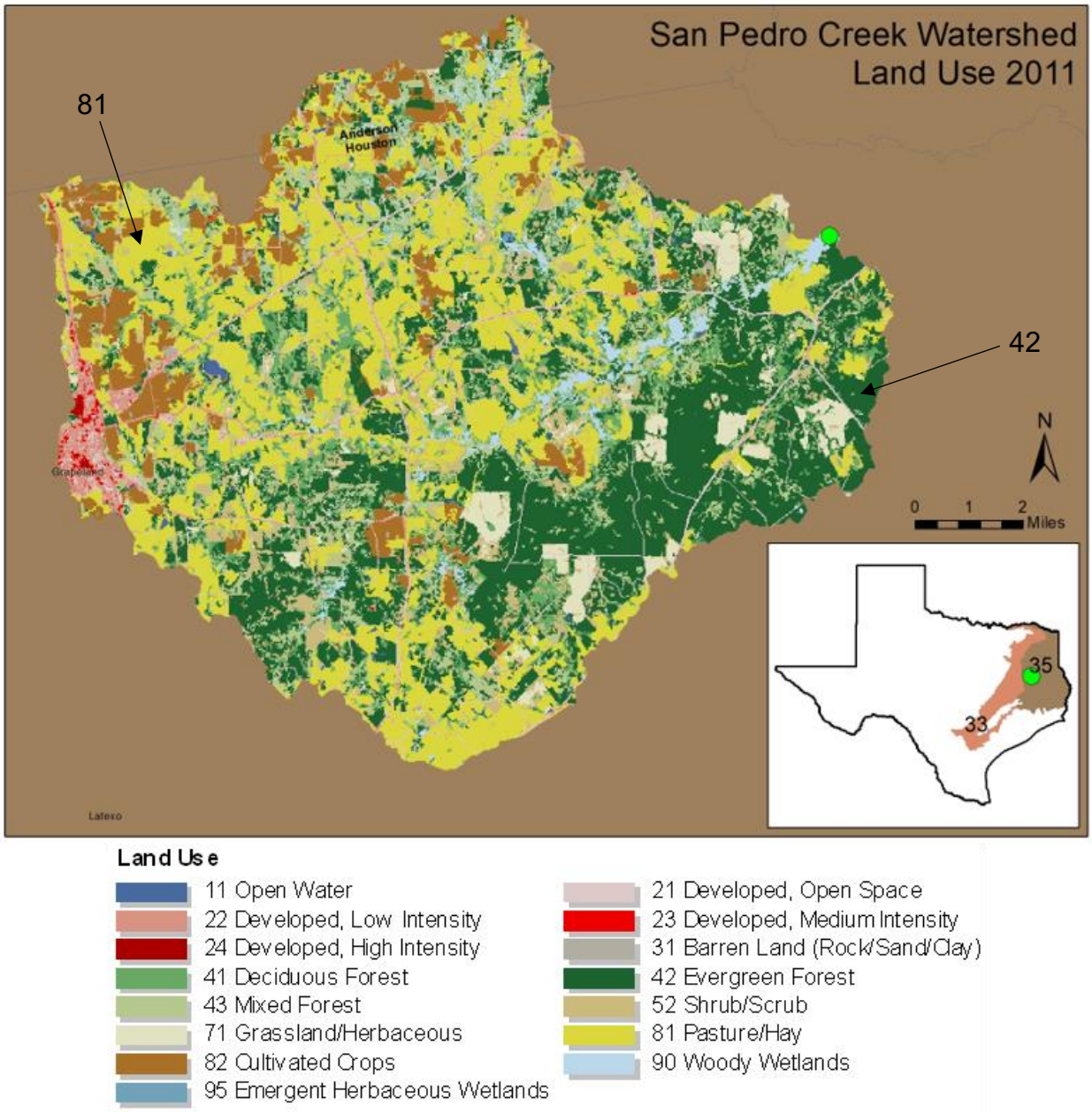

Figure 365. Map of San Pedro Creek watershed location and 2011 land use; forest and pasture/hay were the most common land uses.

Sampling Dates

Physical Habitat:	May 30, 2018
Water Quality:	1 sampling event
Fish:	May 30, 2018
Benthic Invertebrates:	May 30, 2018

Physical Characterization

Watershed and land use

San Pedro Creek lies within the Neches River Basin. Sample site 22071 is located in Mission Tejas State Park, 3 km upstream of the Neches River in Houston County (Figure 365).

The San Pedro Creek watershed at site 22071 is approximately 343.74 sq km. The entire watershed lies within Level IV Ecoregion 35a, the Tertiary Uplands. The dominant land cover in the watershed is forest at 45.79% and is most concentrated in the eastern portion of the watershed (Homer et al. 2015; Figure 365 and Figure 366). Pasture/hay is the secondary land cover encompassing 27.84%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 6.13% and total cover for cultivated crops is 6.8%.

From 1992-2011 there was a 51.1 sq km decrease in pasture/hay and a 3.9 sq km decrease in high intensity development. There was a 24.64 sq km increase in shrub, an 11.43 sq km increase in cultivated crops, and a 10.76 increase in grassland (Figure 367).

There is one industrial wastewater outfall (discharges ≥ 1 million gallons per day) within the San Pedro Creek watershed permitted to the City of Grapeland. This facility does not discharge directly into San Pedro Creek.

In Channel and Riparian Physical Habitat

Physical habitat for San Pedro Creek was evaluated on May 30, 2018. The Habitat Quality Index score of 19 indicates an intermediate aquatic life use rating. Riparian areas were well vegetated throughout the reach with an average riparian buffer measured at greater than 20 meters. The riparian zone was dominated by trees and grasses, which each made up an average of 40% of the total riparian species, followed by shrubs (20%). The average percentage of tree canopy cover was 97%. The dominant substrate was sand and the average percent of substrate gravel size or larger was 0%. Average percent instream cover was 13% and instream cover types include woody debris, root mats, leaf packs, overhanging vegetation, and undercut banks. San Pedro Creek was 0.3 meters deep on average and 7 meters wide. Average stream bank slope was 44 degrees and the average stream bank erosion potential was 69%. Stream flow at the site was 16 cfs. The deepest pool measured at San Pedro Creek was 1.5 meters. No riffles were observed at the site and there were two well defined stream bends.

Water Quality

Water samples were collected at station 22071 at one sampling event on May 30, 2018. Twenty-four-hour data were collected at this sampling event. Grab parameters measured included temperature, flow, transparency, specific conductance, dissolved oxygen, and pH.

Biological Characterization

Fish

Nineteen species (seven families) were collected. Nearly all the species fell within three families - Cyprinidae (six species), Percidae (four species), and Centrarchidae (four species). Blacktail Shiner was the most abundant species. The aquatic life use (based upon the fish assemblage) rated as high. The low catch per unit effort and paucity of piscivores were the main reasons for the creek not obtaining an exceptional rating.

Benthic Macroinvertebrates

Considering the one RBP sample from 2018, a total of 191 individuals representing 28 taxa from 9 orders of macroinvertebrates were collected from San Pedro Creek (Appendix E). Coleoptera, Ephemeroptera, Amphipoda, Hemiptera, and Diptera were the most commonly collected orders, collectively accounting for 93 percent of the total number of individuals collected. The Odonata, Plecoptera, Trichoptera, and Decapoda were the other orders collected, all of which comprised at least one percent of the collection. The Ecoregions 33 and 35 BIBI for the May 2018 San Pedro Creek sample fell in the intermediate aquatic life use category.

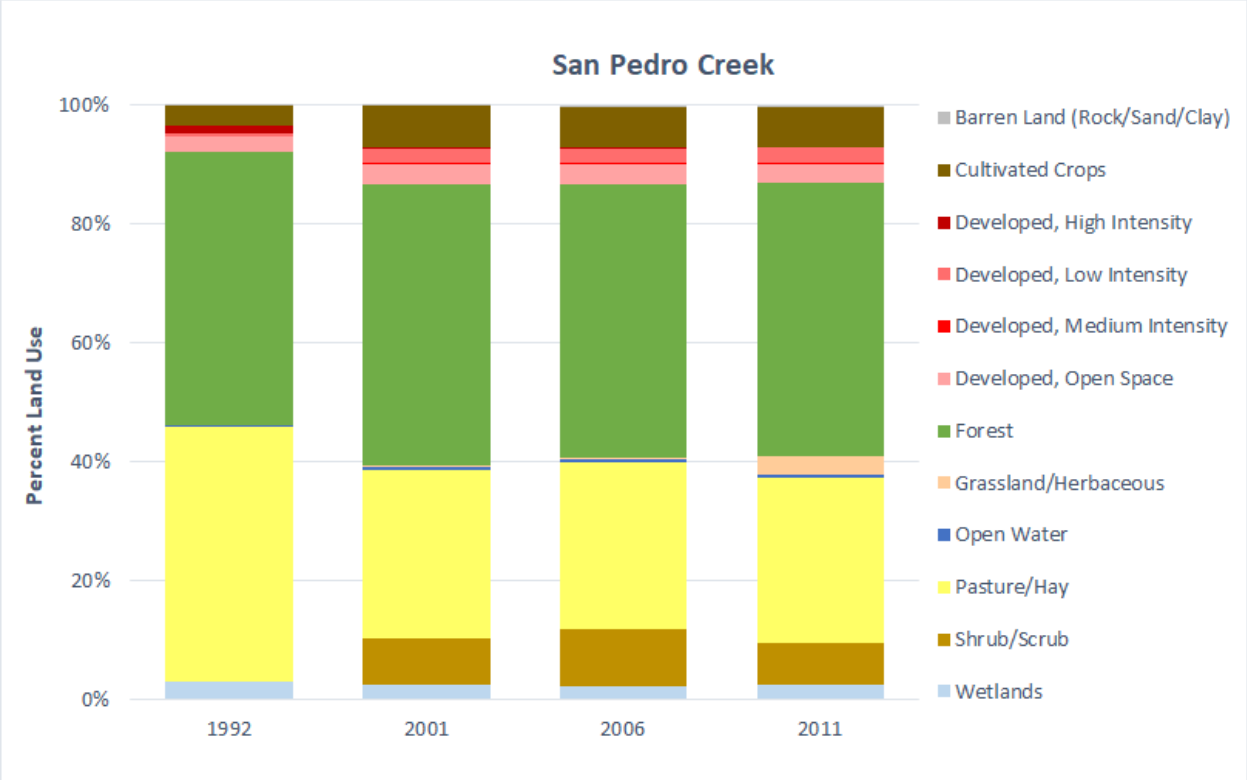

Figure 366. Percent land use in the San Pedro Creek watershed from 1992-2011.

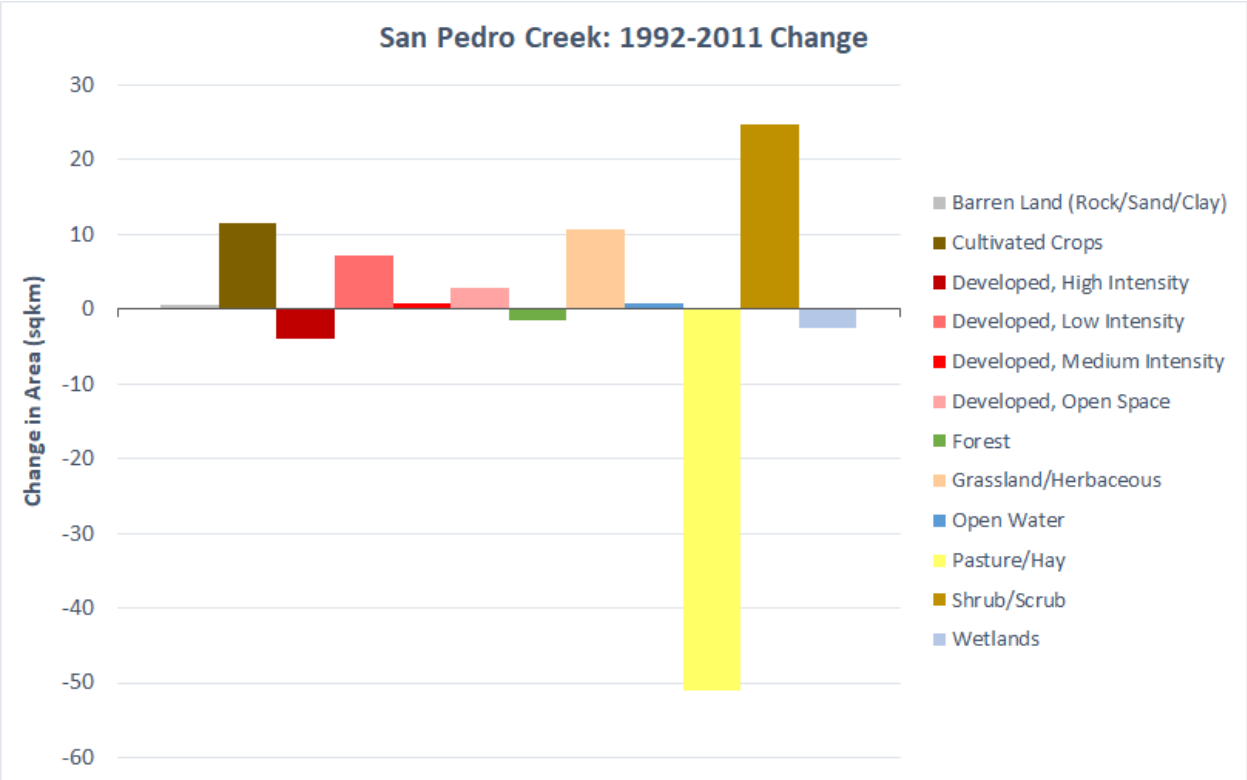

Figure 367. Land use change in area (sq km) from 1992-2011 for the San Pedro Creek watershed.

WEST FORK OF THE SAN JACINTO RIVER

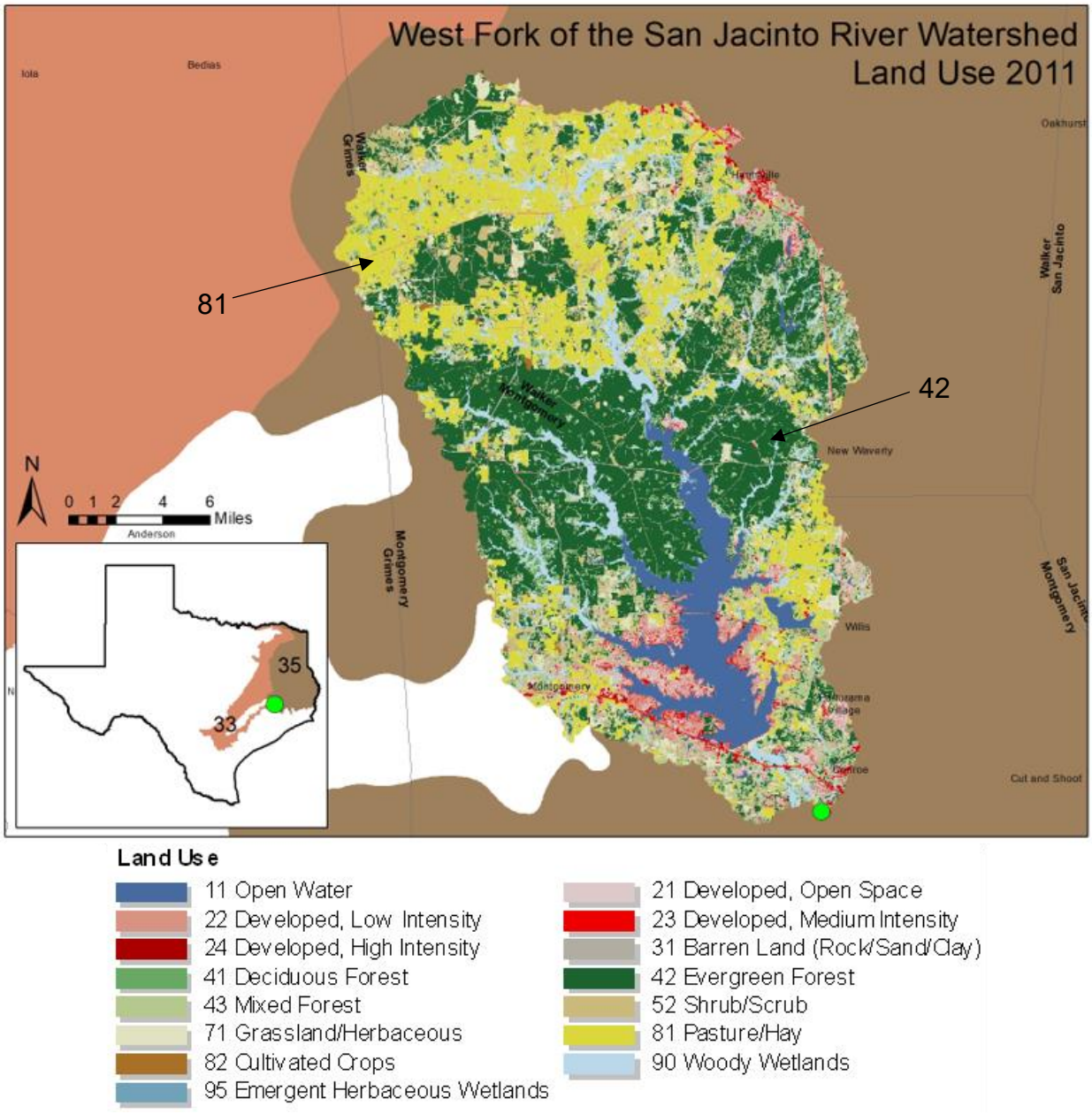

Figure 368. Map of West Fork of the San Jacinto River watershed location and 2011 land use; forest and pasture/hay were the most common land uses.

Sampling Dates

Physical Habitat:	June 3, 2002; September 16, 2002; April 26, 2005
Water Quality:	128 sampling events
Fish:	June 3, 2002; September 16, 2002; April 25, 2005; July 14, 2005
Benthic Invertebrates:	June 3, 2002; September 16, 2002; April 26, 2005; July 14, 2005

Physical Characterization

Watershed and Land Use

The West Fork of the San Jacinto River lies within the San Jacinto River Basin. Sample site 11250 is located at FM 2854 west of Conroe in Montgomery County (Figure 368).

The West Fork of the San Jacinto River watershed at site 11250 is approximately 1225.3 sq km. The watershed lies within Level IV Ecoregion 35e, the Southern Tertiary Uplands. The dominant land cover in the watershed is forest at 42.16% and is most concentrated in the middle portion of the watershed on the northern shores of Lake Conroe (Homer et al. 2015; Figure 368 and Figure 369). The secondary land cover is pasture/hay at 19.59%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 10.43% and total cover for cultivated crops is 0.1%.

From 1992-2011 there was a 144.66 sq km decrease in forest and a 114.51 sq km decrease in pasture/hay. There was a 78.33 sq km increase in grassland and a 75.53 sq km increase in shrub (Figure 370).

There are 41 domestic wastewater outfalls (discharges < 1 million gallons per day) and six industrial wastewater outfalls (discharges ≥ 1 million gallons per day) within the West Fork of the San Jacinto River watershed. The domestic facilities are permitted to the cities of Panorama Village and Montgomery, private residences, residential and commercial developers, municipal utility districts, water and sewer utility companies, Kampgrounds of America (KOA), a sporting goods store, and a few schools. One industrial wastewater facility is permitted to Montgomery County Municipal Utility District, two are permitted to the City of Huntsville, two are permitted to Entergy Texas, Inc - an electric power distribution company, and one is permitted to Lone Star Growers, Inc - a company that grows plants and produce. None of the facilities discharge directly into the West Fork of the San Jacinto River.

In Channel and Riparian Physical Habitat

Physical habitat for the West Fork of the San Jacinto River was evaluated during three sampling events from 2002 to 2005. The West Fork of the San Jacinto River is a perennial stream that drains to Lake Houston. Habitat Quality Index scores are available for all three sample events and indicate a high aquatic life use rating (20-22). Riparian areas were well vegetated throughout the reach with an average riparian buffer ranging from 16 meters wide to 127 meters. The riparian zone was generally dominated by trees followed by shrubs then grasses. The average percentage of tree canopy cover ranged from 47% to 82%. The dominant stream substrate was sand, and the average percent of substrate gravel size or larger varied from 10% to 23%. Average percent instream cover was 7% to 21% and instream cover types include overhanging vegetation, undercut banks, and snags. The West Fork of the San Jacinto River ranged from 0.2-0.4 meters deep on average and 7-10 meters wide. Average stream bank slope ranged from 23-50 degrees. Stream flow at the site was measured at a minimum value of 7 cfs and a maximum of 15 cfs. Average stream bank erosion potential was 10%-19%. The deepest pool measured at the West

Fork of the San Jacinto River was greater than 1 meter. Number of riffles observed at the site varied from two to three, and total number of stream bends ranged from three to four.

Water Quality

Water samples were collected at station 11250 over 128 sampling events from December 1979 through October 2019. Parameters measured included temperature, flow, transparency, specific conductance, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total nitrogen, phosphorus, total organic carbon, chloride, sulfate and chlorophyll-*a*. No 24-hour dissolved oxygen data were collected at this station.

Biological Characterization

Fish

Thirty-six species (12 families) were collected over the course of the four sampling events. Cyprinidae was the most species rich family with 10 species. Blacktail Shiner was the most abundant species in every sample except the one from June 2002 where Fathead Minnow was most abundant. Each sample year had one fish collection that rated as having a high aquatic life use and one rating as exceptional. When the coefficient of variability was applied to the high ratings the one from 2002 rose to exceptional.

Benthic Macroinvertebrates

A total of 997 individuals, representing 14 orders of macroinvertebrates, were collected during the four sample events at West Fork San Jacinto River (Appendix E). The mayflies (Ephemeroptera) were the most abundant order, with taxa from nine genera and five families representing 38.9% of the individuals collected across all sample dates. Diptera and Trichoptera were the next most abundant orders, representing 18.3% and 15.3%, respectively, of the individuals collected. The most abundant families collected were Tricorythidae, Simuliidae, and Hydropsychidae, representing 23.8%, 16.5%, and 8.7%, respectively, of the total number of individuals collected.

The EPT ranged from a minimum of nine to a maximum of 12 with a median value of 10.5, which falls between the 50th and 75th percentile of all EPT values for least disturbed streams sampled in the aggregated ecoregion. The biotic index ranged from a minimum of 4.2 to a maximum of 5.4. The median value of the biotic index, 4.8, falls between the 25th and 50th percentile of all biotic index values for least disturbed streams sampled in the aggregated ecoregion. The maximum EPT value (12) and the median and minimum values for the biotic index indicate that sensitive species are relatively common in the West Fork San Jacinto River.

Considered collectively across all sample dates, the functional organization of the West Fork San Jacinto River macroinvertebrate assemblage was dominated by collector gatherers, filtering collectors, and predators which accounted for 40.1%, 28.6%, and 16.5%, respectively, of the total number of individuals collected. The grazers (8.7%) and shredders (6.1%) functional groups represented a smaller proportion of individuals. Percent dominant functional group is a

macroinvertebrate community structure metric where low to moderate values reflect a balanced community, and higher values indicate a stressed community. Values for % Dominant FFG for West Fork San Jacinto River ranged from 47.7% to 61.2%. The median value of 56.0 % falls between the 50th and 70th percentile of all values for least disturbed streams sampled in the aggregated ecoregion. These metrics indicate that the West Fork San Jacinto River has a moderately balanced community structure, with the maximum value of 61.2% dominant FFG skewed by the high proportion of filtering collectors (blackfly larvae) collected in the April 2005 sample.

Results for the Ecoregions 33 and 35 BIBI for the four RBP samples collected at the West Fork San Jacinto River reflect a somewhat high degree of variability (CV 11.5%), ranging from 26 (intermediate) to 34 (high). The median of the four benthic IBI scores, 29.5, falls between the 50th and 75th percentile of all benthic RBP IBIs for the South Central and Southern Humid, Mixed Land Use Region.

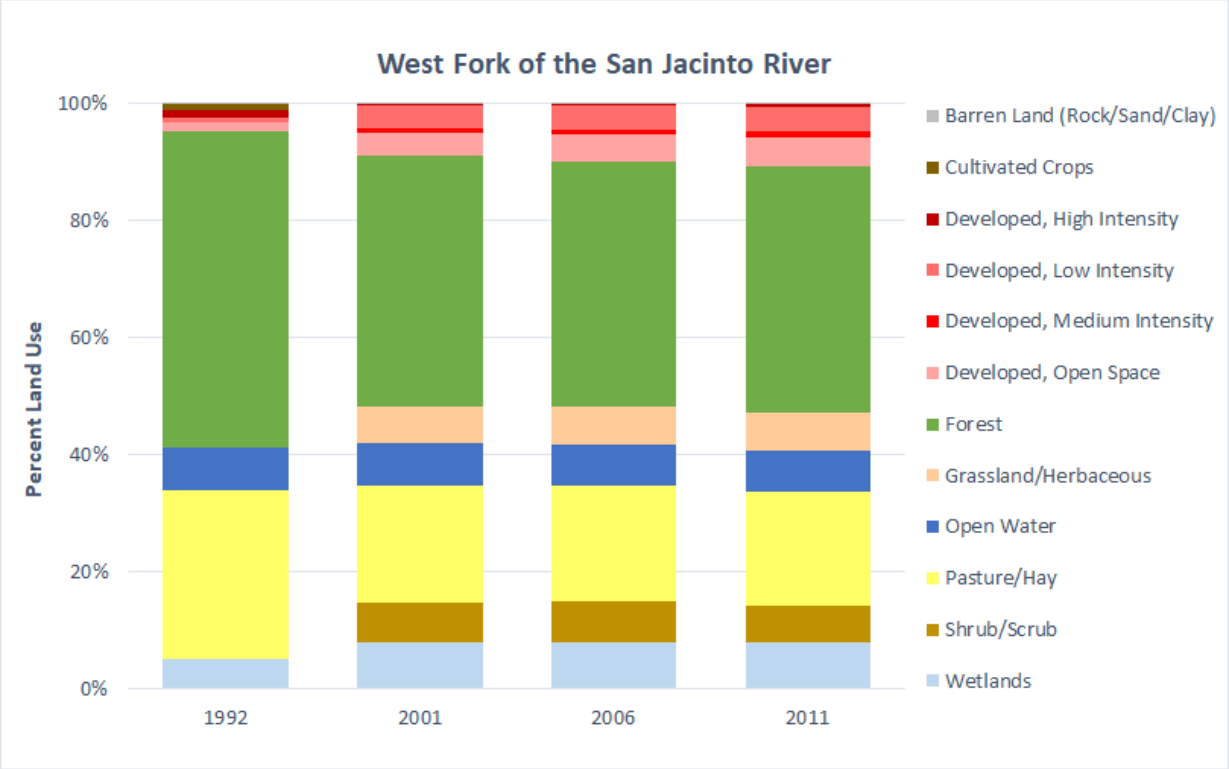

Figure 369. Percent land use in the West Fork of the San Jacinto River watershed from 1992-2011.

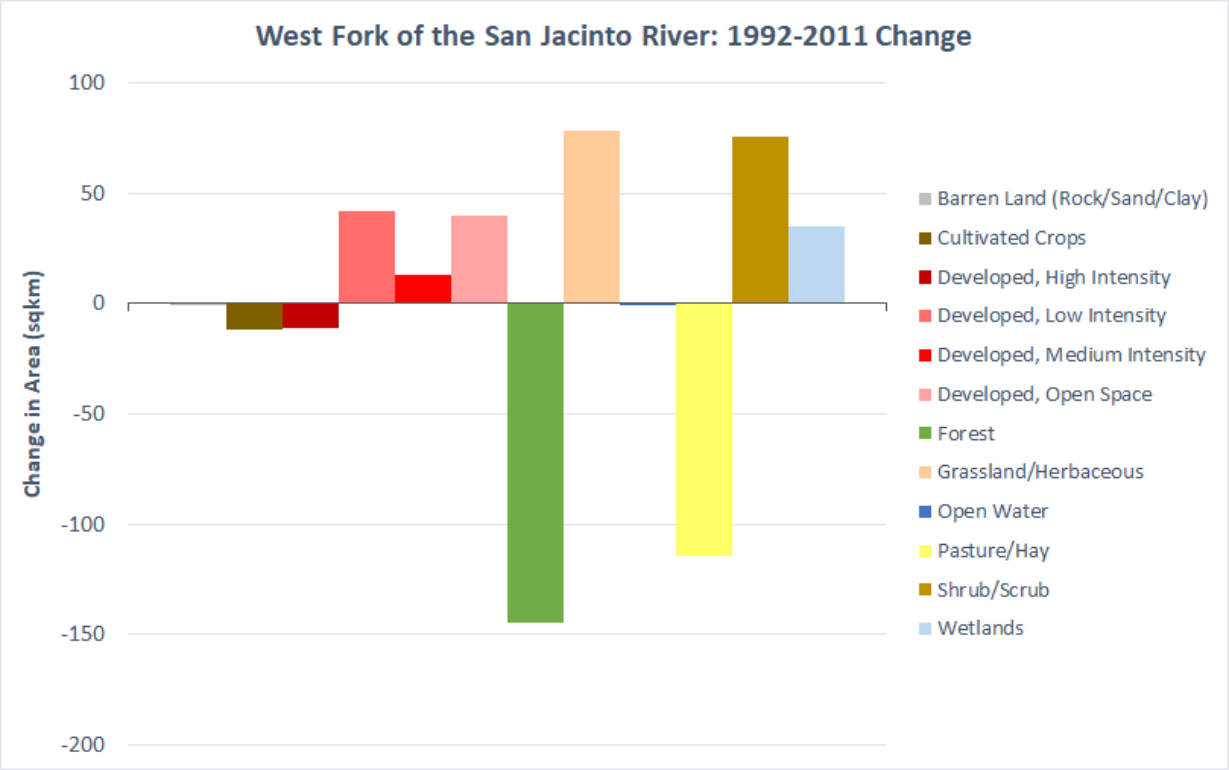

Figure 370. Land use change in area (sq km) from 1992-2011 for the West Fork of the San Jacinto River watershed.

WHITE OAK CREEK

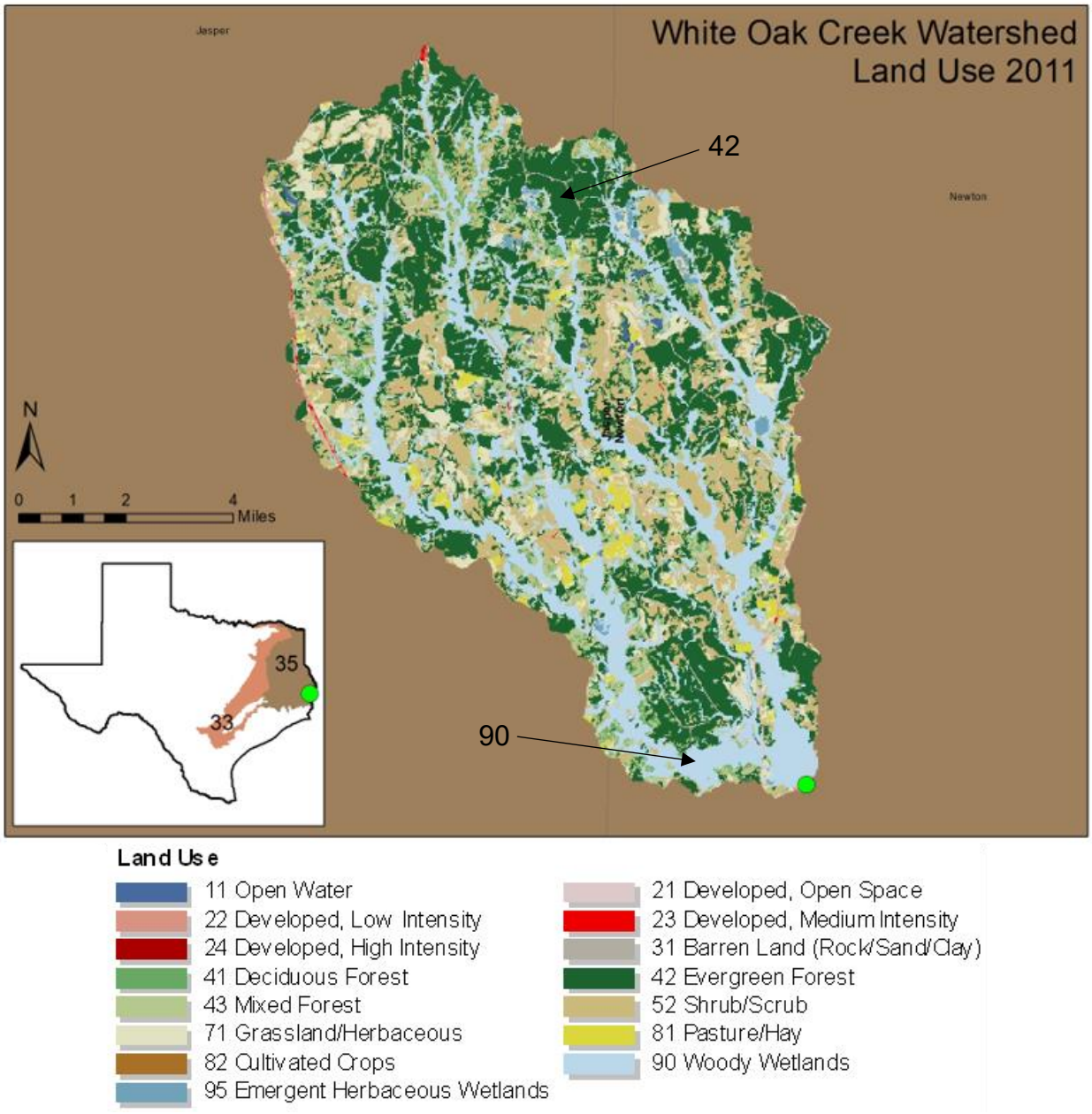

Figure 371. Map of White Oak Creek watershed location and 2011 land use; forest and wetlands were the most common land uses.

Sampling Dates

Physical Habitat:	September 13, 1989
Water Quality:	8 sampling events
Fish:	September 12, 1989
Benthic Invertebrates:	September 13, 1989

Physical Characterization

Watershed and Land Use

White Oak Creek lies within the Sabine River Basin. Sample site 10341 is located at FM 363 east of Bleakwood in Newton County (Figure 371).

The White Oak Creek watershed at site 10341 is approximately 233.25 sq km. The lower portion of the watershed lies within Level IV Ecoregion 35f, the Flatwoods, while the middle and upper portions of the watershed lay within Level IV Ecoregion 35e, the Southern Tertiary Uplands. The dominant land cover in the watershed is forest at 44.6% and is present throughout the watershed (Homer et al. 2015; Figure 371 and Figure 372). Wetlands is the secondary land cover encompassing 23.53%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 3.64% and there is no cultivated crop cover present within the watershed.

From 1992-2011 there was a 108.25 sq km decrease in forest and a 7.9 sq km decrease in pasture/hay. There was a 49.19 sq km increase in wetlands and a 45.17 sq km increase in shrub (Figure 373).

There are no permitted wastewater outfalls within the White Oak Creek watershed.

In Channel and Riparian Physical Habitat

Physical habitat for White Oak Creek was evaluated on September 13, 1989. White Oak Creek drains to Big Cow Creek east of Kirbyville in Newton County. The riparian width was 91 meters. The riparian zone was dominated by trees, which made up an average of 80% of the total riparian species, followed by shrubs (15%) then grasses (5%). The average percentage of tree canopy cover was 82%. The dominant substrate was silty sand, and the average percent of substrate that was gravel size or larger was 2%. Average percent instream cover was 53% and instream cover types included fallen logs, undercut banks, root snags, cypress knees and overhanging vegetation. White Oak Creek had an average depth of 0.9 meters and a maximum depth of 1.9 meters. The average width was 8.5 meters and average stream bank slope was 50 degrees. Stream flow at the site was 26 cfs. Average stream bank erosion potential was 71%. Two riffles were observed at the site and there were six total stream bends.

Water Quality

Water samples were collected at station 10341 over 8 sampling events from September 1989 through July 1999. Parameters measured included temperature, flow, transparency, specific conductance, dissolved oxygen, pH, alkalinity, ammonia, total Kjeldahl nitrogen, total nitrogen, phosphorus, total organic carbon, chloride, sulfate and chlorophyll-*a*. No 24-hour dissolved oxygen data were collected at this station.

Biological Characterization

Fish

Twenty species (eight families) were collected from White Oak Creek. Only three families were represented by more than one species. Percidae, Cyprinidae, and Centrarchidae each yielded five species. Weed Shiner was the most abundant species. The aquatic life use rating (based upon the fish assemblage) rated as high.

Benthic Macroinvertebrates

A total of 186 individuals representing 13 orders of macroinvertebrates were collected in the Surber sample from White Oak Creek (Appendix E). Coleoptera, Diptera, Oligochaeta, and Trichoptera were the most abundant orders, representing 26.9%, 24.2%, 17.7%, and 10.2%, respectively, of the total number of individuals collected. Gastropoda (5.9%), Pelecypoda (5.4%), and Ephemeroptera (4.3%) were also well represented in the collection. Other taxa, representing greater than 1% of the nine collections combined, include Hemiptera (1.6%), Lepidoptera (1.1%), and Decapoda (1.1%).

The functional organization of the White Oak Creek macroinvertebrate assemblage is dominated by collector gatherers, scrapers, and filtering collectors, which accounted for 47.1%, 23.4%, and 15.6%, respectively, of the total number of individuals collected. Predators (7.1%) and shredders (6.3%) were represented at lower relative abundance.

Nine EPT taxa were collected in White Oak Creek. This value falls between the 50th and 75th percentile for all EPT values for least disturbed streams in ecoregion aggregate 33/35. The biotic index value for the White Oak Creek benthic assemblage (6) falls between the 75th and 95th percentiles for all biotic index values in the ecoregion aggregate indicating a moderately tolerant macroinvertebrate assemblage.

The sample BIBI score falls in the range indicating an exceptional aquatic life use. The exceptional BIBI score is a result of maximum scores for the metrics total number of taxa, number of Diptera taxa, number of intolerant taxa, percent tolerant, percent grazers, and percent gatherers, and a low relative dominance of the three most abundant taxa in the Surber sample.

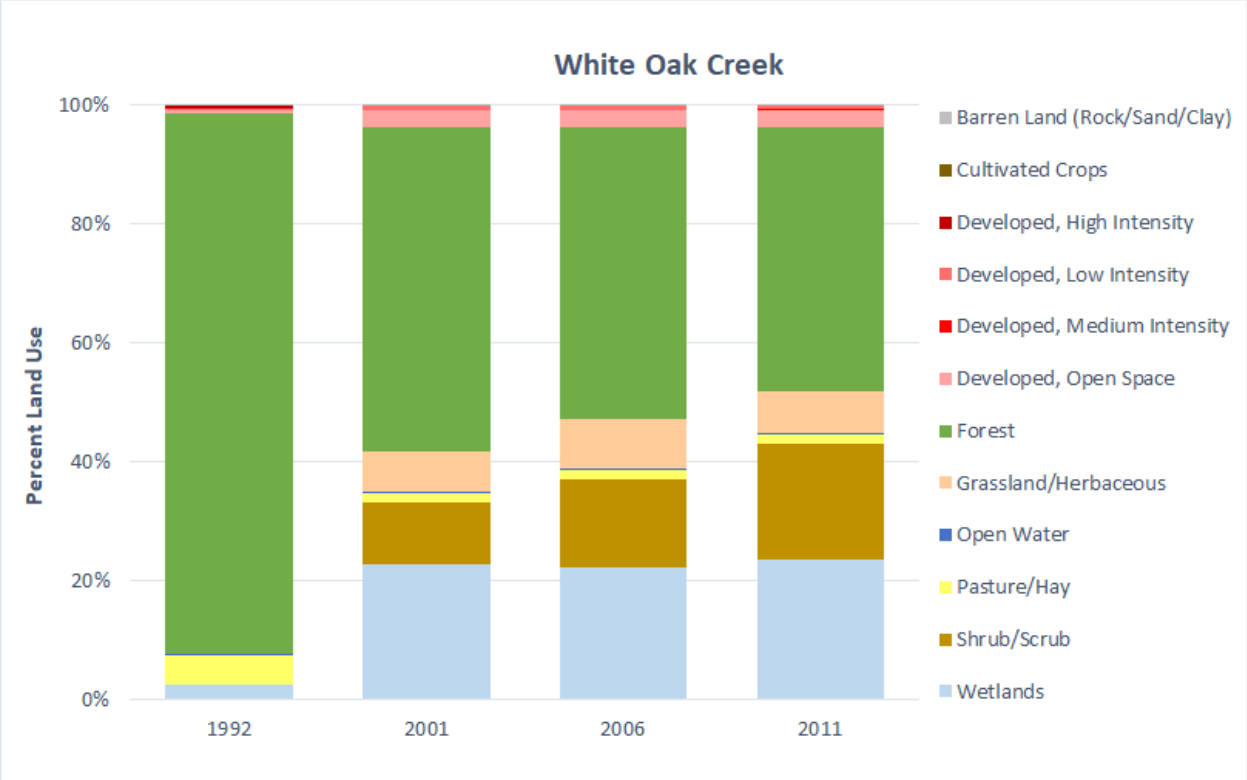

Figure 372. Percent land use in the White Oak Creek watershed from 1992-2011.

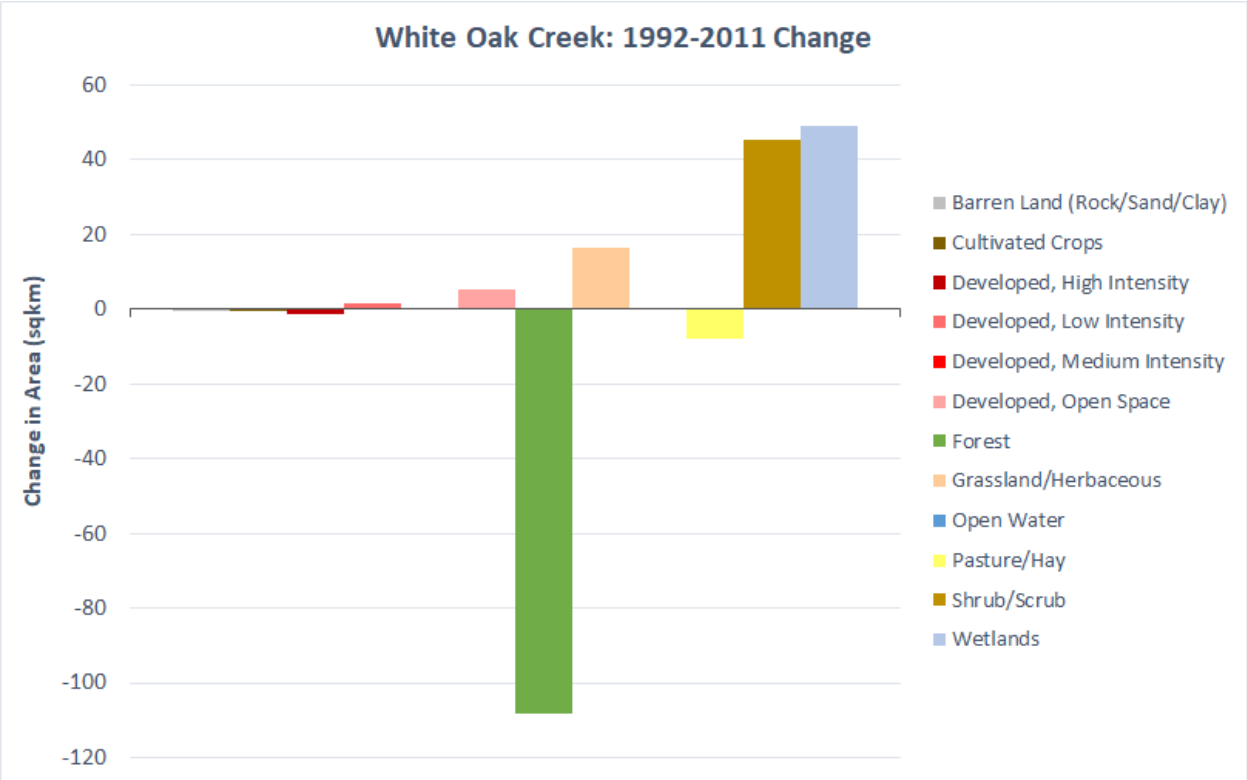

Figure 373. Land use change in area (sq km) from 1992-2011 for the White Oak Creek watershed.

Ecoregions 33 and 35 Summary and Historical Characterization

Watershed and Land Use

Ecoregion 33 was historically covered by post oak savannas with a dense underlying clay pan. Much of this area is now used for pasture and rangeland (Griffith et al. 2007). In 2011 the overall primary land cover in the study watersheds was pasture/hay and the secondary land cover was forest. Between 1992-2011, forest experienced the largest decrease in combined land cover area across all watersheds (~382.75 sq km) and shrub experienced the largest increase (~212.11 sq km).

Ecoregion 35 was historically a mix of pine and hardwood forests, but due to timber production much of the area has been replanted to loblolly and shortleaf pine plantations. Lumber and pulpwood production, livestock grazing, poultry production, as well as oil and gas production are major economic activities (Griffith et al. 2007). In 2011 the overall primary land cover in the study watersheds was forest and the secondary land cover was pasture/hay. Between 1992-2011, forest experienced the largest decrease in combined land cover across all watersheds (~1,130.01 sq km) and shrub experienced the largest increase (~408.10 sq km).

In Channel and Riparian Physical Habitat

Physical habitat for the South Central and Southern Humid, Mixed Land Use Region was evaluated at 31 streams over 135 sampling events from 1986 to 2018. Watershed area varied from a minimum of 11 sq km at Blair Creek to a maximum of 1,225 sq km at the West Fork of the San Jacinto River. The sites generally had well vegetated riparian zones, and the riparian buffer was measured at a minimum of 4 meters and maximum of 250 meters. Trees were the dominant riparian species, followed by grasses then shrubs, and average percent tree canopy coverage was 73%. Dominant substrate at the sites was generally sand followed by clay then silt. Average percentage of substrate gravel sized or larger was 14% and varied from a minimum of 0% to a maximum of 76%. Average percent instream cover was 26% and common instream cover types include large and small woody debris, undercut banks, overhanging vegetation, root mats, leaf packs, snags, macrophytes, algae, and gravel. Average stream depth and width measurements were 0.3 meters and 9 meters, respectively. Average stream bank slope was 37 degrees and erosion potential was moderate, with an average of 40% which was reflected in the average bank stability HQI score (1.7) indicating moderately stable to moderately unstable stream banks. Maximum pool depth ranged from a minimum of 0 meters to a maximum of 2 meters. Total number of riffles varied from zero to seven, and total number of stream bends ranged from zero to ten. Additional in-channel and riparian physical habitat attributes are summarized in Appendix B.

HQI scores are available for 110 events and range from a maximum score of 24 (high) for four Cummins Creek samples to a minimum score of 11 (limited) at Ponds Creek and Beech Creek. Of the 110 sampling events with an HQI score, 64 (58%) received a habitat assessment rating of high, 40 (36%) received a rating of intermediate, and the remaining six (6%) received a rating of limited. The highest scoring HQI metrics for the South Central and Southern Humid, Mixed Land Use

Region were the dimensions of largest pool metric, the channel sinuosity metric, and the riparian buffer vegetation metric. The lowest scoring HQI metrics on average were the bottom substrate stability metric and the bank stability metric.

Water Quality

Water quality data from ecoregions 33 and 35 were similar between stations. Specific conductivity was low in these freshwater systems with a range between 16 and 1908 with a median value of 160 us/cm at 25C. The transparency in the water column had a median secchi value of 0.43 m. Transparency values were low in these ecoregions, indicative of the muddy slow-moving streams that characterize these ecoregions. The pH values ranged from 6.7 to 9.61. Nutrient concentrations in the streams were higher for nitrogen species than for total phosphorus. The median total phosphorus concentration of 0.009 mg/L and the median TKN concentration was 0.61 mg/L. Additional water quality variables are summarized in appendix C of the report.

Fish

A total of 57,398 individuals consisting of 18 families and 95 species have been documented in 173 sampling events across 31 streams in the South Central and Southern Humid, Mixed Land Use Region from 1986 to 2018 (Appendix D - 6). For individual sites, taxa richness ranged from 56 species at Mill Creek across 33 sampling events from 1988 to 2017 to a low of 15 species at Smackover Creek during two sampling events in 2008. Taxa richness at each site was heavily correlated with the number of sampling events during the period of record. The most abundant species collected across all sites and sampling events were Blacktail Shiner (n = 16,031), Western Mosquitofish (n = 6,903), Longear Sunfish (n = 4,774), Red Shiner (n = 3,025), and Blackstripe Topminnow (n = 2,960).

Index of biotic integrity scores across all sites and sampling events ranged from 29 to 58 resulting in aquatic life use categories of limited (n = 7), intermediate (n = 26), high (n = 107), and exceptional (n = 33; Figure 374). Of the 173 sampling events in this ecoregion, 81% received an ALU rating of high or exceptional; 19% received an ALU of intermediate or limited. Most sites that were sampled multiple times received ALUs in at least two different categories. All sites received one ALU score of high or better except for Kickapoo and Cuthand creeks which both received ALU scores of intermediate only.

Overall, IBI scores and individual metrics 1-2, 4-8, and 10-11 did not change through time (Figure 375; Figure 376; Figure 377); however, the number of benthic invertivores, percentage of individuals as piscivores and the percentage of individuals with disease/anomaly significantly decreased through time (Figure 376(3): $R^2 = 0.03$, $p = 0.03$; Figure 377(9): $R^2 = 0.02$, $p = 0.049$; Figure 377(12): $R^2 = 0.11$, $p < 0.01$). Although these were significant relationships, R^2 values were very low.

The decrease in number of benthic invertivores could be due to a slight decrease in benthic invertivore taxa which are primarily native catostomids and percids. The decrease in the percentage of individuals as piscivores is likely due to a few samples that were collected on

Black Bayou in the early 1990s where only a backpack shocker was used which probably resulted in an increase in larger-bodied piscivores resulting in elevated metric scores. The decrease in the proportion of individuals with a disease/anomaly is likely due to sampler bias rather than a significant change in disease/anomaly. This is a characteristic that is often overlooked while in the field.

Benthic Macroinvertebrates

The aquatic macroinvertebrate assemblage in this region is highly diverse. A total of 44,537 individuals representing 509 taxa from 24 orders were present across 174 sampling events in least disturbed streams in the South Central and Southern Humid, Mixed Land Use region (Aggregated Ecoregions 33 and 35) over the time period from 1987 to 2018 (Appendix E). This includes 10 of 13 insect orders, as well as representatives of Oligochaeta, Amphipoda, Pelecypoda, Gastropoda, Isopoda, Hirudinea, Hydracarina, Turbellaria, Nematoda, Ostracoda, and Nemertea. For individual sites, taxa richness ranged from a total of 106 in a Surber sample and eight RBP samples collected over the period from 1989 to 2016 at Frazier Creek to a low of 11 in single RBP samples collected at Little Mustang and Davidson creeks.

This finding reflects the relative permanence of wetted channel in the region as a result of typical annual rainfall ranging from 71 to 102 cm in the western and southern portions to 112 to 147 cm in the eastern and central portions of the region. Also, most of the streams are characterized by relatively abundant instream cover such as logs, snags, leaf pack, and undercut banks which provide excellent habitat for aquatic invertebrates. Instream food resources, primarily allochthonous due to shading, are also abundant in the form of leaf litter and associated microbial growth as well as suspended organic matter from the surrounding forests which characterize large portions of the region.

Mayflies (Ephemeroptera) were the most abundant taxa overall, representing 23% of the total number of individuals collected.

Overall, the results of the regionalized IBI’s for the 174 benthic macroinvertebrate samples collected over the interval from 1987 to 2018 indicate relatively constant benthic macroinvertebrate biotic integrity (Figure 378; Figure 379).

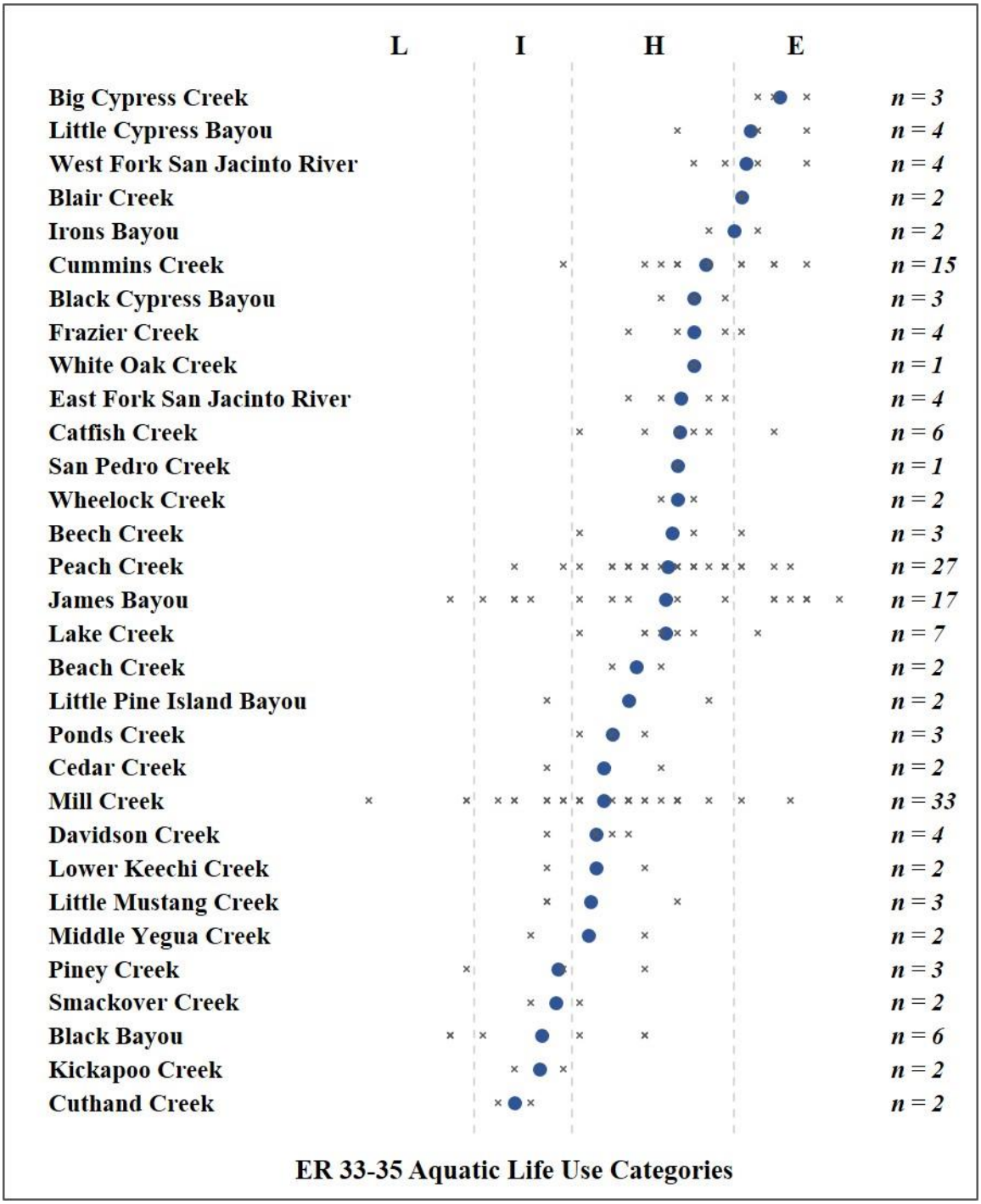

Figure 374. Aquatic life use categories (L – limited; I – intermediate; H – high; E – exceptional) for all fish sampling events in Ecoregions 33 and 35 grouped by site and ranked by mean ALU score (blue dot); number of sampling events per site noted on right.

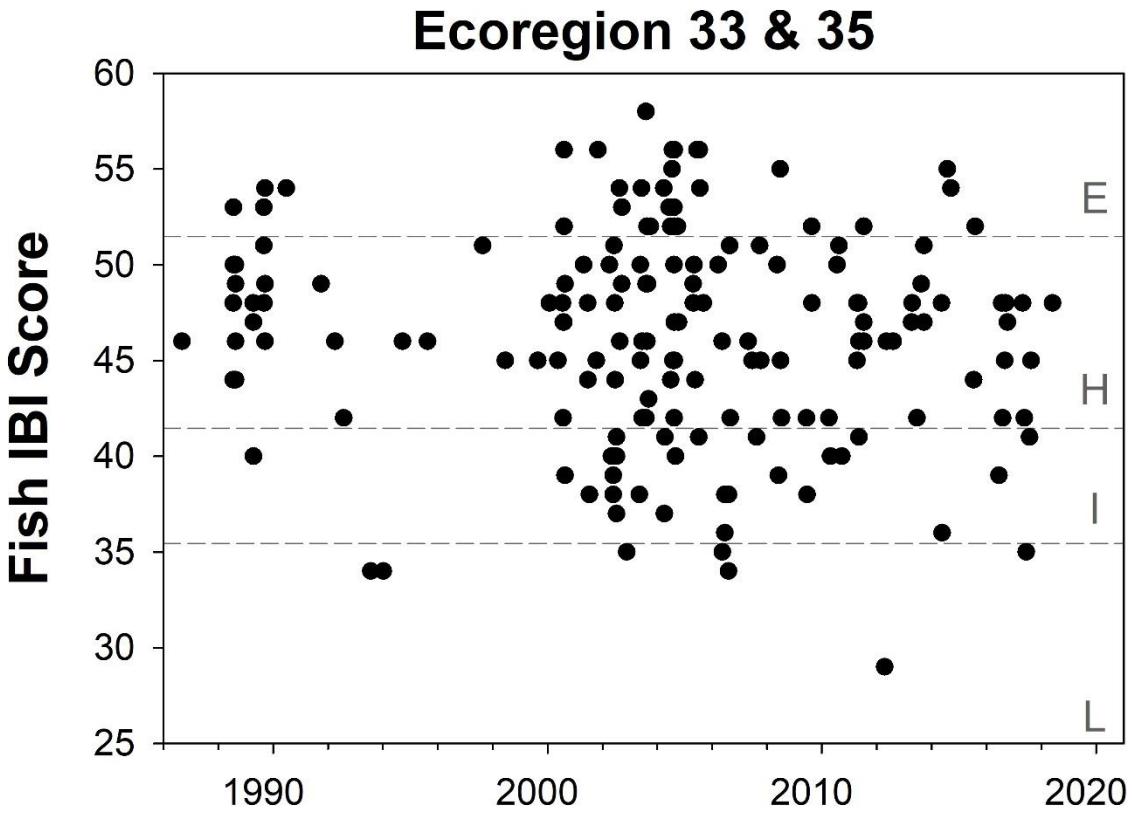

Figure 375. Fish index of biotic integrity scores through time for all sampling events in Ecoregions 33 and 35; break lines for aquatic life use categories (i.e., limited, intermediate, high, and exceptional) shown on each graph for reference (see Linam et al. 2002).

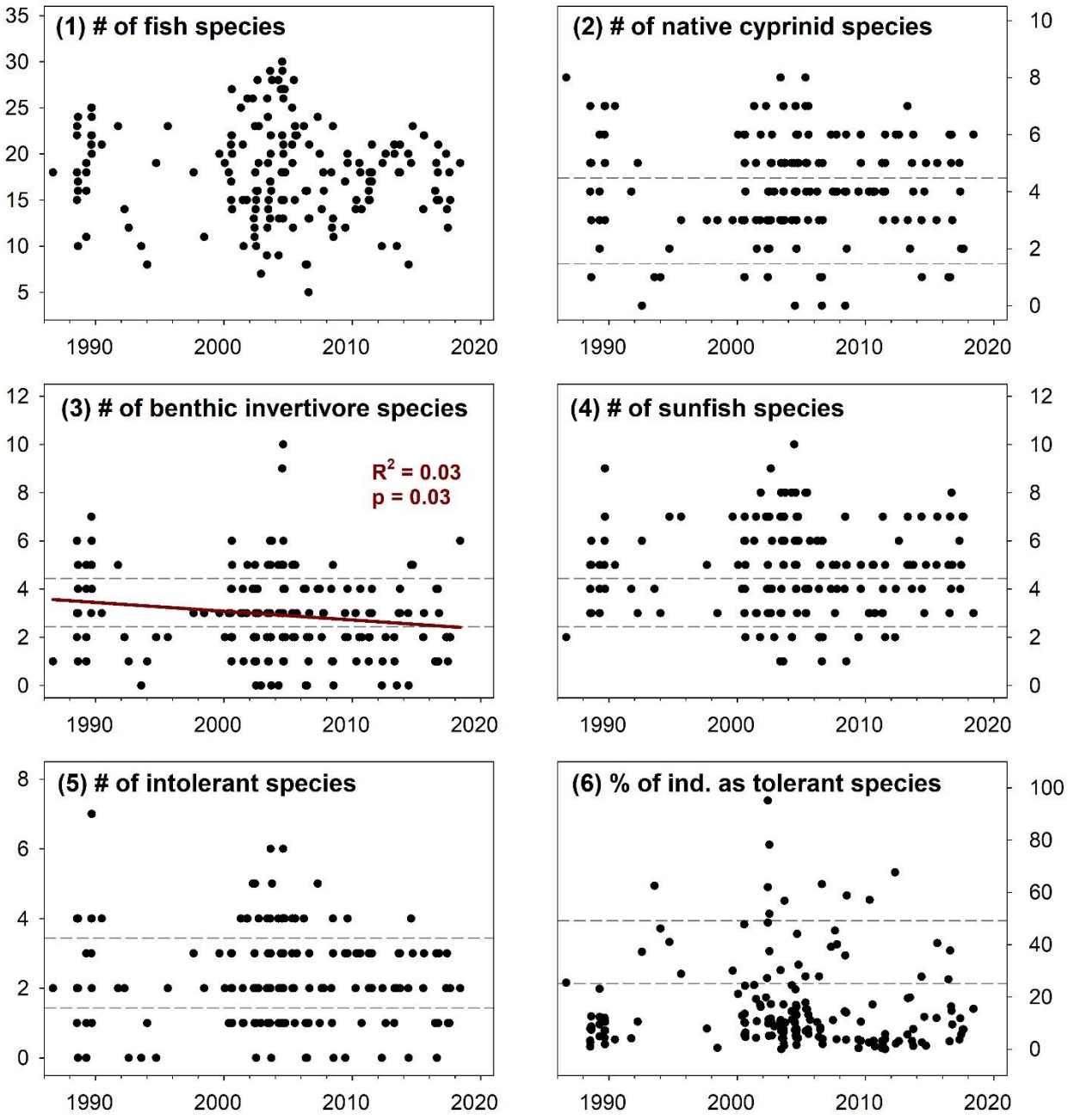

Figure 376. Raw values for fish index of biotic integrity metrics 1-6 through time for all sampling events in Ecoregions 33 and 35; break lines for scoring criteria (i.e., 1, 3, and 5) shown on each graph for reference (see Linam et al. 2002).

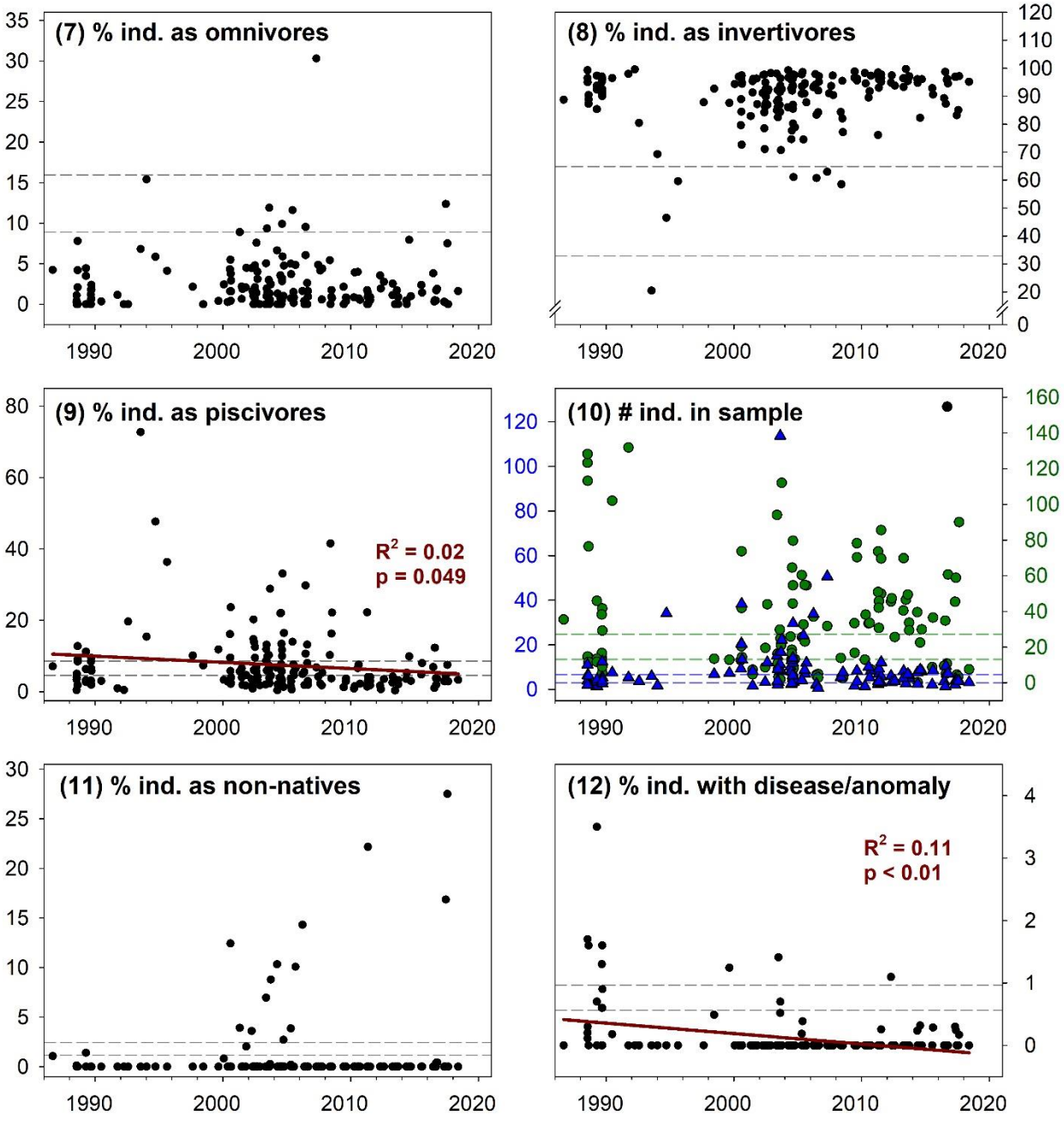

Figure 377. Raw values for fish index of biotic integrity metrics 7-12 through time for all sampling events in Ecoregions 33 and 35; break lines for scoring criteria (i.e., 1, 3, and 5) shown on each graph for reference (see Linam et al. 2002); number of ind./seine haul represented by green circles and number of ind./min electrofishing represented by blue triangles for metric number 10.

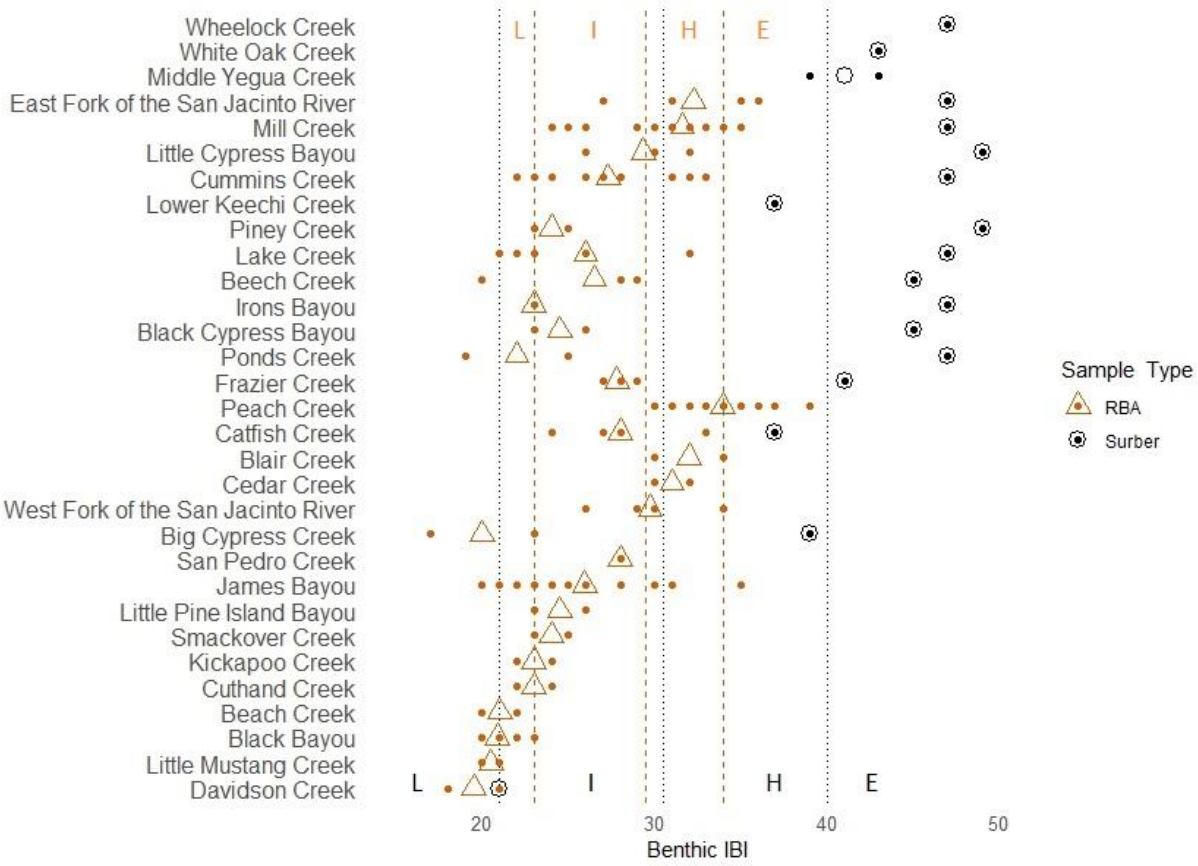

Figure 378. Benthic IBIs and aquatic life use categories (L – limited; I – intermediate; H – high; E – exceptional) for all benthic sampling events in Ecoregions 33 and 35 grouped by site and ranked by mean IBI score. Site scores are solid circles, and mean scores are hollow circles for Surber IBI sample and hollow triangles for RBP IBI samples. RBP IBI ALU cut offs are red dashed lines and Surber ALU cutoffs are in black dotted lines.

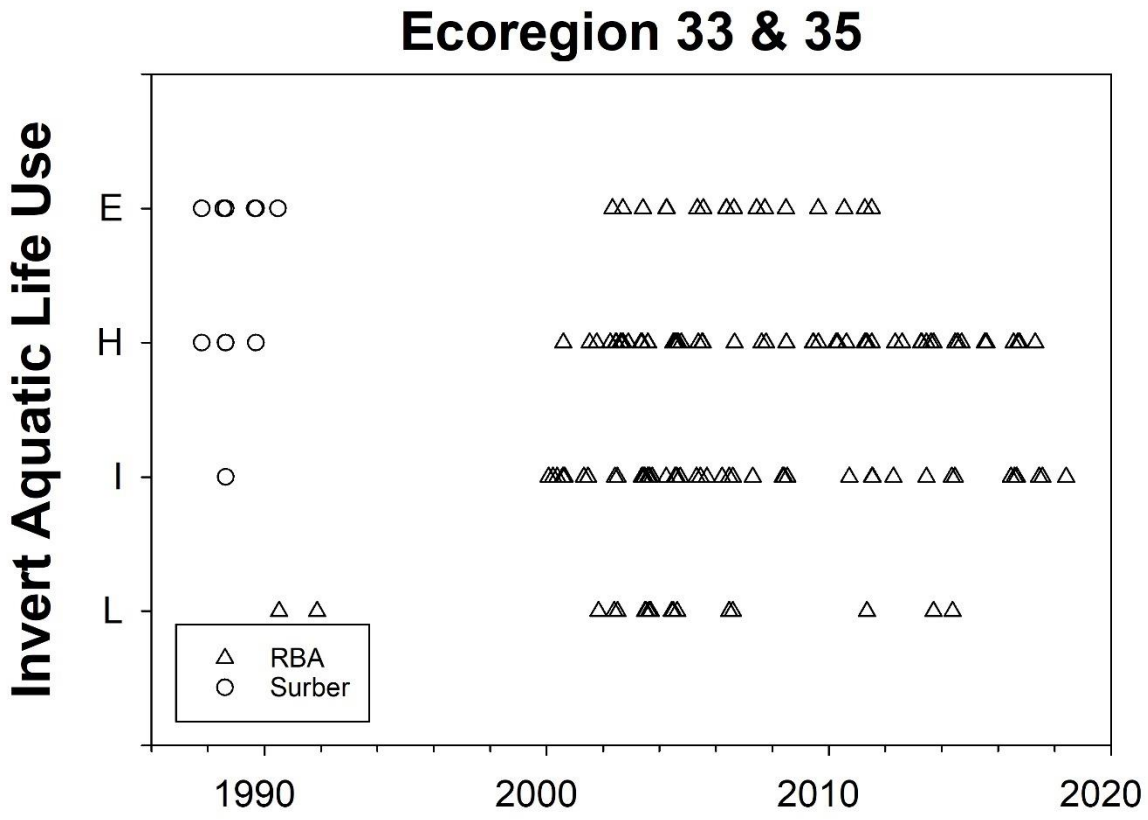

Figure 379. Benthic aquatic life use (ALU) categories through time for all sampling events in Ecoregions 33 and 35; Surber ALUs are noted by circles and RBP ALUs are noted by triangles.