ECOREGION 24 – SOUTHERN DESERTS

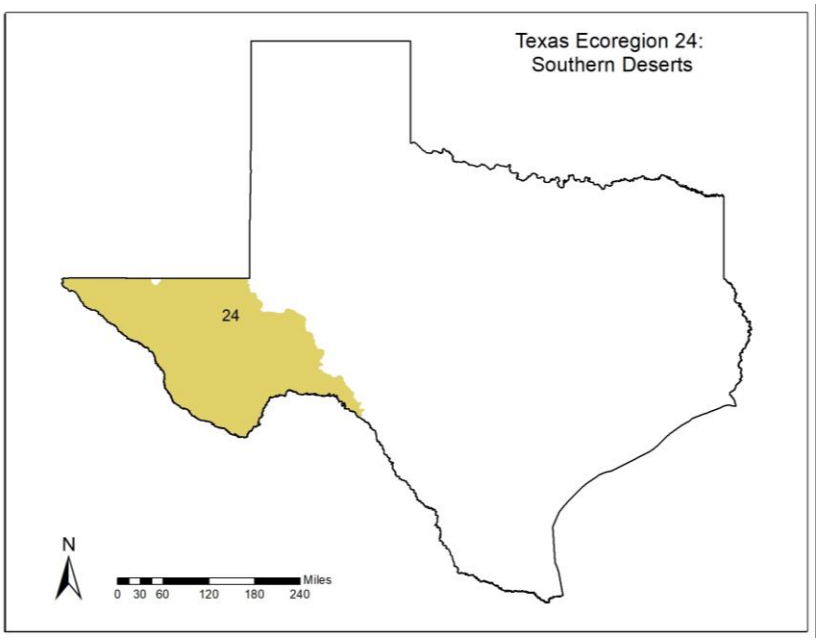

Figure 4. Map of Texas Ecoregion 24 – Southern Deserts.

Figure 5. Site photo from Independence Creek.

Ecoregion 24 Characterization

The Chihuahuan Deserts ecoregion extends from southeastern Arizona to the Edwards Plateau in south-central Texas and extends nearly 800 kilometers south into Mexico. In Texas, the ecoregion includes approximately 91,360 square kilometers. The High Plains, Edwards Plateau, and the Southern Texas Plains bound the Chihuahuan Deserts on the east, while the Rio Grande defines the western extent in Texas (Figure 4).

The region is relatively diverse and includes basins that exhibit the lowest surface elevations in west Texas, as well as mid-elevation grasslands, and mountains with elevations up to 1,800 meters. The Chihuahuan Deserts exhibit some of the lowest annual precipitation totals in Texas, ranging from 20 cm in low altitude basins up to 66 cm at higher altitudes in the mountains (Griffith et al. 2007). Rainfall occurs mostly between June and September, and the sparse precipitation often falls in heavy, episodic events.

Portions of the Rio Grande, and the Pecos River watersheds constitute the major drainages in the Chihuahuan in Texas. Most other streams in the ecoregion are ephemeral, flowing only after heavy rainfall events. Aside from a few isolated springs, notably Independence Creek near Sheffield, the Rio Grande, and the Pecos rivers provide the only stable aquatic habitats in the ecoregion. With the exception of the spring fed streams, surface waters in the ecoregion exhibit relatively high dissolved solids concentrations. Cottonwood (*Populus sp*.) are common in the riparian zone of these streams and provide a good landmark for the location of springs. The saltcedar (*Tamarix sp.*) and the river cane (*Phragmites australis*) have invaded riparian areas, and often become the dominant riparian vegetation.

Table 4. Streams sampled in Ecoregion 24.

Alamito Creek	Rio Grande: Presidio	Terlingua Creek
Independence Creek	Rio Grande: Contrabando	
Pecos River	Rio Grande: Johnson Ranch	

ALAMITO CREEK

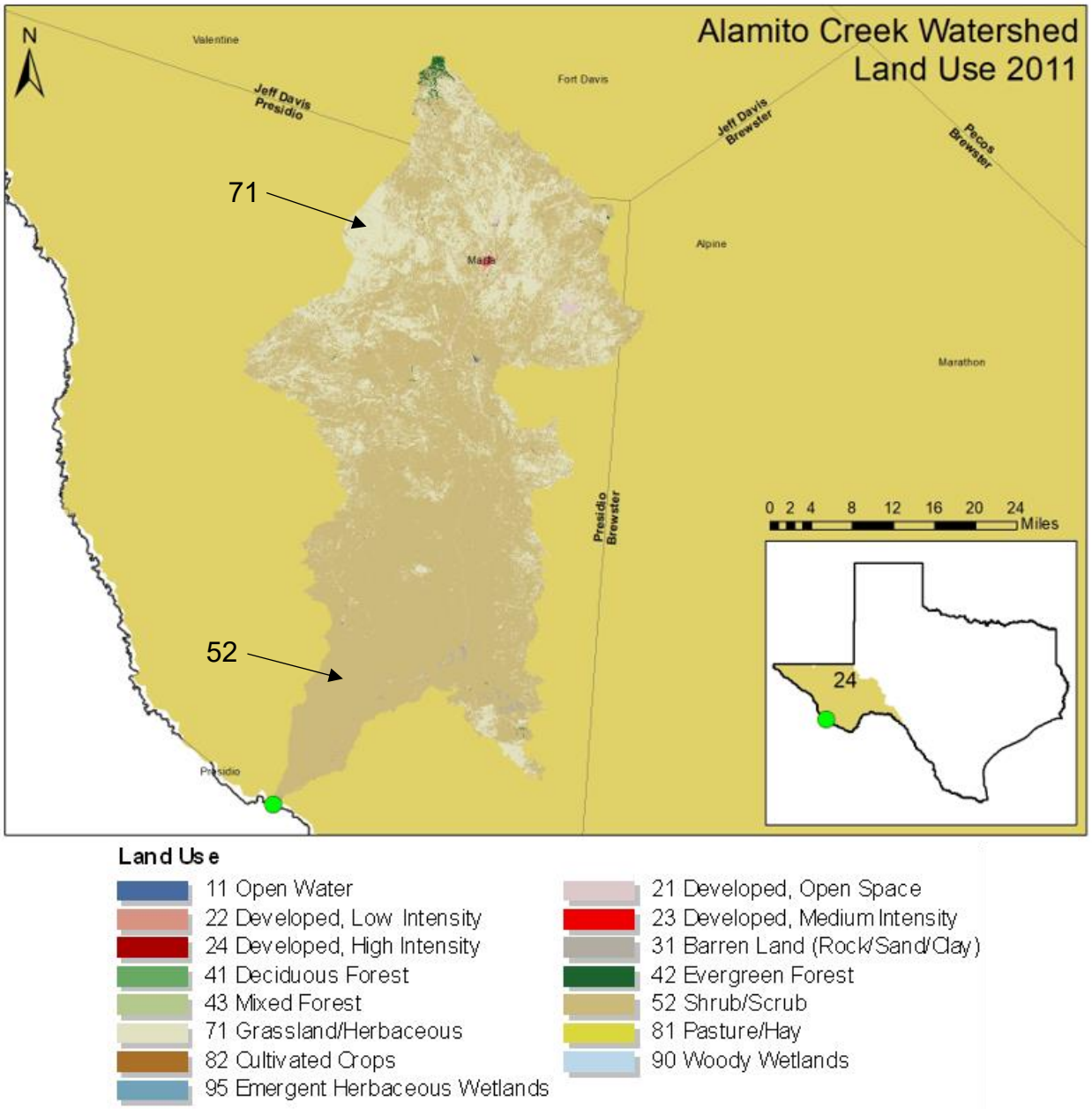

Figure 6. Map of Alamito Creek watershed location and 2011 land use; shrub/scrub and grasslands/herbaceous were the most common land uses.

Sampling Dates

Physical Habitat:	July 11, 1989
Water Quality:	68 sample events
Fish:	July 11, 1989
Benthic Invertebrates:	July 11, 1989

Physical Characterization

Watershed and Land Use

Alamito Creek lies within the Rio Grande Basin. Sample site 13108 is located near FM 170, approximately 9.66 km southeast of Presidio in Presidio County (Figure 6).

The Alamito Creek watershed at site 13108 is approximately 3604.76 sq km. The station and much of the lower watershed are located in Level IV Ecoregion 24c, the Low Mountains and Bajadas, while the remaining watershed lie in Level IV Ecoregion 24b, the Chihuahuan Desert Grasslands. The dominant land cover in the watershed is shrub at 74.24% and is present throughout the watershed (Homer et al. 2015; Figure 6 and Figure 7). Grassland/herbaceous is the secondary land cover encompassing 24.25%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 0.89% and total cover for cultivated crops is 0.004%.

From 1992-2011 there was a 483 sq km decrease in grassland and a 14.09 sq km decrease in barren land (rock/sand/clay). There was a 469.82 sq km increase in shrub and a 27.05 sq km increase in open space development (Figure 8).

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

In Channel and Riparian Physical Habitat

Alamito Creek is a tributary to the Rio Grande River. Physical habitat for the creek was evaluated on July 11, 1989. The riparian width was 19 meters and was dominated by trees and shrubs, which each made up an average of 40% of the total riparian species, followed by grasses (20%). The average percentage of tree canopy cover was 8%. The dominant substrate was gravel and sand, and the average percent of substrate that was gravel size or larger was 40%. Average percent instream cover was 10%. Alamito Creek had an average depth of 0.1 meters and a maximum depth of 0.4 meters. The average width was 0.7 meters and average stream bank slope was 39 degrees. Stream flow at the site was 0.65 cfs. Average stream bank erosion potential was 70%. Three riffles were observed at the site and there were two total stream bends.

Water Quality

Water samples were collected at station 13108 over 68 sampling events from June 1977 through August 2007. Data were collected for many parameters including 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

Nine species (six families) were collected from Alamito Creek. The only family represented by more than one species was Cyprinidae with four. Western Mosquitofish *Gambusia affinis* was the most abundant species. Of particular note was the collection of three state listed threatened

species, Mexican Stoneroller *Campostoma ornatum*, Chihuahua Shiner *Notropis chihuahua*, and Conchos Pupfish *Cyprinodon eximius*. Based on the fish assemblage, Alamito Creek rated as having an exceptional aquatic life use.

Benthic Macroinvertebrates

Considering the single Surber sample, a total of 2337 individuals representing 57 taxa from 12 orders of macroinvertebrates were collected from Alamito Creek (Appendix E). The Basommatophora, Diptera, Ephemeroptera, Hirudinida, Oligochaeta, and Trichoptera were the most commonly collected orders, collectively accounting for 93.8 percent of the total number of individuals collected (Appendix E). The Podocopida and Coleoptera were the only other orders which comprised at least one percent of the collections.

The functional organization of the Alamito Creek macroinvertebrate assemblage was dominated by scrapers, collector-gatherers, and predators which accounted for 40.8%, 31%, and 22.5%, respectively of the total number of individuals collected. The shredders (1.2%) were the least abundant functional group. This functional structure was relatively consistent.

The Central Bioregion Surber BIBI for the July 1989 Surber sample fell in the exceptional aquatic life use category.

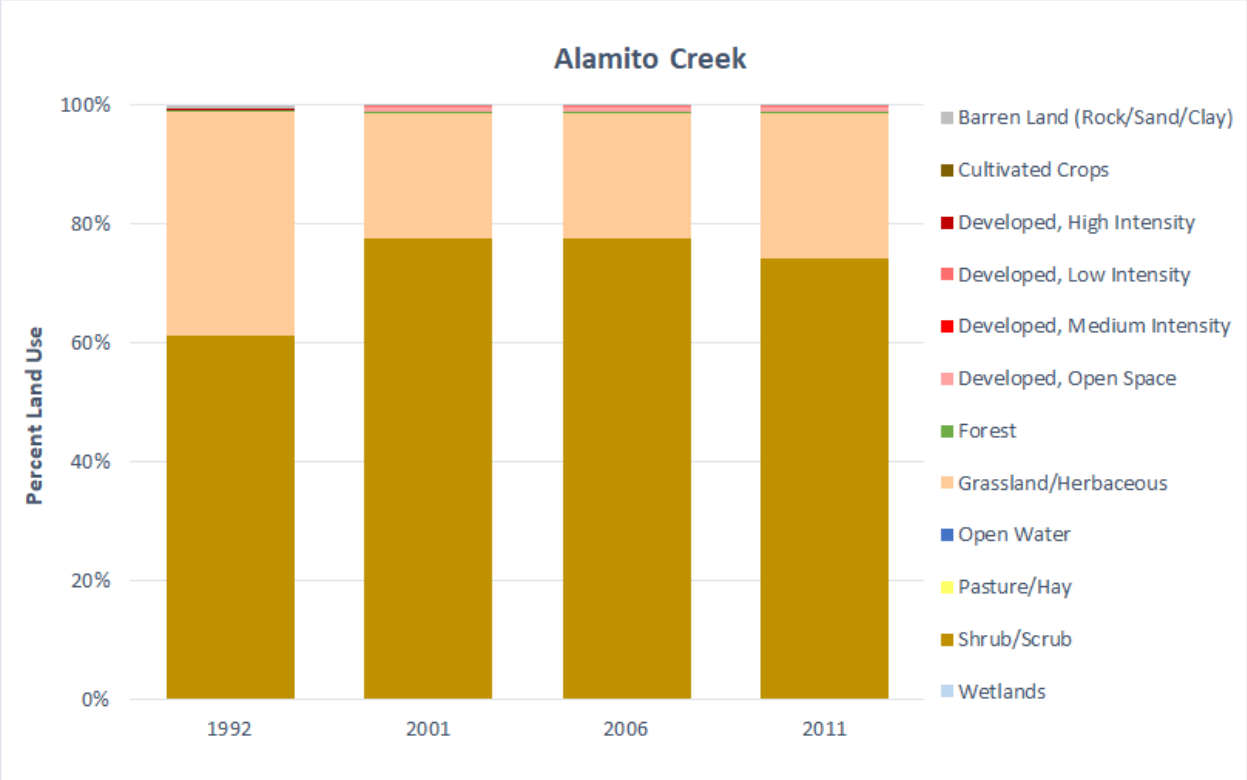

Figure 7. Percent land use in the Alamito Creek watershed from 1992-2011.

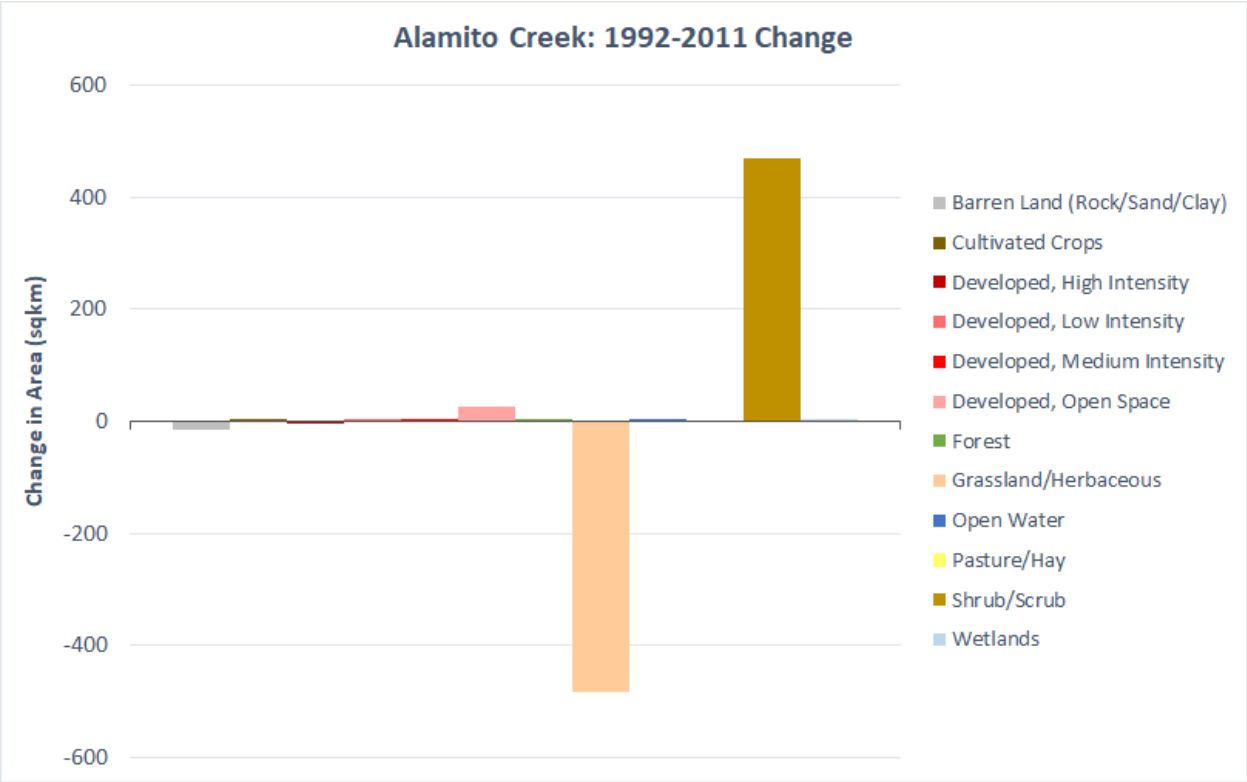

Figure 8. Land use change in area (sq km) from 1992-2011 for the Alamito Creek watershed.

INDEPENDENCE CREEK

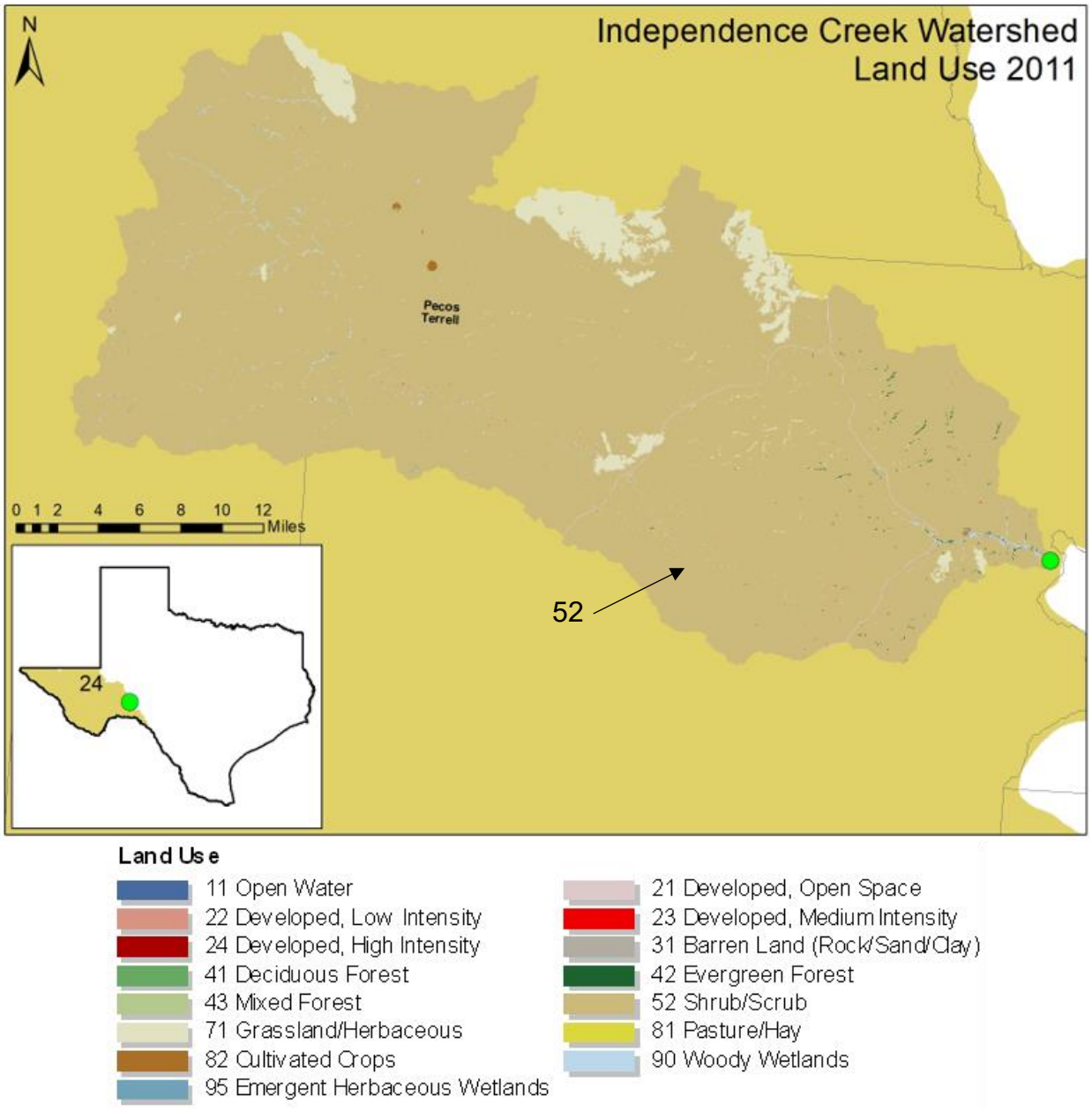

Figure 9. Map of Independence Creek watershed location and 2011 land use; shrub/scrub was the most common land use.

Sampling Dates

Physical Habitat:	August 28, 1990; September 28, 2016
Water Quality:	255 sampling events
Fish:	August 28, 1990; September 28, 2016
Benthic Invertebrates:	August 28, 1990; September 28, 2016

Physical Characterization

Watershed and Land Use

Independence Creek lies within the Rio Grande Basin. Sample site 13109 is located 0.8 km downstream of the John Chandler Ranch headquarters, approximately 27.9 km southeast of Sheffield in Terrell County (Figure 9).

The Independence Creek watershed at site 13109 is approximately 1996.50 sq km. The entire watershed is located in Level IV Ecoregion 24e, the Stockton Plateau. The dominant land cover in the watershed is shrub at 94.68% and is present throughout the watershed (Homer et al. 2015; Figure 9 and Figure 10). Grassland/herbaceous is the secondary land cover encompassing 4.31%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 0.36% and total cover for cultivated crops is 0.04%.

From 1992-2011 there was a 362.97 sq km decrease in grassland and a 5.89 sq km decrease in barren land (rock/sand/clay). There was a 352.49 sq km increase in shrub and an 8.49 sq km increase in wetlands (Figure 11).

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

In Channel and Riparian Physical Habitat

Physical habitat for Independence Creek was evaluated on August 28, 1990 and again on September 28, 2016. The 2016 Habitat Quality Index score of 26 indicates an exceptional aquatic life use rating. Independence Creek is a perennial spring-fed stream that drains to the Pecos River. 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 shrubs, which make up an average of 48% of the total riparian species, followed by grasses (31%) then trees (11%). The average percentage of tree canopy cover was 3%. The dominant substrate was gravel and cobble, and the average percent of substrate that was gravel size or larger was 82%. Average percent instream cover was 63% and instream cover types include boulders, cobble/gravel, algae, and macrophytes. Independence Creek ranges from 0.1-0.3 meters deep on average and 8.6-12.7 meters wide. Average stream bank slope was 16 degrees. Stream flow at the site was measured at a minimum value of 17.4 cfs and a maximum of 21 cfs. Average stream bank erosion potential was 34%. The deepest pool measured at Independence Creek was 0.7 meters. A maximum of eleven riffles were observed at the site in 2016 and the channel was highly braided with three total stream bends.

Water Quality

Water samples were collected at stations 13109 and 13110. Station 13109 was sampled over 253 sampling events from July 1976 through July 2020. Station 13110 was sampled twice, once in August 1990 and again in July 1999. Data from both stations 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.

Continuous flow is available from USGS gage 08447020 (Figure 12). Between January 1985 through December 2019, the median flow was 22.1 cfs. Flow data for this site were not reported from October 1985 through August 2002. Daily average flows ranged from 7.33 cfs to 12,600 cfs, though flows were greater than 1000 cfs less than 0.2 percent of the time. Data were log transformed to better visualize flow patterns.

Biological Characterization

Fish

Nineteen species (10 families) were collected between the two sampling events (Appendix D). Cyprinidae was the richest family with five species. Texas Shiner *Notropis amabilis* was the most abundant species in 1987. Manantial Roundnose Minnow *Dionda argentosa* was the most abundant species in 2016. Of particular note was the collection of two state listed threatened species during both surveys, Proserpine Shiner *N. proserpina* and Rio Grande Darter *Etheostoma grahami*. The aquatic life use rated as high and exceptional for the 1990 and 2016 collections, respectively; however, when the coefficient of variability is applied to the 1990 fish assemblage data it also rises to exceptional.

Benthic Macroinvertebrates

Considering the single Surber sample and single RBP sample together, a total of 3168 individuals representing 82 taxa from 17 orders of macroinvertebrates were collected from Independence Creek (Appendix E). The Neotaenioglossa, Trichoptera, Amphipoda, Coleoptera, and Ephemeroptera were the most commonly collected orders, collectively accounting for 90.5 percent of the total number of individuals collected. The Neoophora, Hemiptera, and Diptera were the only other orders which comprised at least one percent of the collections.

The Central Bioregion Surber BIBI for the August 1990 Surber sample fell in the high aquatic life use category. Likewise, the Ecoregion 24 BIBI for the September 2016 RBP sample fell in the high aquatic life use category.

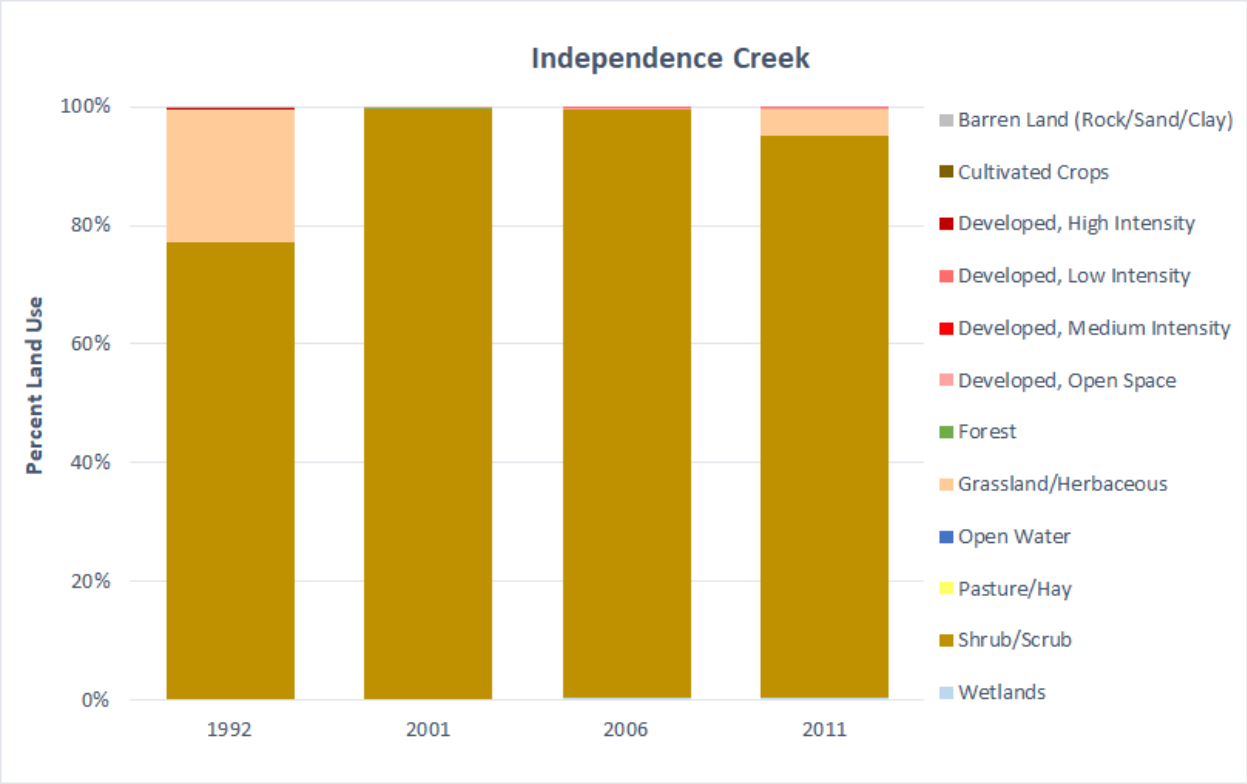

Figure 10. Percent land use in the Independence Creek watershed from 1992-2011.

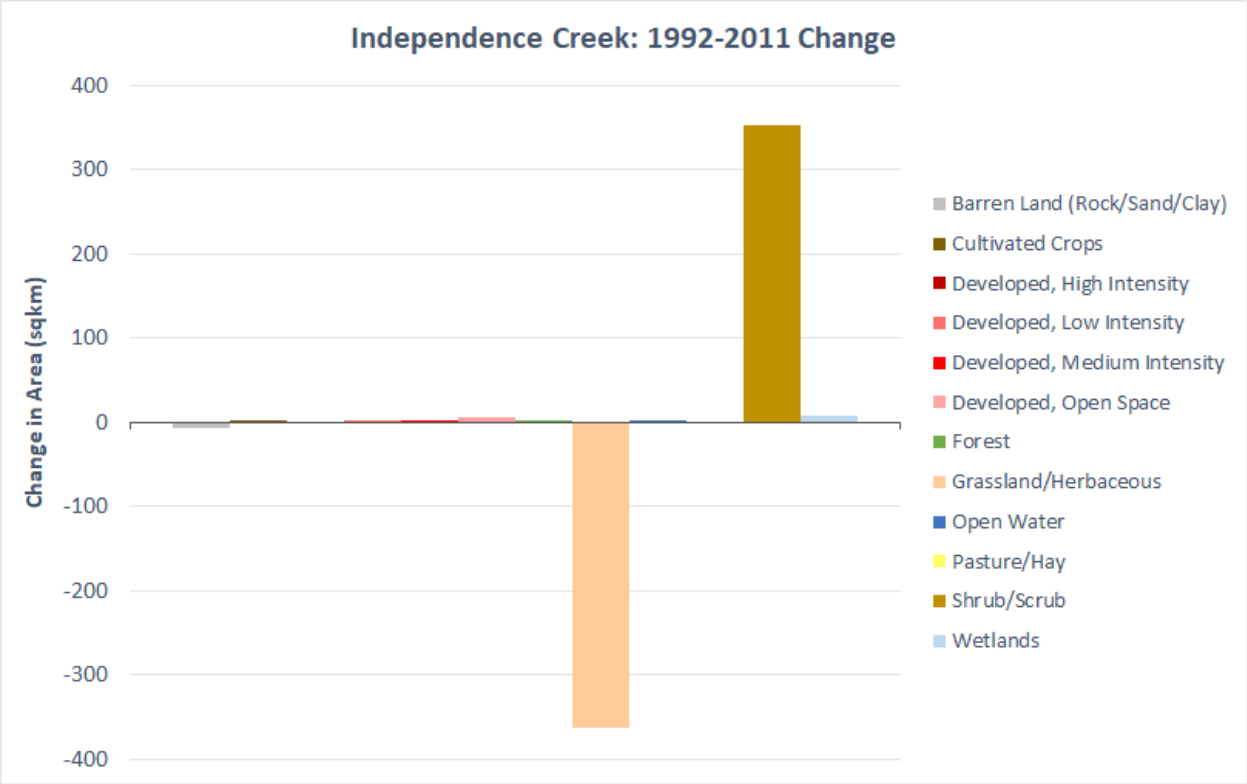

Figure 11. Land use change in area (sq km) from 1992-2011 for the Independence Creek watershed.

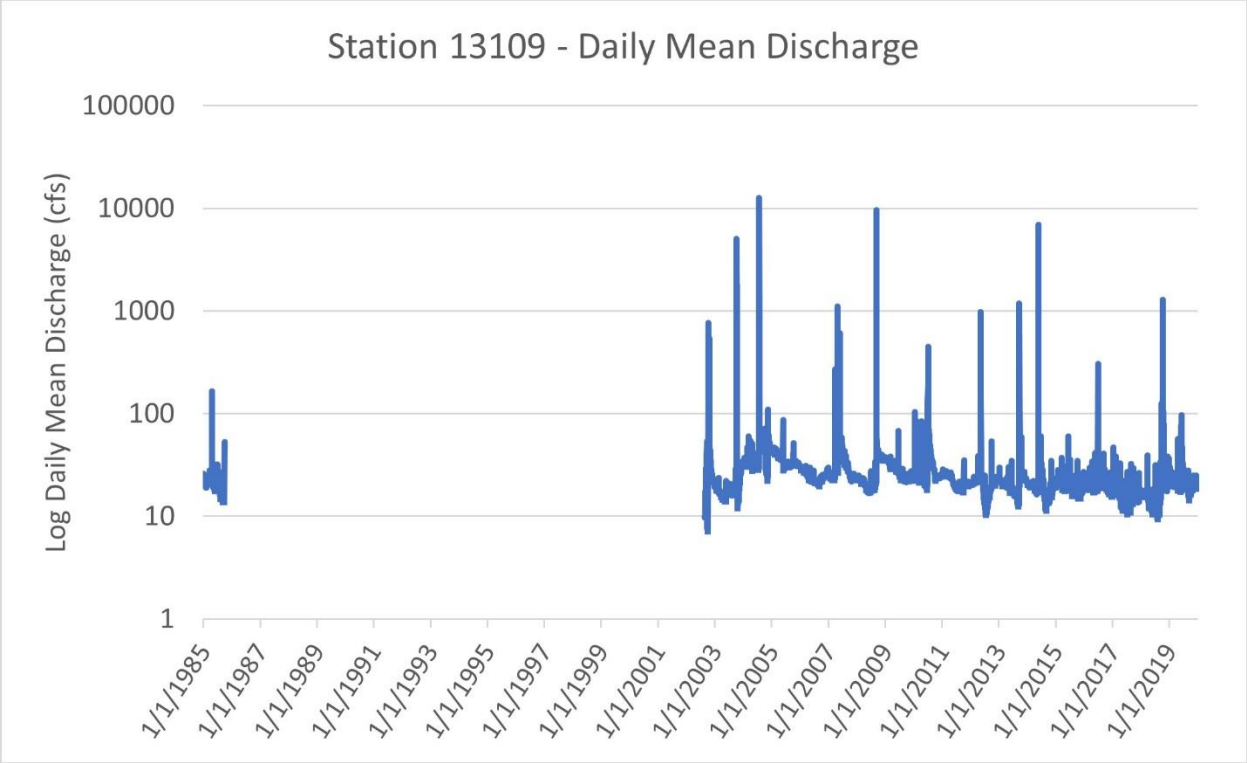

Figure 12. Log transformed daily mean discharge for Independence Creek at station 13109.

PECOS RIVER

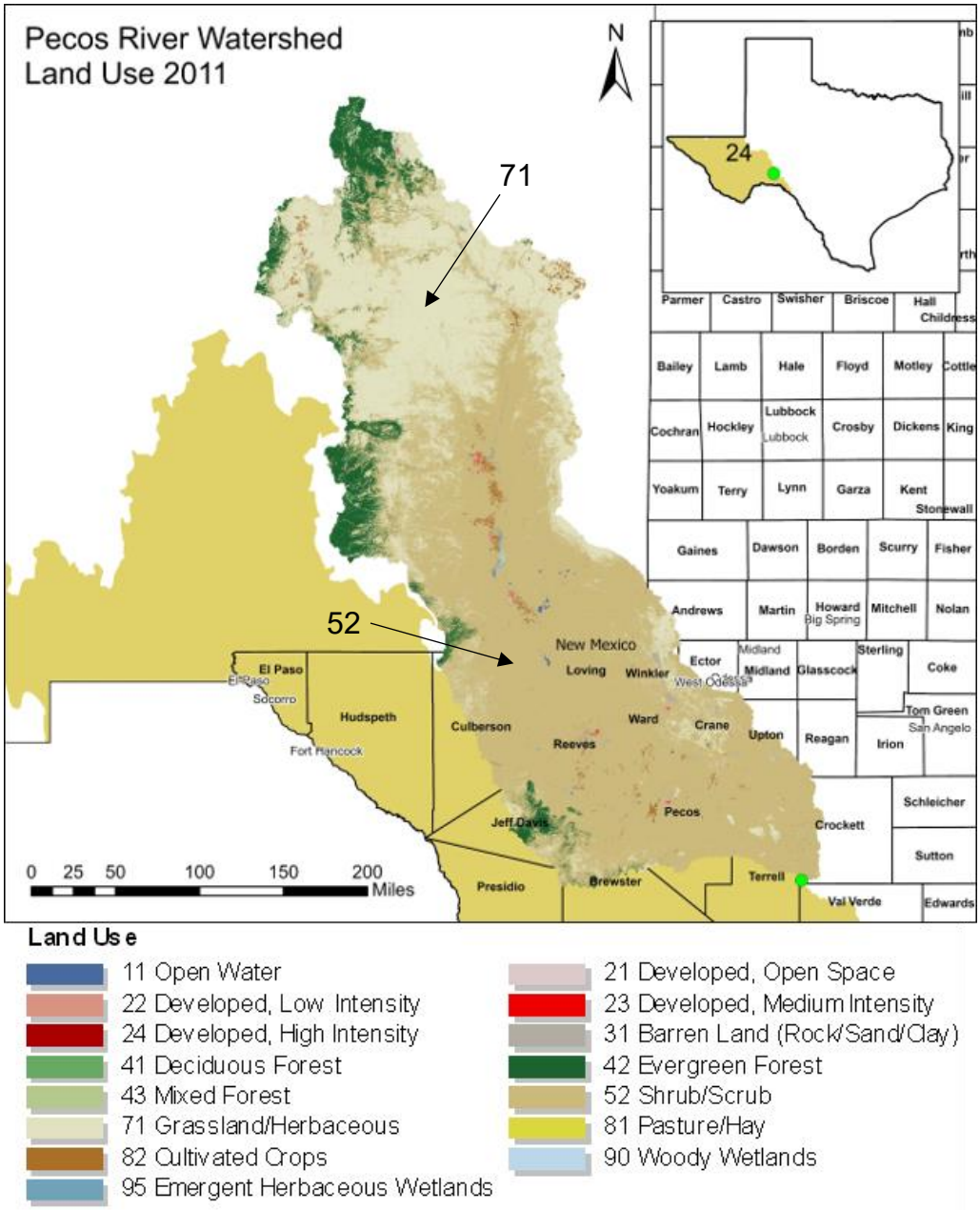

Figure 13. Map of Pecos River watershed location and 2011 land use; shrub/scrub and grassland/herbaceous were the most common land uses.

Sampling Dates

Physical Habitat:	September 29, 2016
Water Quality:	69 sampling events
Fish:	September 29, 2016
Benthic Invertebrates:	September 29, 2016

Physical Characterization

Watershed and Land Use

The Pecos River lies within the Rio Grande Basin. Sample site 18801 is located on the Brotherton Ranch 3.56 km upstream of the Terrell/Val Verde/Crockett County line, approximately 42.74 km south southeast of Sheffield in Terrell County (Figure 13).

The Pecos River watershed at site 18801 is approximately 3,613,942.76 sq km. The station and portion of the lower watershed are located in Level IV Ecoregion 24e, the Stockton Plateau. The middle portion of the watershed is located in Level IV Ecoregion 24a, the Chihuahuan Basins and Playas. Some of the watershed is located in Level IV Ecoregion 24b, the Chihuahuan Desert Grasslands, while other portions of the watershed cross into Ecoregions 23, 25, 26, and 30. The dominant land cover in the watershed is shrub at 62.67% and is present throughout the watershed (Homer et al. 2015; Figure 13 and Figure 14). Grassland/herbaceous is the secondary land cover encompassing 27.72%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 1.15% and total cover for cultivated crops is 0.91%.

From 1992-2011 there was an 828,497.53 sq km decrease in grassland/herbaceous and a 29,576.94 sq km decrease in barren land (rock/sand/clay). There was a 793,775.77 sq km increase in shrub and a 36,782.61 sq km increase in forest (Figure 15).

Within the Pecos River watershed in the state of Texas, there is one pending and three current domestic wastewater outfalls (discharges < 1 million gallons per day), three current stormwater outfalls, and one pending and three industrial wastewater outfalls (discharges ≥ 1 million gallons per day) within the Pecos River watershed. The one pending and one current domestic wastewater facilities are permitted to Quail Run Services, LLC, which is focused on wastewater generated on well site locations. The remaining domestic facilities are permitted to the University of Texas at Austin's McDonald Observatory and Fort Davis Water Supply Corporation. The three stormwater outfalls and two industrial wastewater facilities are permitted to Andrews County and Waste Control Specialists, LLC. The pending industrial wastewater facility is for the Town of Pecos City. The remaining industrial facility is permitted to the City of Alpine.

The pending industrial wastewater permit for the Town of Pecos City would discharge directly into the upper Pecos River.

In Channel and Riparian Physical Habitat

Physical habitat for the Pecos River was evaluated on September 29, 2016. The Pecos River originates in New Mexico and is one of the major tributaries of the Rio Grande. The site was located below the confluence with Independence Creek and the Habitat Quality Index score of 26 indicates an exceptional 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 shrubs, which made up an average of 90% of the total riparian species,

followed by grasses (5%) and trees (5%). The average percentage of tree canopy cover was 29%. The dominant substrate was boulders, and the average percent of substrate gravel size or larger was 56%. Average percent instream cover was 44% and instream cover types include boulders, undercut banks, cobble/gravel, macrophytes, woody debris, algae, and overhanging vegetation. The Pecos River site was 0.4 meters deep on average and 21.8 meters wide. Average stream bank slope was 36 degrees. Stream flow at the site was measured at 101 cfs. Average stream bank erosion potential was 31%. The deepest pool measured at the site was 0.5 meters. Four riffles were observed at the site and there were four total stream bends.

Water Quality

Water samples were collected at station 18801 over 69 sampling events from November 2008 through July 2020. Data were collected for 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 species (11 families) were collected from the Pecos River. Cyprinidae was the richest family with six species. Red Shiner *Cyprinella lutrensis* was the most abundant species collected, closely followed by Bullhead Minnow *Pimephales vigilax*. Of particular note was the collection of two state listed threatened species, Proserpine Shiner and Rio Grande Darter. The aquatic life use (based upon the fish assemblage) rated as exceptional.

Benthic Macroinvertebrates

Considering the single RBP sample, a total of 333 individuals representing 28 taxa from 12 orders of macroinvertebrates were collected from the Pecos River (Appendix E). The Ephemeroptera, Coleoptera, Trichoptera, Diptera, Neoophora, and Hemiptera were the most commonly collected orders, collectively accounting for 93.1 percent of the total number of individuals collected. The Odonata and Veneroida were the only other orders which comprised at least one percent of the collections.

The Ecoregion 24 BIBI for the September 2016 RBP sample fell in the high aquatic life use category.

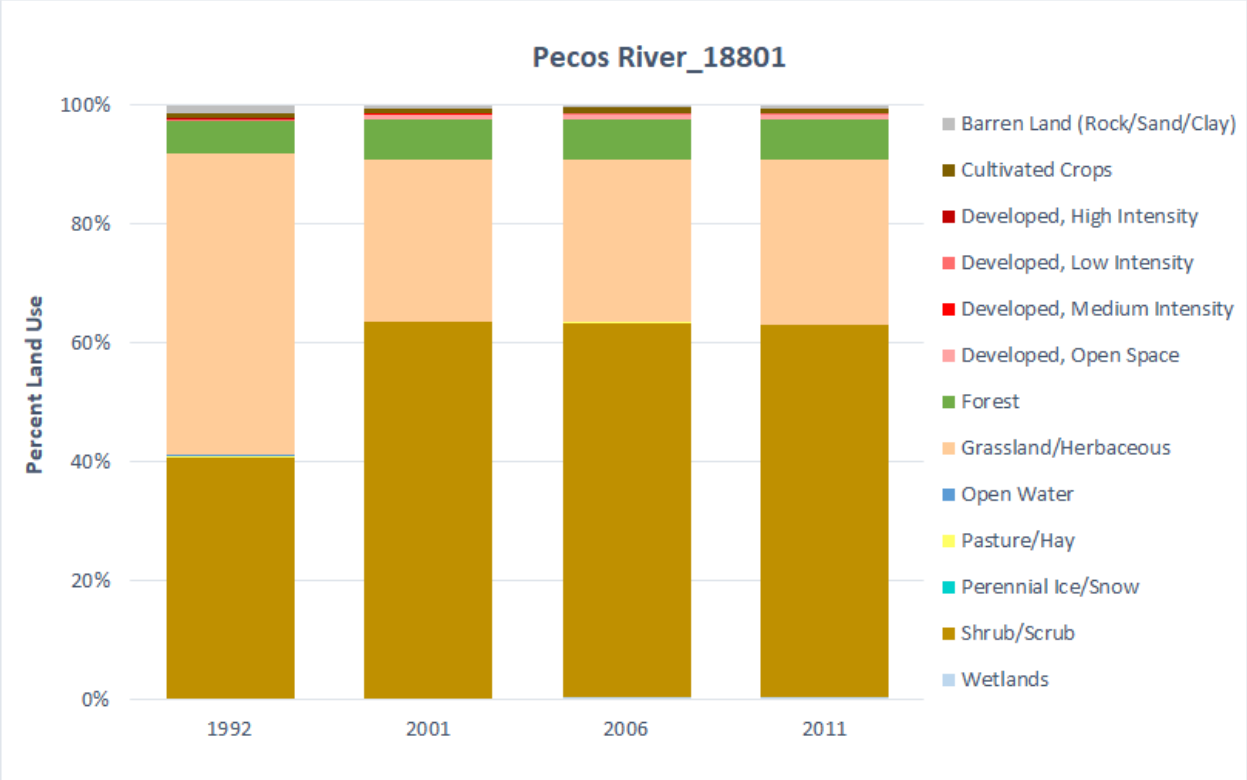

Figure 14. Percent land use in the Pecos River watershed from 1992-2011.

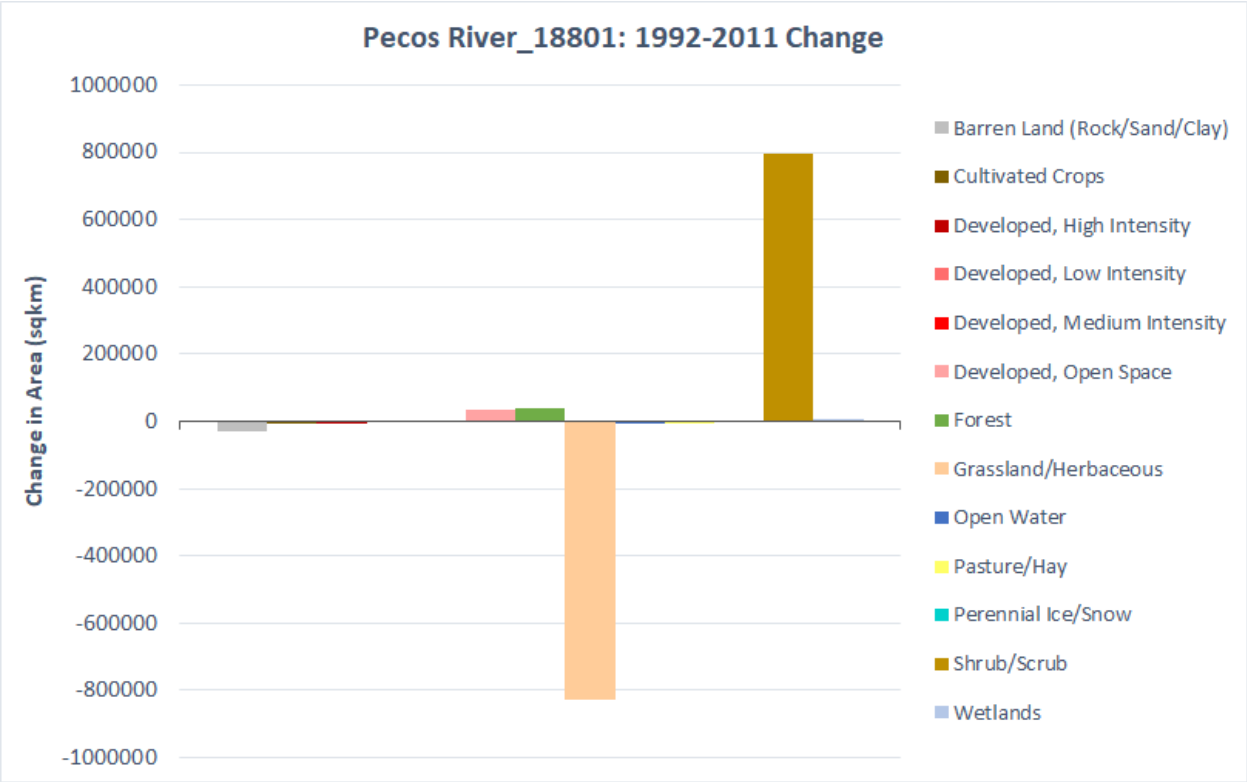

Figure 15. Land use change in area (sq km) from 1992-2011 for the Pecos River watershed.

RIO GRANDE: PRESIDIO

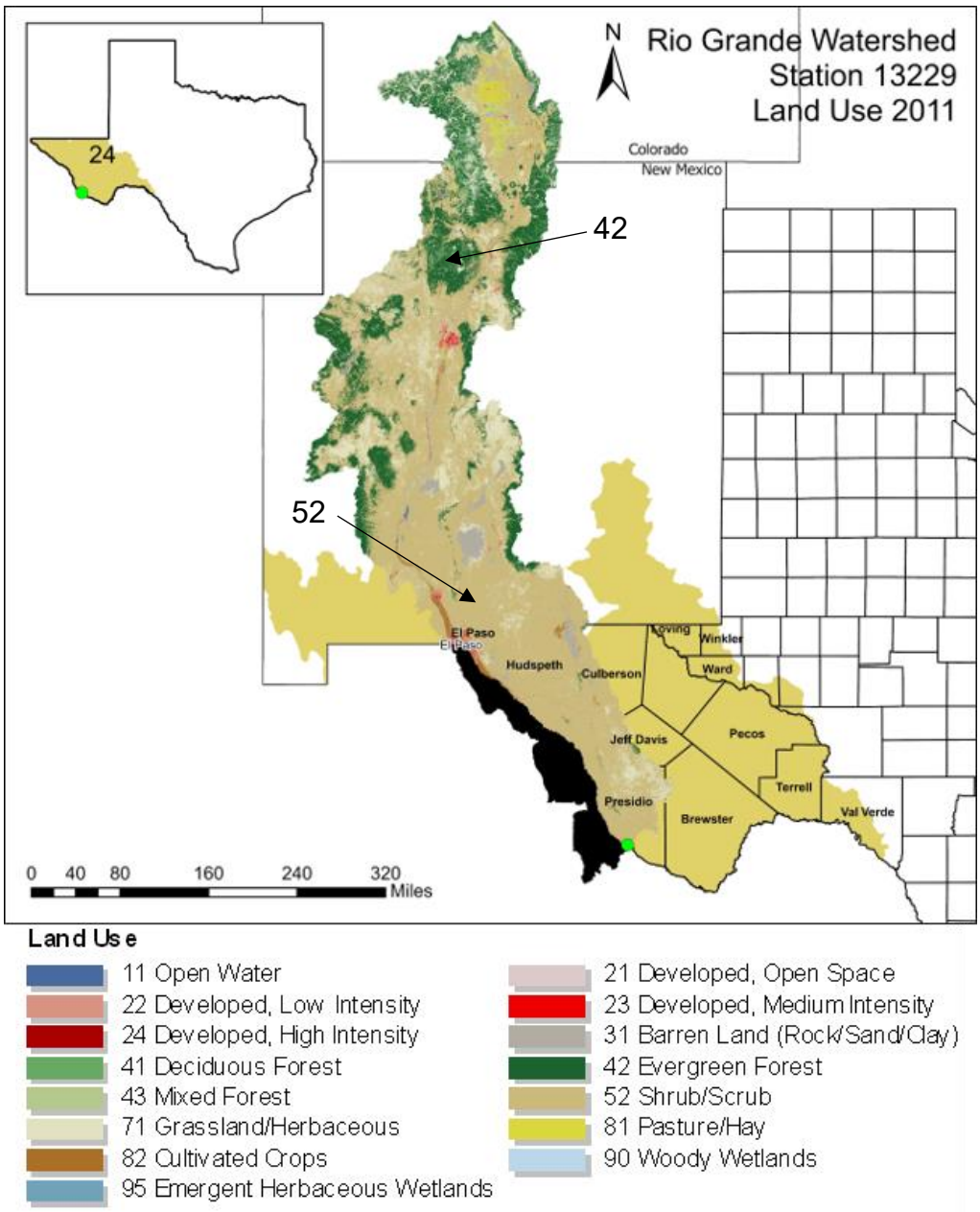

Figure 16. Map of Rio Grande watershed at Presidio and 2011 land use; shrub/scrub and forest were the most common land uses.

Sampling Dates

Physical Habitat:	March 28, 2017
Water Quality:	566 sampling events
Fish:	March 28, 2017
Benthic Invertebrates:	March 28, 2017

Physical Characterization

Watershed and Land Use

The Rio Grande is the border between Texas and Mexico and is the basin's namesake. The Rio Grande Basin drains all west Texas, along the southwest border of Texas through Laredo, and the south Texas valley. Sample site 13229 is located 0.75 km downstream of the confluence with Alamito Creek, approximately 11 km southeast of Presidio in Presidio County (Figure 16).

The Rio Grande watershed at site 13229 is approximately 5,201,992.85 sq km. The station and portion of the lower watershed are located in Level IV Ecoregion 24c, the Low Mountains and Bajadas. The lower watershed also encompasses Level IV Ecoregion 24b, the Chihuahuan Desert Grasslands. The middle portion of the watershed is located in New Mexico and encompasses Level IV Ecoregion 24a, the Chihuahuan Basins and Playas. The middle portion of the watershed extends through Ecoregions 22 and 23. The upper watershed extends into Colorado and contains a portion of Ecoregion 21. The dominant land cover in the watershed is shrub at 53.67% and is present throughout the watershed (Homer et al. 2015; Figure 16 and Figure 17). Forest is the secondary land cover encompassing 17.07%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 1.49% and total cover for cultivated crops is 0.74%.

From 1992-2011 there was a 653,448.97 sq km decrease in grassland/herbaceous and a 50,939.49 sq km decrease in barren land (rock/sand/clay). There was a 591,336.72 sq km increase in shrub and a 40,768.72 sq km increase in wetlands (Figure 18).

Within the Rio Grande watershed in the state of Texas, there are six domestic wastewater outfalls (discharges < 1 million gallons per day), one current mining outfall (and one pending), and 10 industrial wastewater outfalls (discharges ≥ 1 million gallons per day) within the Rio Grande watershed at site 13229. The domestic wastewater facilities are permitted to the towns of Anthony, Fort Hancock, and Van Horn, Canutillo Independent School District (ISD), El Paso County, and Hudspeth County. The mining outfall is permitted to the Rio Grande Mining Company. The pending industrial wastewater facility is permitted to the Esperanza Water Service Company and six of the industrial wastewater facilities are permitted to the El Paso Water Utilities Public Service Board. The remaining industrial wastewater facilities are permitted to the City of Presidio, El Paso County Water Control and Improvement District No 4, Horizon Regional Municipal Water District, and El Paso Electric Company.

The domestic wastewater facility for Canutillo ISD and industrial wastewater facilities for the City of Presidio and El Paso Water Utilities Public Service Board discharge directly into the Rio Grande.

In Channel and Riparian Physical Habitat

Physical habitat for the Rio Grande River near Presidio was evaluated on March 28, 2017. The Habitat Quality Index score of 18.5 indicates an intermediate aquatic life use rating. The riparian

buffer at the site was measured to be 15 meters wide on average. The riparian zone was dominated by shrubs and grasses, which each make up an average of 35% of the total riparian species, followed by mowed fields (25%). The average percentage of tree canopy cover was 19%. The dominant substrate was cobble, and the average percent of substrate gravel size or larger was 65%. Average percent instream cover was 29% and instream cover types include overhanging vegetation, cobble/gravel, woody debris, algae and undercut banks. The Rio Grande near Presidio was 0.3 meters deep on average and 31 meters wide. Average stream bank slope was 30 degrees. Stream flow was recorded at 63 cfs from an IBWC gaging station at the site. Average stream bank erosion potential was 36%. The largest pool was measured to be one meter deep. One large riffle was observed at the site and there were two total stream bends.

Water Quality

Water samples were collected at station 13229 over 566 sampling events from May 1969 through December 2019. Data were collected for 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

Ten species (five families) were collected from this site on the Rio Grande. The richest family was Cyprinidae with five. Red shiner was the most abundant species. Of particular note was the collection of 50 juvenile Blue Sucker *Cycleptus elongatus,* a state listed threatened species. Based on the fish assemblage, the Rio Grande rated as having an intermediate aquatic life use; however, when the coefficient of variability is applied it rises to high. Metrics receiving the lowest score (1) included: number of sunfish species (none were collected); percentage of individuals as tolerant species (82%); and number of individuals.

Benthic Macroinvertebrates

Considering the single RBP sample, a total of 240 individuals representing 25 taxa from 7 orders of macroinvertebrates were collected from the Rio Grande at Presidio (Appendix E). The Ephemeroptera, Trichoptera, and Diptera were the most commonly collected orders, collectively accounting for 92.9 percent of the total number of individuals collected. Odonata and Hemiptera were the only other orders which comprised at least one percent of the collections. The Ecoregion 24 BIBI for the March 2017 Rio Grande at Presidio sample fell in the high aquatic life use category.

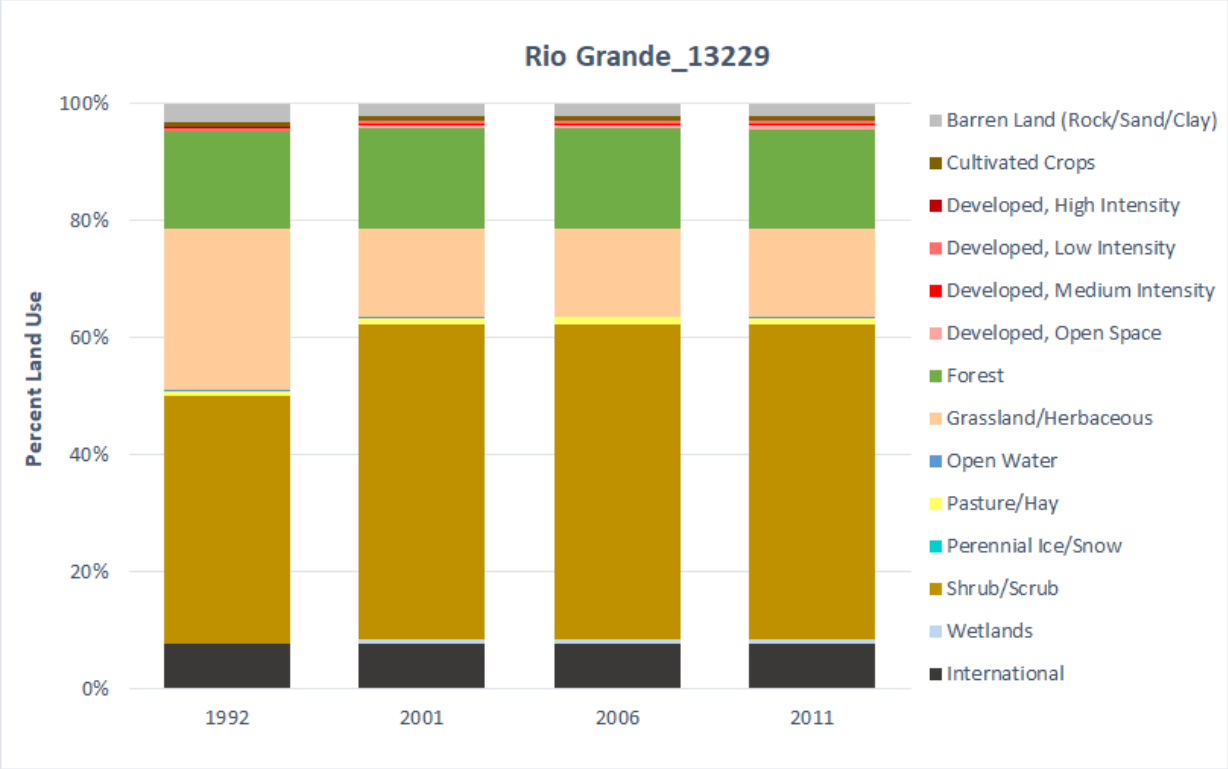

Figure 17. Percent land use in the Rio Grande watershed at Presidio from 1992-2011.

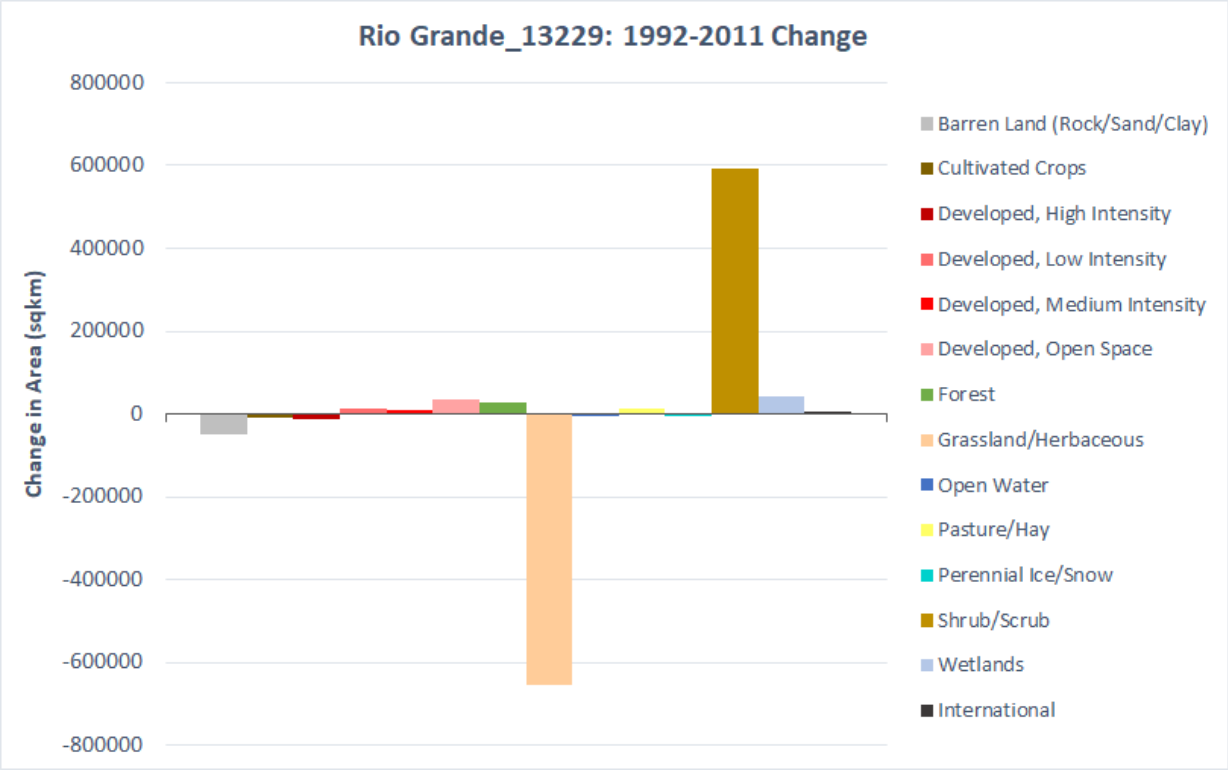

Figure 18. Land use change in area (sq km) from 1992-2011 for the Rio Grande watershed at Presidio.

RIO GRANDE: CONTRABANDO

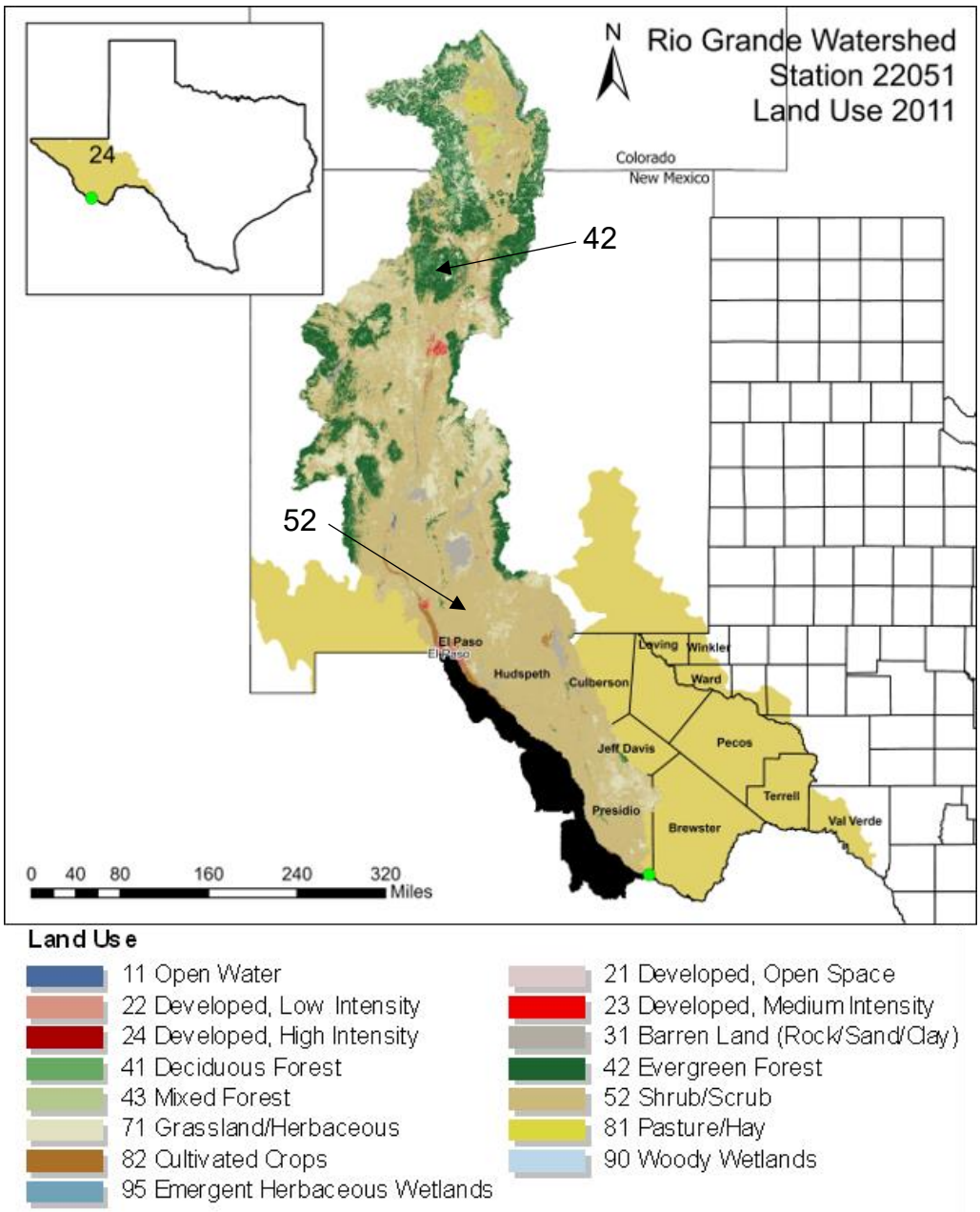

Figure 19. Map of Rio Grande watershed at Contrabando and 2011 land use; shrub/scrub and forest were the most common land uses.

Sampling Dates

Physical Habitat:	March 29, 2017
Water Quality:	No sampling events
Fish:	March 29, 2017
Benthic Invertebrates:	March 29, 2017

Physical Characterization

Watershed and Land Use

The Rio Grande is the border between Texas and Mexico and is the basin's namesake. The Rio Grande Basin drains all west Texas, along the southwest border of Texas through Laredo, and the south Texas valley. Sample site 22051 is located downstream of the confluence with Contrabando Creek within Big Bend Ranch State Park on FM 170 in Presidio County (Figure 19).

The Rio Grande watershed at site 22051 is approximately 5,300,669.55 sq km. The station and portion of the lower watershed are located in Level IV Ecoregion 24c, the Low Mountains and Bajadas. The lower watershed also encompasses Level IV Ecoregion 24b, the Chihuahuan Desert Grasslands. The middle portion of the watershed is located in New Mexico and encompasses Level IV Ecoregion 24a, the Chihuahuan Basins and Playas. The middle portion of the watershed extends through Ecoregions 22 and 23. The upper watershed extends into Colorado and contains a portion of Ecoregion 21. The dominant land cover in the watershed is shrub at 53.26% and is present throughout the watershed (Homer et al. 2015; Figure 19 and Figure 20). Forest is the secondary land cover encompassing 16.75%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 1.47% and total cover for cultivated crops is 0.73%.

From 1992-2011 there was a 651,855.20 sq km decrease in grassland/herbaceous and a 51,111.82 sq km decrease in barren land (rock/sand/clay). There was a 589,422.05 sq km increase in shrub and a 40,783.23 sq km increase in wetlands (Figure 21).

Within the Rio Grande watershed in the state of Texas, there are six domestic wastewater outfalls (discharges < 1 million gallons per day), one current mining outfall (and one pending), and 10 industrial wastewater outfalls (discharges ≥ 1 million gallons per day) within the Rio Grande watershed at site 22051. The domestic wastewater facilities are permitted to the towns of Anthony, Fort Hancock, and Van Horn, Canutillo ISD, El Paso County, and Hudspeth County. The mining outfall is permitted to the Rio Grande Mining Company. The pending industrial wastewater facility is permitted to the Esperanza Water Service Company and six of the industrial wastewater facilities are permitted to the El Paso Water Utilities Public Service Board. The remaining industrial wastewater facilities are permitted to the City of Presidio, El Paso County Water Control and Improvement District No 4, Horizon Regional Municipal Water District, and El Paso Electric Company.

The domestic wastewater facility for Canutillo ISD and industrial wastewater facilities for the City of Presidio and El Paso Water Utilities Public Service Board discharge directly into the Rio Grande.

In Channel and Riparian Physical Habitat

Physical habitat for the Rio Grande River at Contrabando Creek was evaluated on March 29, 2017. The Habitat Quality Index score of 26 indicates an exceptional 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 shrubs, which make up an average of 55% of the total riparian species, followed by grasses (40%), and a small developed area (old movie set and dirt trails) covered approximately 5% of the riparian area. The average percentage of tree canopy cover was 36.5%. The dominant substrate was cobble, and the average percent of substrate gravel size or larger was 92.5%. Average percent instream cover was 50% and instream cover types include cobble/gravel, overhanging vegetation, undercut banks, boulders, algae, and woody debris. The Rio Grande at Contrabando Creek was 0.4 meters deep on average and 36 meters wide. Average stream bank slope was 50 degrees. Stream flow was not measured at this site. Average stream bank erosion potential was 27%. The deepest pool was 1.25 meters. Five riffles were observed at the site and there were three total stream bends.

Water Quality

Station 22051 was not sampled for water quality.

Biological Characterization

Fish

Nine species (four families) were collected from this site on the Rio Grande. The richest family was Cyprinidae with five. Blue Sucker, a state listed threatened species, was the most abundant species. Based on the fish assemblage, the Rio Grande rated as having an intermediate aquatic life use; however, when the coefficient of variability is applied it rises to high. Two metrics received the lowest score (1) - number of sunfish species (none were collected) and number of individuals.

Benthic Macroinvertebrates

Considering the single RBP sample, a total of 250 individuals representing 22 taxa from 8 orders of macroinvertebrates were collected from the Rio Grande at Contrabando Creek (Appendix E). The Ephemeroptera, Trichoptera, Coleoptera, and Hemiptera were the most commonly collected orders, collectively accounting for 92.4 percent of the total number of individuals collected. The Odonata, Diptera, Megaloptera, and Oligochaeta were the other orders collected, all of which comprised at least one percent of the collection. The Ecoregion 24 BIBI for the March 2017 Rio Grande at Contrabando Creek sample fell in the high aquatic life use category.

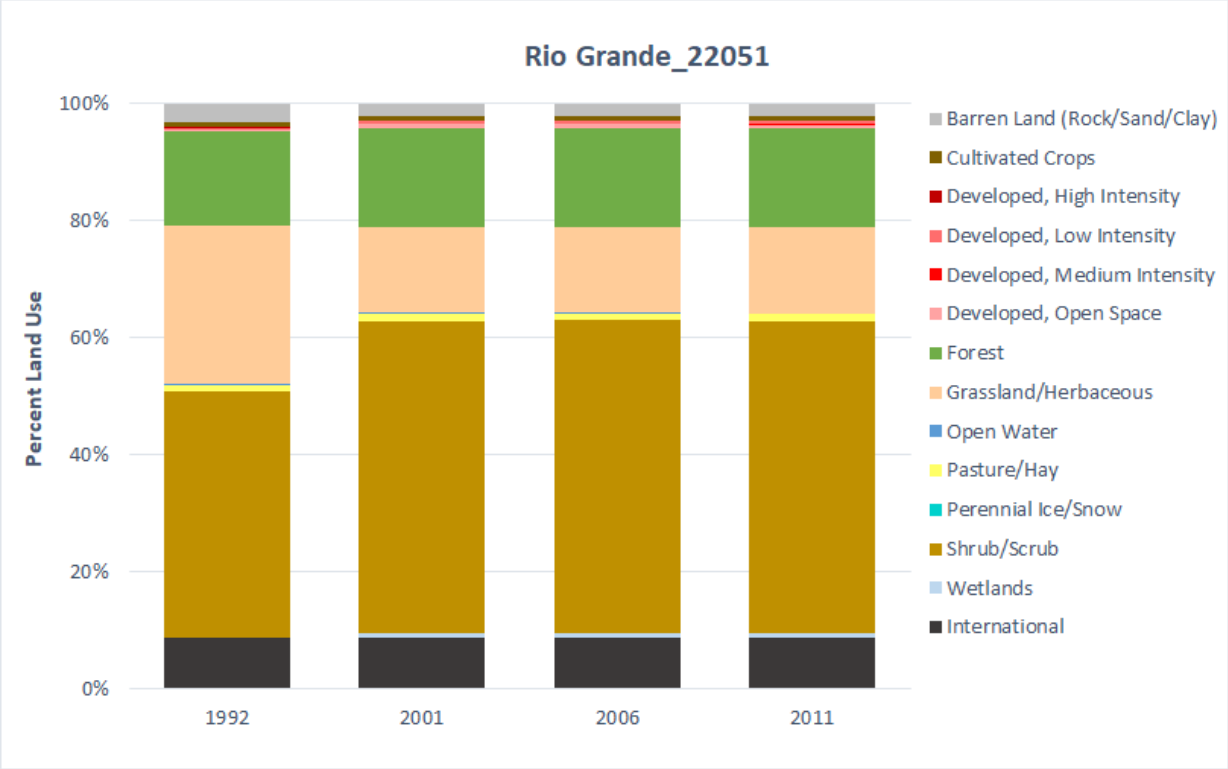

Figure 20. Percent land use in the Rio Grande watershed at Contrabando from 1992-2011.

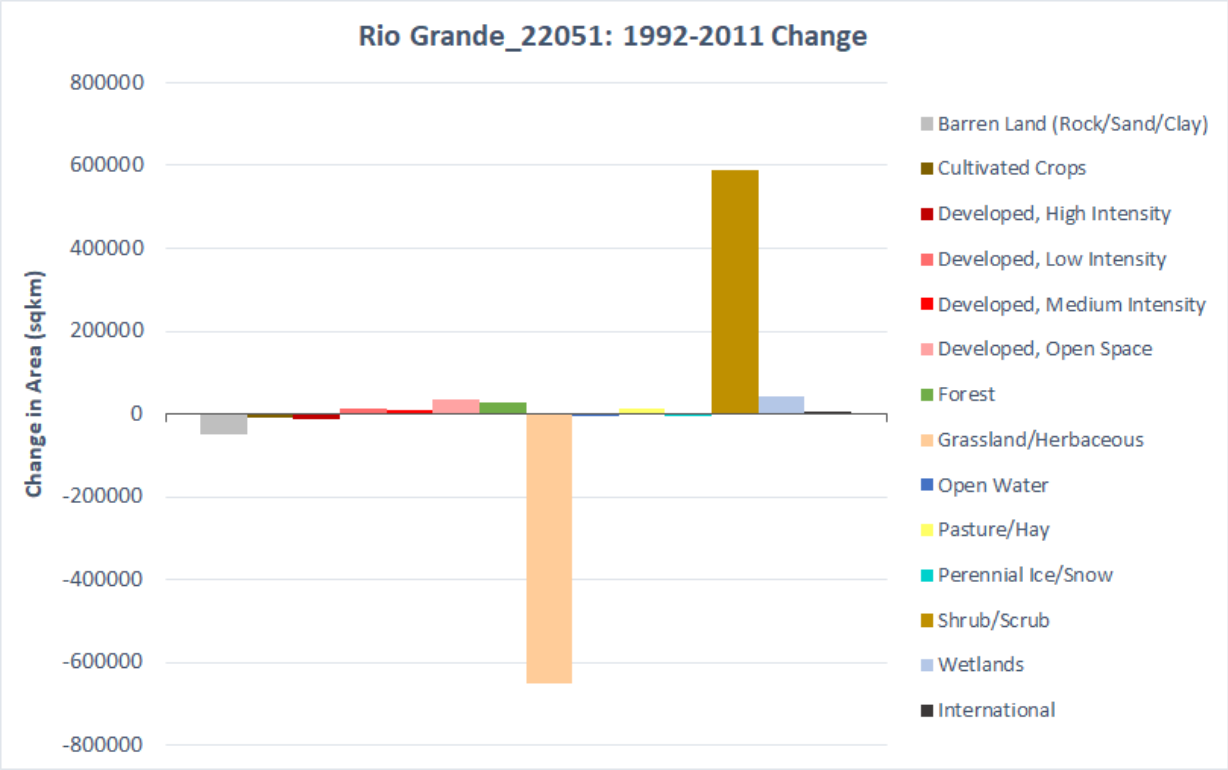

Figure 21. Land use change in area (sq km) from 1992-2011 for the Rio Grande watershed at Contrabando.

RIO GRANDE: JOHNSON RANCH

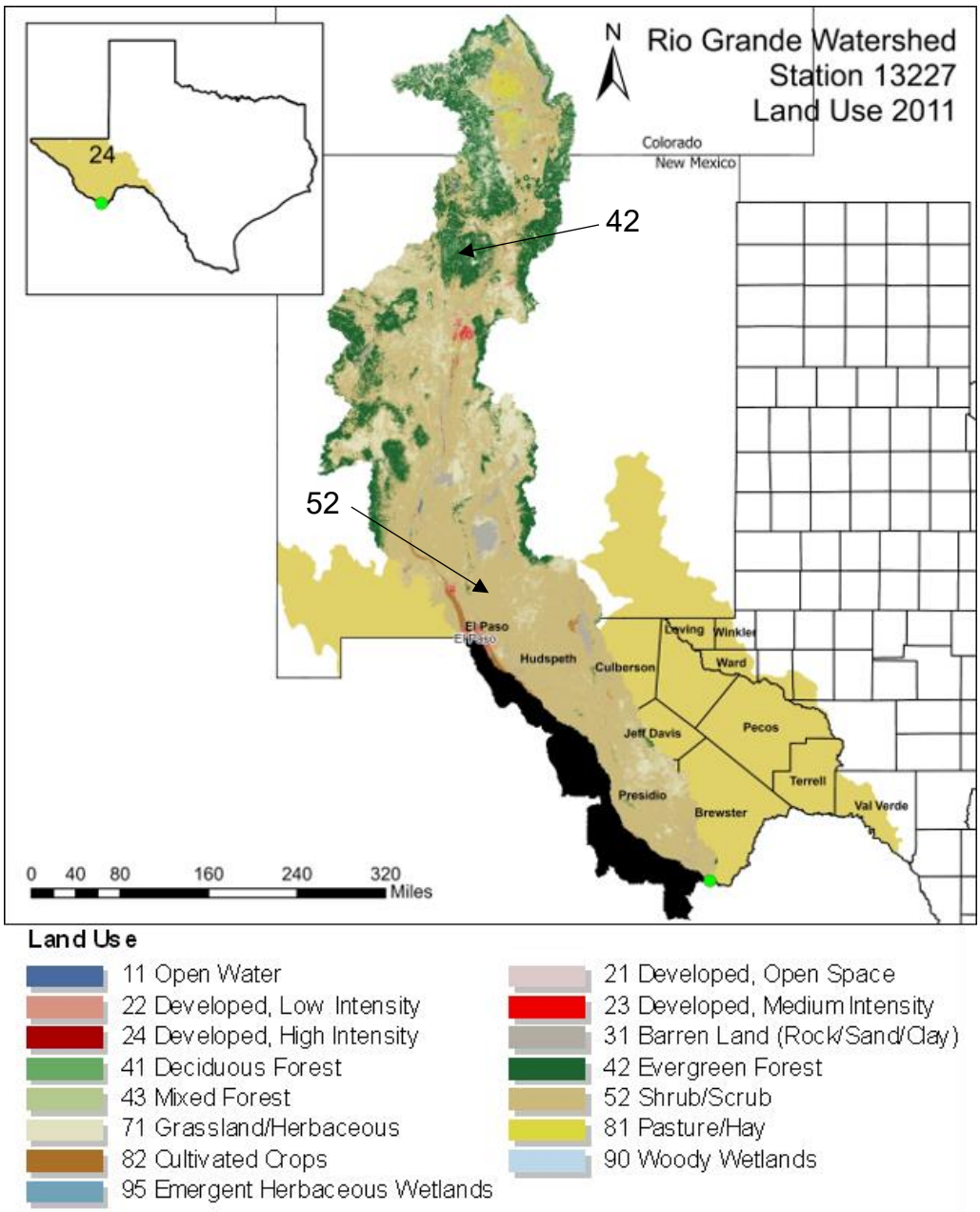

Figure 22. Map of Rio Grande watershed at Johnson Ranch and 2011 land use; shrub/scrub and forest were the most common land uses.

Sampling Dates

Physical Habitat:	March 30, 2017
Water Quality:	70 sampling events
Fish:	March 30, 2017
Benthic Invertebrates:	March 30, 2017

Physical Characterization

Watershed and Land Use

The Rio Grande is the border between Texas and Mexico and is the basin's namesake. The Rio Grande Basin drains all west Texas, along the southwest border of Texas through Laredo, and the south Texas valley. Sample site 13227 is located approximately 3.22 km upstream of Johnson Ranch near Santa Elena, east of Castolon in Brewster County (Figure 22).

The Rio Grande watershed at site 13227 is approximately 5,510,980.99 sq km. The station and portion of the lower watershed are located in Level IV Ecoregion 24c, the Low Mountains and Bajadas. The lower watershed also encompasses Level IV Ecoregion 24b, the Chihuahuan Desert Grasslands. The middle portion of the watershed is located in New Mexico and encompasses Level IV Ecoregion 24a, the Chihuahuan Basins and Playas. The middle portion of the watershed extends through Ecoregions 22 and 23. The upper watershed extends into Colorado and contains a portion of Ecoregion 21. The dominant land cover in the watershed is shrub at 53.21% and is present throughout the watershed (Homer et al. 2015; Figure 22 and Figure 23). Forest is the secondary land cover encompassing 16.12%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 1.42% and total cover for cultivated crops is 0.70%.

From 1992-2011 there was a 657,738.72 sq km decrease in grassland/herbaceous and a 55,241.35 sq km decrease in barren land (rock/sand/clay). There was a 598,557.29 sq km increase in shrub and a 40,829.48 sq km increase in wetlands (Figure 24).

Within the Rio Grande watershed in the state of Texas, there are eight domestic wastewater outfalls (discharges < 1 million gallons per day), one current mining outfall, and one pending and eleven industrial wastewater outfalls (discharges ≥ 1 million gallons per day) within the Rio Grande watershed at site 13227. The domestic wastewater facilities are permitted to the towns of Anthony, Fort Hancock, and Van Horn, Canutillo ISD, El Paso County, Hudspeth County, Lajitas Municipal Services Company, and U.S. Department of Interior for Big Bend National Park. The mining outfall is permitted to the Rio Grande Mining Company. The pending industrial wastewater facility is permitted to the Esperanza Water Service Company and six of the industrial wastewater facilities are permitted to the El Paso Water Utilities Public Service Board. The remaining industrial wastewater facilities are permitted to the City of Presidio, El Paso County Water Control and Improvement District No 4, Horizon Regional Municipal Water District, El Paso Electric Company, and Study Butte Water Supply Corporation.

The domestic wastewater facility for Canutillo ISD and industrial wastewater facilities for the City of Presidio and El Paso Water Utilities Public Service Board discharge directly into the Rio Grande.

In Channel and Riparian Physical Habitat

Physical habitat for the Rio Grande River at Johnson Ranch in Big Bend National Park was evaluated on March 30, 2017. The Habitat Quality Index score of 24 indicates a high 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 shrubs, which make up an average of 82.5% of the total riparian species, followed by grasses (12.5%) then trees (5%). The average percentage of tree canopy cover was 38%. The dominant substrate was silt, and the average percent of substrate gravel size or larger was 53%. Average percent instream cover was 21% and instream cover types include cobble/gravel, undercut banks, overhanging vegetation, and woody debris. The Rio Grande at Johnson Ranch was 0.4 meters deep on average and 23 meters wide. Average stream bank slope was 45 degrees. Stream flow was recorded at 57 cfs from an IBWC gaging station at the site. Average stream bank erosion potential was 51%. The deepest pool measured at the site was 2.6 meters. Three riffles were observed at the site and there were four total stream bends.

Water Quality

Water samples were collected at station 13227 over 70 sampling events from September 1968 through February 2006. Data collected included temperature, flow, specific conductivity, dissolved oxygen, pH, ammonia, total nitrogen, phosphorus, chloride, sulfate, and chlorophyll-a.

Biological Characterization

Fish

Eight species (four families) were collected from this site on the Rio Grande. The family Cyprinidae was represented by three species, Catostomidae two species, Ictaluridae two species, and Fundulidae one. Blue Sucker, a state listed threatened species, was the most abundant species. Based on the fish assemblage, the Rio Grande rated as having a high aquatic life use. This site received a higher IBI metric score for percentage of tolerant species than the site sampled downstream of Presidio (5 versus 1), a higher metric score for percentage of non-native species than the Contrabando sample site (5 versus 3), and a higher metric score than both upstream sites for percentage of omnivores (5 versus 3).

Benthic Macroinvertebrates

Considering the single RBP sample, a total of 269 individuals representing 25 taxa from 8 orders of macroinvertebrates were collected from the Rio Grande at Johnson Ranch (Appendix E). The Ephemeroptera, Trichoptera, Coleoptera, and Odonata were the most commonly collected orders, collectively accounting for 91.4 percent of the total number of individuals collected. Hemiptera, Diptera, and Veneroida were the only other orders which comprised at least one percent of the collections. The Ecoregion 24 BIBI for the March 2017 Rio Grande at Presidio sample fell in the exceptional aquatic life use category.

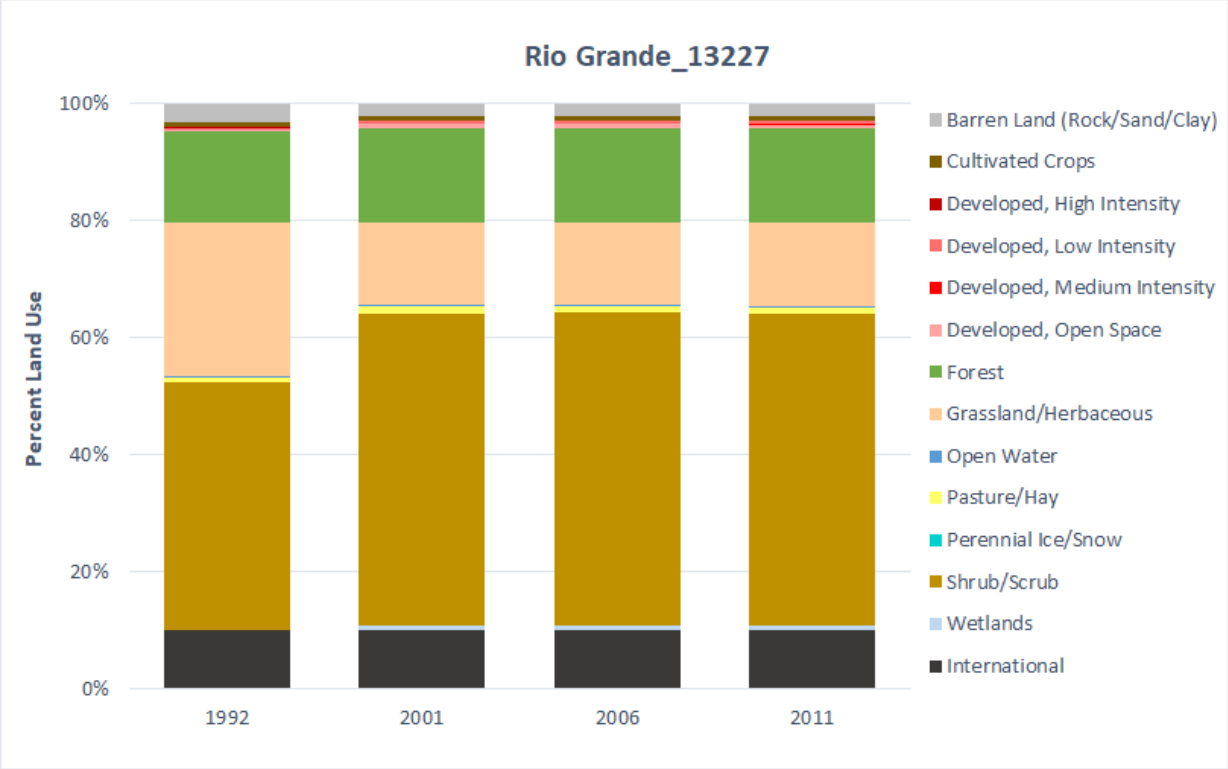

Figure 23. Percent land use in the Rio Grande watershed at Johnson Ranch from 1992-2011.

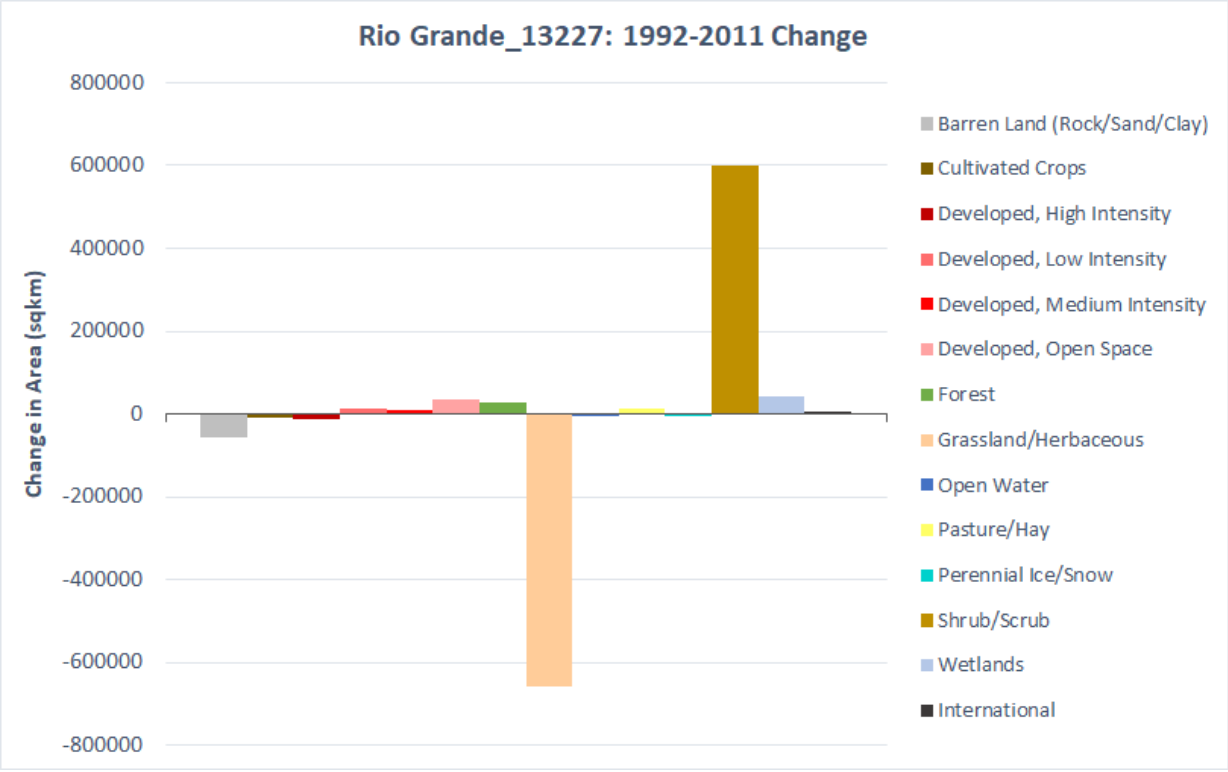

Figure 24. Land use change in area (sq km) from 1992-2011 for the Rio Grande watershed at Johnson Ranch.

TERLINGUA CREEK

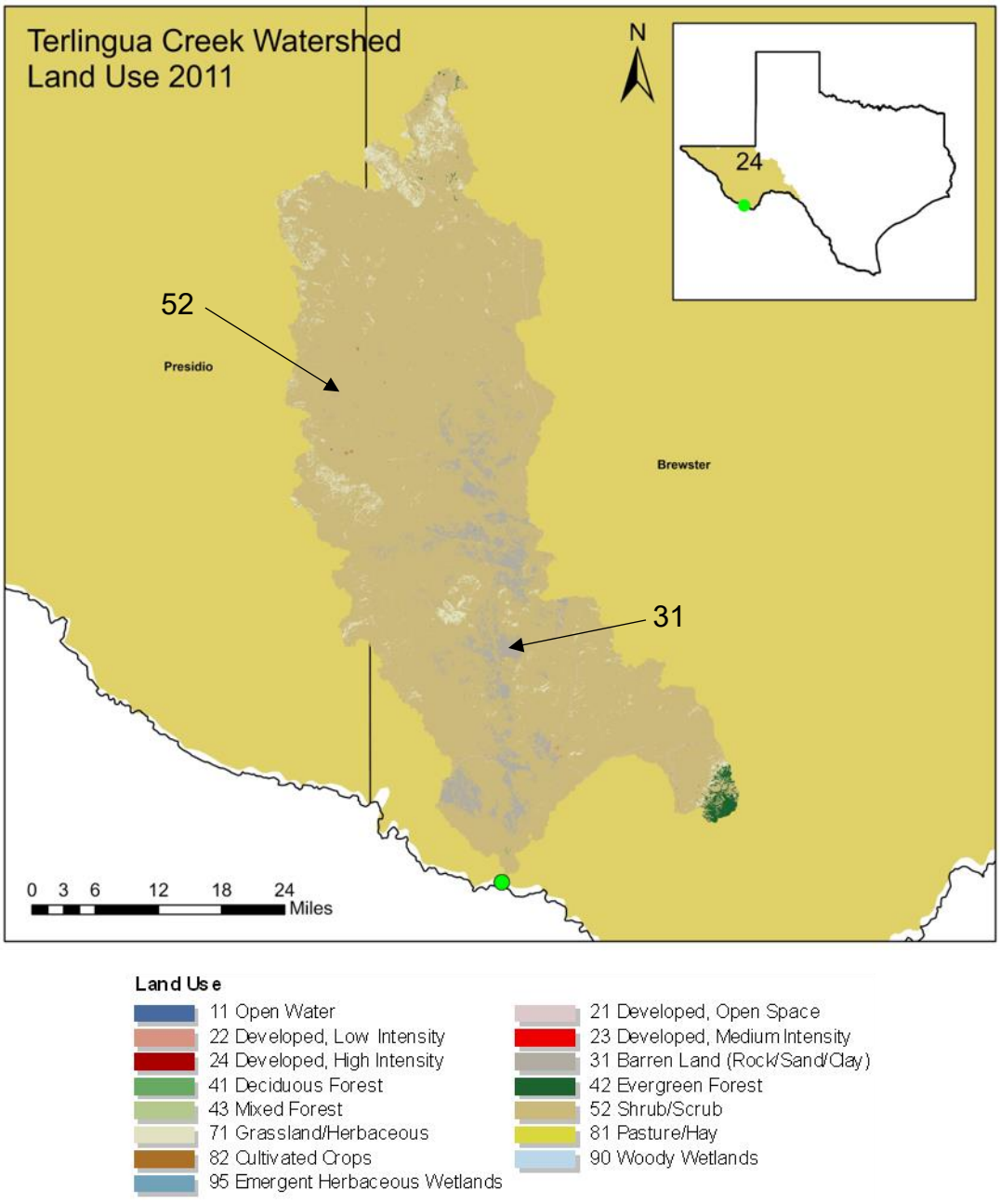

Figure 25. Map of Terlinuga Creek watershed location and 2011 land use; shrub/scrub and barren land were the most common land uses.

Sampling Dates

Physical Habitat:	No samples
Water Quality:	3 sampling events
Fish:	July 12, 1989
Benthic Invertebrates:	No samples

Physical Characterization

Watershed and Land Use

Terlingua Creek lies within the Rio Grande Basin. Sample site 13714 is located 250 m upstream from the confluence with the Rio Grande and approximately 13.7 km south of Terlingua in Brewster County (Figure 25).

The Terlingua Creek watershed at site 13714 is approximately 2831.74 sq km. The watershed spans across Level IV Ecoregions 24c, the Low Mountains and Bajadas, and 24b, the Chihuahuan Desert Grasslands. The dominant land cover in the watershed is shrub at 89.92% and is present throughout the watershed (Homer et al. 2015; Figure 25 and Figure 26). Barren land is the secondary land cover encompassing 5.57%. The combined land cover for developed land use (open space and low, medium, and high intensity) totals 0.23% and total cover for cultivated crops is 0.01%.

From 1992-2011 there was a 145.92 sq km decrease in grassland and a 116.32 sq km decrease in barren land (rock/sand/clay). There was a 259.04 sq km increase in shrub and a 4.94 sq km increase in open space development (Figure 27).

There are two wastewater outfalls – one domestic wastewater outfall (discharges < 1 million gallons per day) and one industrial wastewater outfall (discharges ≥ 1 million gallons per day) – within the Terlingua Creek watershed. The domestic wastewater facility is permitted to the US Department of the Interior for Big Bend National Park and the industrial wastewater facility is permitted to the Study Butte Water Supply Corporation. None of these facilities discharge directly into Terlingua Creek.

In Channel and Riparian Physical Habitat

Physical habitat data is not available for Terlingua Creek.

Water Quality

Water samples were collected at station 13714 over three sampling events in November 1992, August 1993, and August 2004. Data were collected for 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

Ten species (four families) were collected from Terlingua Creek. Cyprinidae was represented by seven species and was the only family with more than one species. Plains Killifish *Fundulus zebrinus* was the most abundant species. Of particular note was the presence of two state listed threatened species, Mexican Stoneroller and Chihuahua Shiner. Based on the fish assemblage, this site only rated as having an intermediate aquatic life use; however, when the coefficient of variability is applied it rises to high. Five of the eleven IBI metrics only received the lowest score

(1). These metrics included: number of sunfish species (none were collected); number of benthic invertivore species (none were collected); number of intolerant species (none were collected); percentage of individuals as tolerant species (82%); and number of individuals. The remaining six metrics each received the highest score (5).

Benthic Macroinvertebrates

No samples were collected for benthic macroinvertebrates.

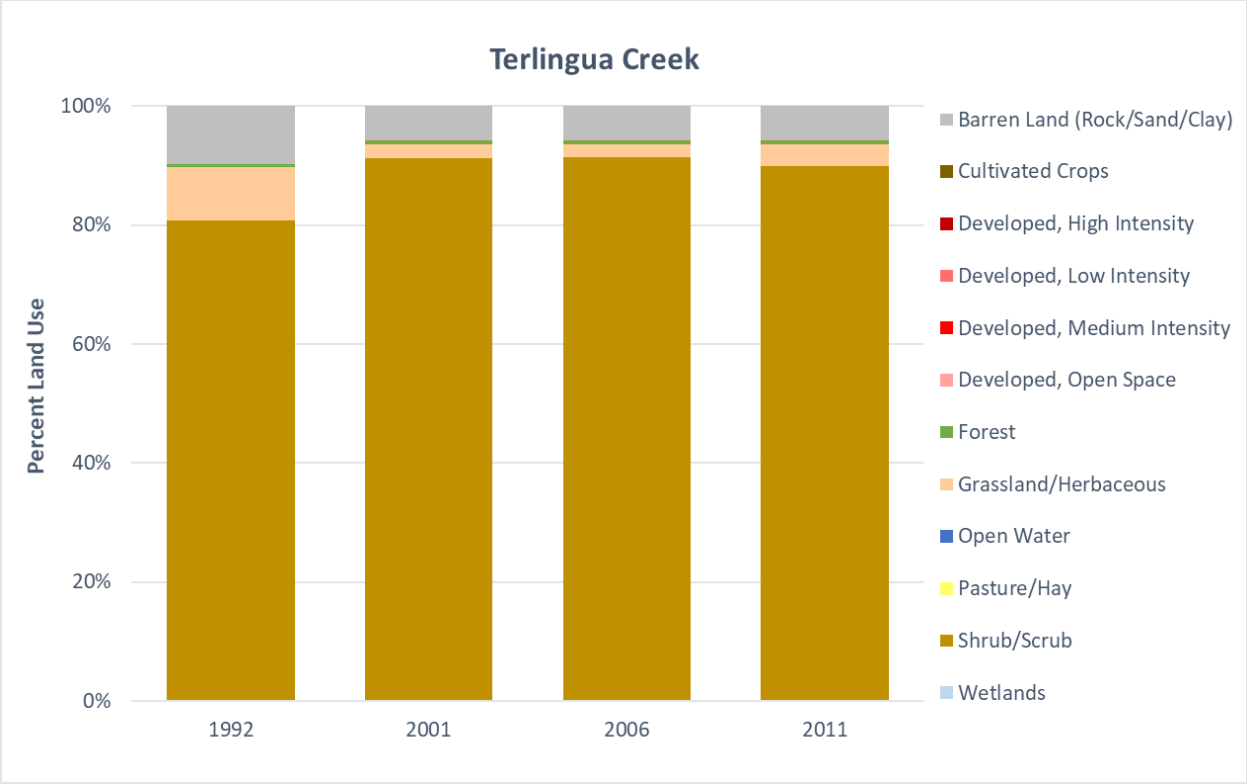

Figure 26. Percent land use in the Terlingua Creek watershed from 1992-2011.

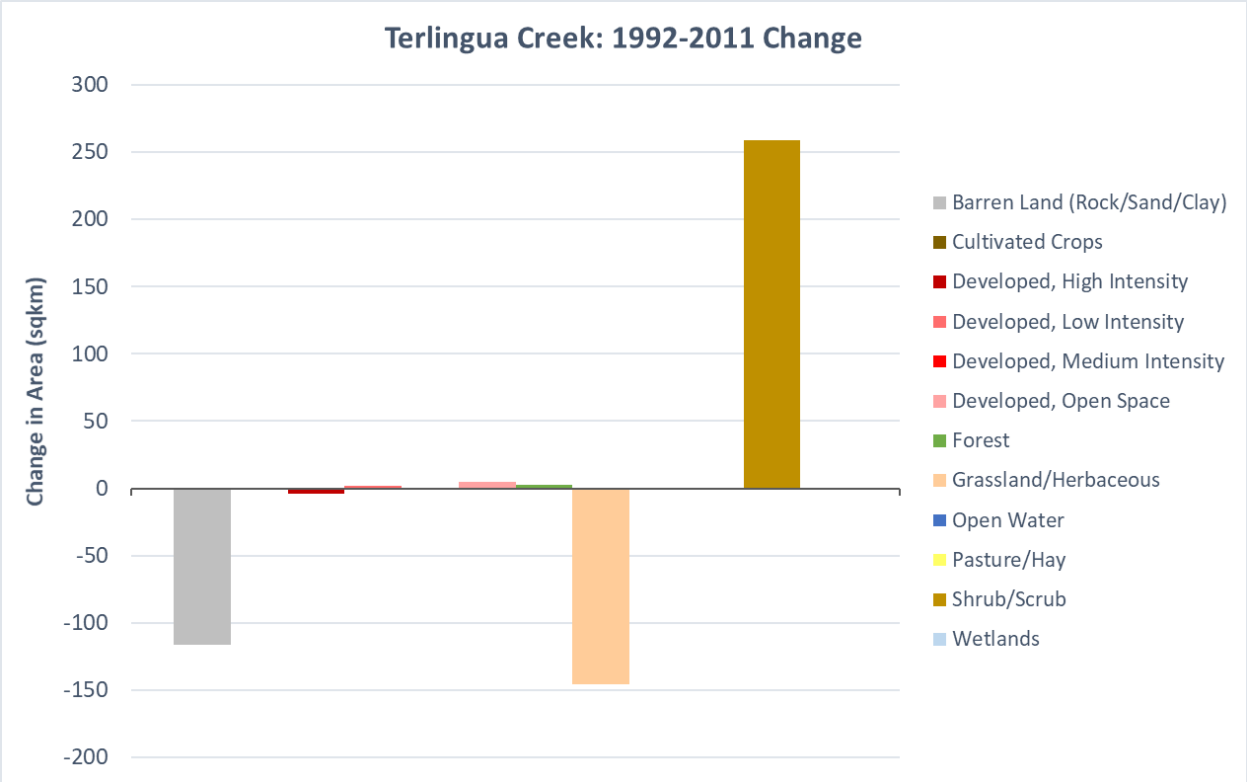

Figure 27. Land use change in area (sq km) from 1992-2011 for the Terlingua Creek watershed.

Ecoregion 24 Summary and Historical Characterization

Watershed and Land Use

Ecoregion 24 was historically predominately covered by vegetated semi-desert grassland and arid shrubland. The extent of desert shrubland is increasing due to gradual desertification partly due to historical grazing pressures (Griffith et al. 2007). In 2011 the overall primary land cover in the study watersheds was shrub and the secondary land covers were grassland and forest. Between 1992-2011, grassland experienced the largest decrease in combined land cover area across all watersheds (~2,792,532 sq km) and shrub experienced the largest increase (~2,574,173 sq km).

In Channel and Riparian Physical Habitat

Physical habitat for the Southern Deserts was evaluated at six stream sites over seven sampling events from 1989 to 2017. Watershed area varied from a minimum of 1,521 sq km at Independence Creek to a maximum of 5,510,981 sq km at the Rio Grande River at Johnson Ranch in Big Bend National Park. The sites generally had well vegetated riparian zones, and the riparian buffer was 25 meters on average with a minimum of 15 meters and maximum of 61 meters. Shrubs were the dominant riparian species (57% on average), followed by grasses (25%) then trees (11%), and average percent tree canopy coverage was 19.5%. Of the five sampling events that documented substrate type, cobble was the dominant substrate at three sites, with boulders reported as dominant at one site and silt at the remaining site. Average percentage of substrate gravel sized or larger was 67% and varied from a minimum of 40% to a maximum of 99.7%. Average percent instream cover was 40% and common instream cover types include boulders, undercut banks, cobble/gravel, macrophytes, woody debris, algae, and overhanging vegetation. Average stream depth and width measurements were 0.3 meters and 19 meters, respectively. Average stream bank slope was 33 degrees and erosion potential was moderate with an average of 40% which was reflected in the average bank stability HQI score (1.5) indicating moderately stable to moderately unstable stream banks. Maximum pool depth ranged from a minimum of 0.4 meters to a maximum of 2.6 meters. Total number of riffles varied from one to eleven, and total number of stream bends ranged from one to four.

HQI scores are available for five events and range from a maximum score of 26 (exceptional) at three sites (Pecos River, Rio Grande River at Contrabando Creek, and Independence Creek) to a minimum score of 18.5 (intermediate) at the Rio Grande River near Presidio. Of the five sampling events with an HQI score, three (60%) received a habitat assessment rating of exceptional, one received a rating of high (20%) and the remaining site (20%) received a rating of intermediate. The highest scoring HQI metrics for the Southern Deserts were the bottom substrate stability metric, number of riffles metric, and dimensions of largest pool metric. The lowest scoring HQI metrics on average were the bank stability metric and the channel flow status metric.

Water Quality

Water quality data from ecoregion 24 includes both small streams and larger rivers in west Texas. In this arid environment, temperature was 10 degrees Celsius in the 5th percentile to 29.3 degrees Celsius in the 95th percentile, and specific conductivity ranged from 163 to 8,990 us/cm. The secchi values observed indicated turbid waters at most sampling events with a median value of 0.24 meters with a range from 0.01 to 6.8 meters. The pH values had a range of 5.4 to 11. Chlorophyll-a data was highly variable between stations with a range of 0.1 to 205 ug/L. Additional water quality variables are summarized in appendix C of the report.

Fish

A total of 7,165 individuals consisting of 12 families and 36 species have been documented in eight sampling events across seven streams in the Southern Deserts from 1989 to 2017 (Appendix D - 1). For individual sites, taxa richness ranged from 20 species at the Pecos River from one sampling event in 2016 to a low of eight species at the Rio Grande at Johnson Ranch from one sampling event in 2017. The most abundant species collected across all sites and sampling events were Red Shiner (n = 1,703), Western Mosquitofish (n = 1,502), Bullhead Minnow (n = 934), Manantial Roundnose Minnow (n = 580), and Mexican Stoneroller (n = 370).

Index of biotic integrity scores across all sites and sampling events ranged from 35 to 47 resulting in aquatic life use categories of intermediate (n = 3), high (n = 2), and exceptional (n = 3; Figure 28). Of the eight sampling events in this ecoregion, 62.5% received an ALU rating of high or exceptional; 37.5% received an ALU of intermediate. Independence Creek was sampled twice and received a high and exceptional ALU. Three sites were sampled one time and received the same IBI score of 35 (intermediate): Rio Grande at Presidio, Rio Grande at Contrabando, and Terlingua Creek. All other sites received an ALU score of high or better.

Overall, IBI scores and individual metrics 1-11 did not significantly change through time (Figure 29; Figure 30; Figure 31); however, the percentage of individuals with disease/anomaly significantly decreased through time (Figure 31(12): $R^2 = 0.54$, $p = 0.04$). 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

A total of 6,597 individuals representing 19 orders of aquatic macroinvertebrates were collected in the two Surber samples, and five RBP samples collected at six sites in the Chihuahuan Deserts ecoregion over the interval from July 1989 to March 2017 (Appendix E). Seven orders (Coleoptera, Diptera, Ephemeroptera, Trichoptera, Hemiptera, Odonata, and Clitellata) were represented at all six sites. The most commonly collected orders included Neotaenioglossa, Ephemeroptera, Trichoptera, Diptera, and Coleoptera which collectively represented 82% of the total number of individuals collected.

In terms of relative abundance, *Pyrgulopsis sp*. (Neotaenioglossa, Hydrobiidae) was the most abundant taxon, representing 18.7% of the total number of individuals collected at all sites.

However, it should be noted that all 1,371 individuals of this taxon were collected in a single Surber sample at Independence Creek. Other relatively abundant taxa include *Helicopsyche sp*., *Fallceon quilleri*, *Elimia comalensis*, *Cochliopina riograndensis*, *Cheumatopsyche sp*., and *Traverella sp*. Four of these six taxa are considered scraper/grazers, utilizing attached periphyton as a primary energy source. This reflects the open canopy, and ample insolation characterizing streams in the Chihuahuan Deserts.

Fallceon quilleri, was the only genus collected at all six sites, and six of seven collections. *Cheumatopsyche sp*., and *Erpetogomphus sp*. were also widely distributed genera/species, occurring in collections from five of six sites.

The BIBI scores for the Surber samples collected at Alamito Creek in 1989, and at Independence Creek in 1990 fell in the exceptional and high aquatic life use categories respectively. Similarly, the RBP IBI score for four of five RBP samples collected over the interval from September 2016 thru March 2017 RBP IBI scores fell in the high aquatic life use category, while the RBP IBI score for the sample collected on the Rio Grande at Johnson Ranch in Big Bend National Park fell in the exceptional. These findings suggest that the biotic integrity of these streams has remained relatively constant and in the high to exceptional range over the 28-year interval (Figure 32; Figure 33).

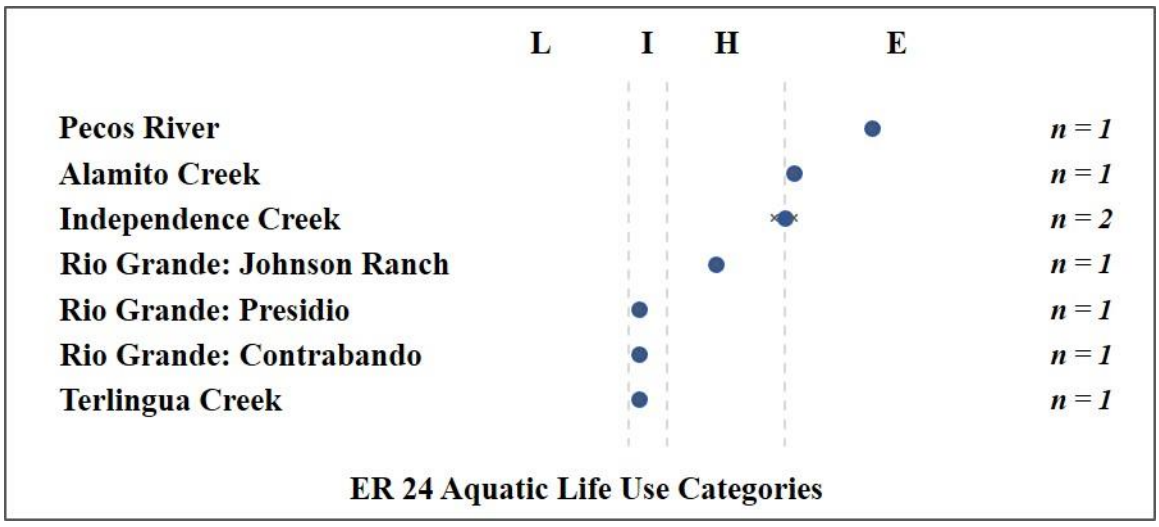

Figure 28. Aquatic life use categories (L – limited; I – intermediate; H – high; E – exceptional) for all fish sampling events in Ecoregion 24 grouped by site and ranked by mean ALU score (blue dot); number of sampling events per site noted on right.

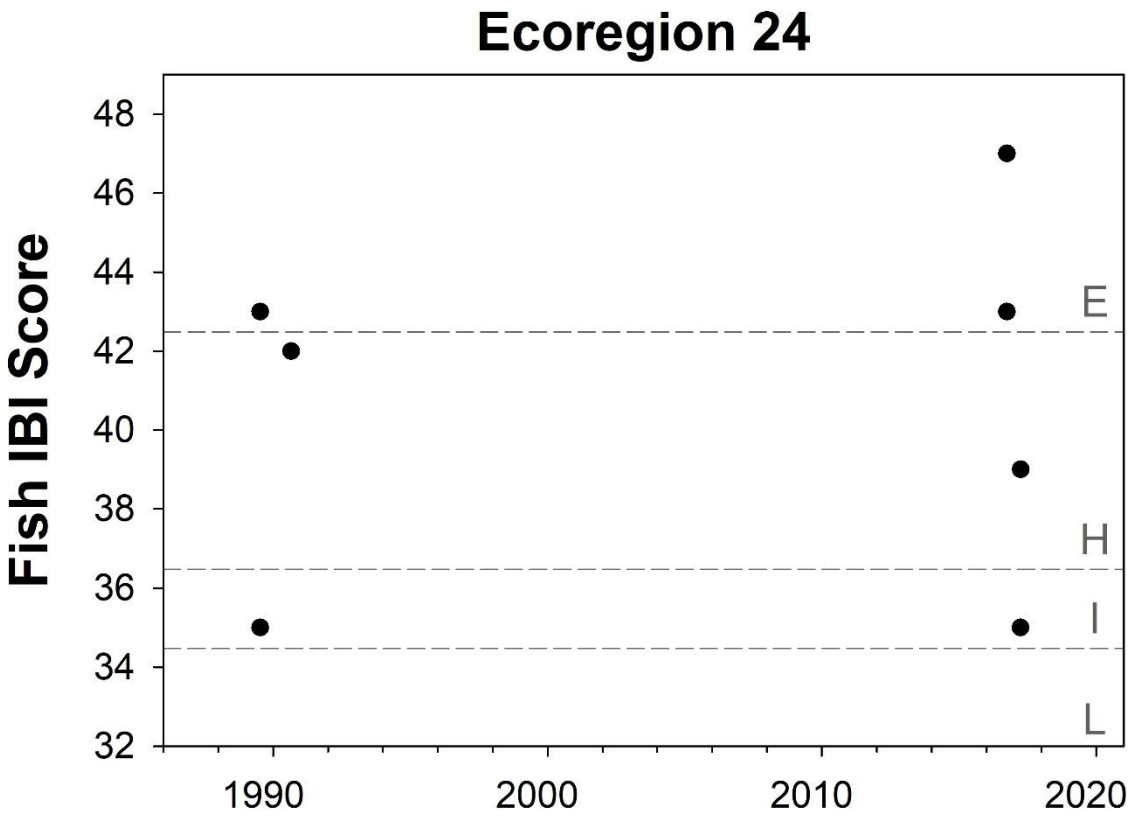

Figure 29. Fish index of biotic integrity scores through time for all sampling events in Ecoregion 24; break lines for aquatic life use categories (i.e., limited, intermediate, high, and exceptional) shown on each graph for reference (see Linam et al. 2002).

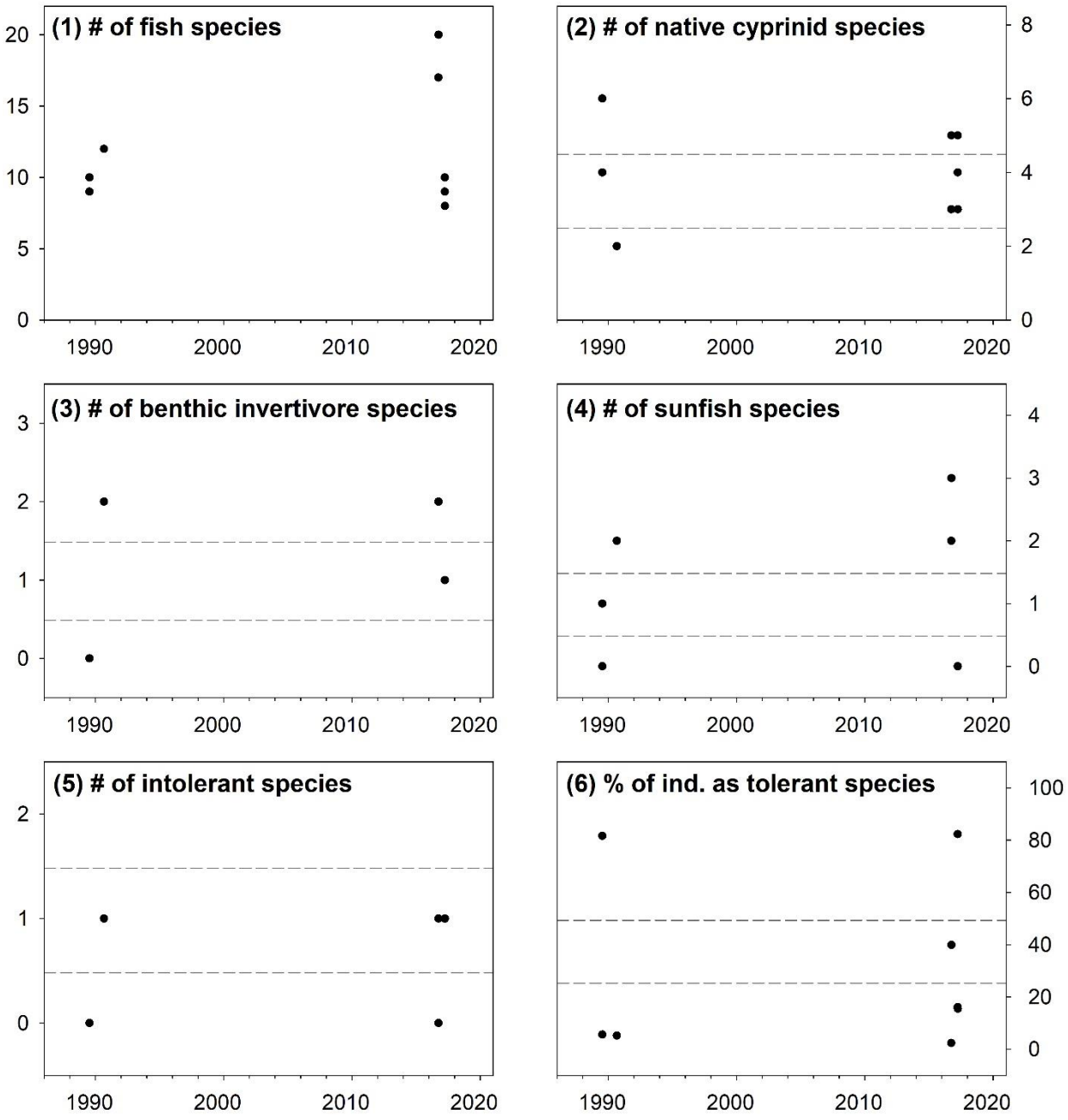

Figure 30. Raw values for fish index of biotic integrity metrics 1-6 through time for all sampling events in Ecoregion 24; break lines for scoring criteria (i.e., 1, 3, and 5) shown on each graph for reference (see Linam et al. 2002).

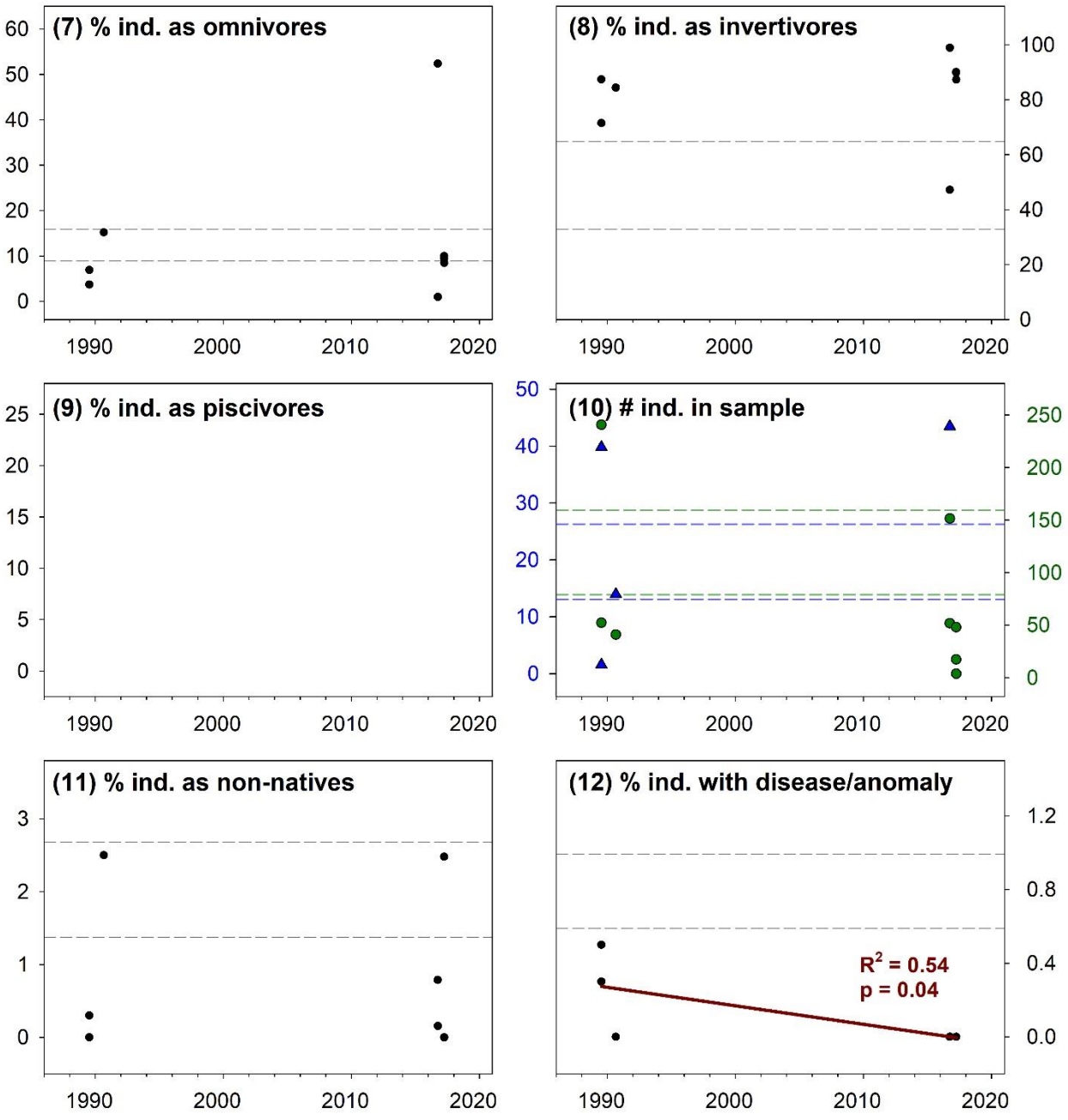

Figure 31. Raw values for fish index of biotic integrity metrics 7-12 through time for all sampling events in Ecoregion 24; break lines for scoring criteria (i.e., 1, 3, and 5) shown on each graph for reference (see Linam et al. 2002); number of ind./seine haul represented by green circles and number of ind./min electrofishing represented by blue triangles for metric number 10; metrics that are not included in the IBI for this ecoregion are blank.

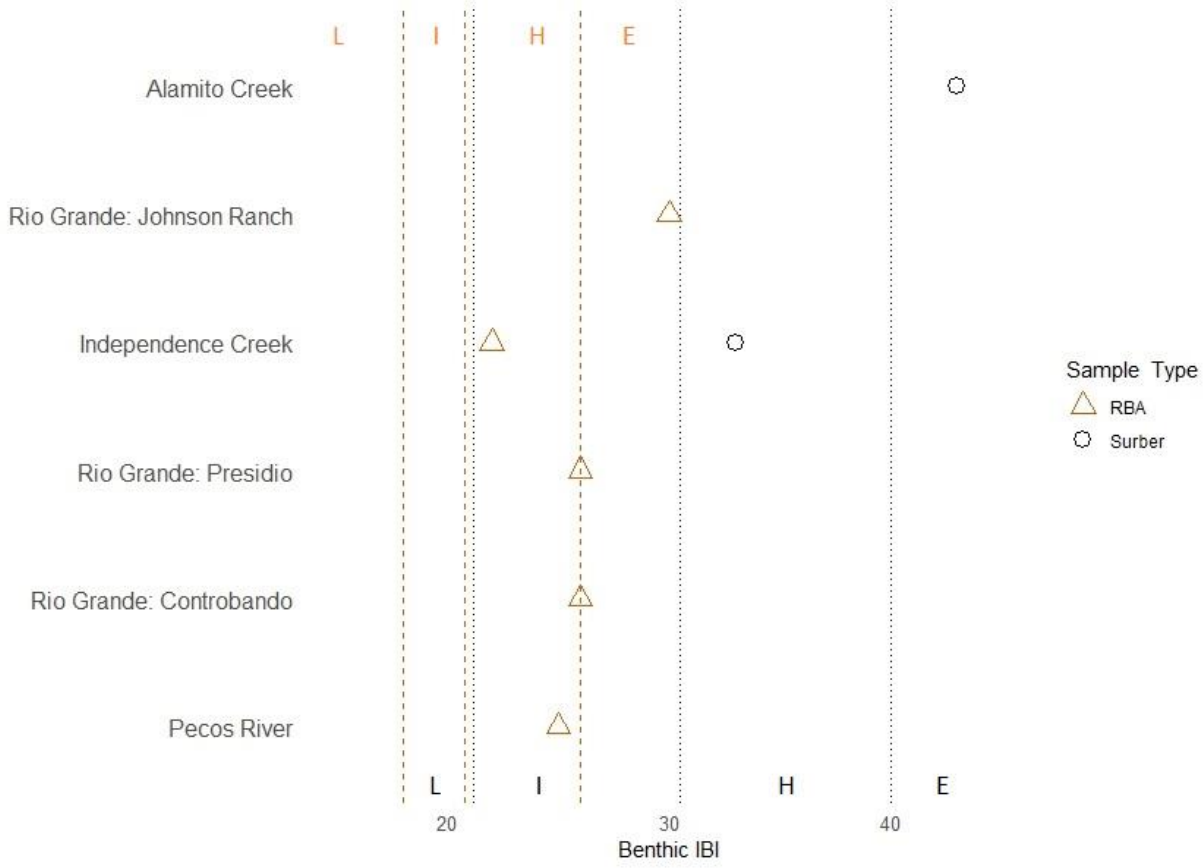

Figure 32. Benthic IBIs and aquatic life use categories (L – limited; I – intermediate; H – high; E – exceptional) for all benthic sampling events in Ecoregions 24 grouped by site and ranked by mean IBI score. RBP IBIs scores are red triangles and ALU cutoffs are in red dashed lines. Surber IBI scores are black circles and ALU cutoffs are in black dotted lines.

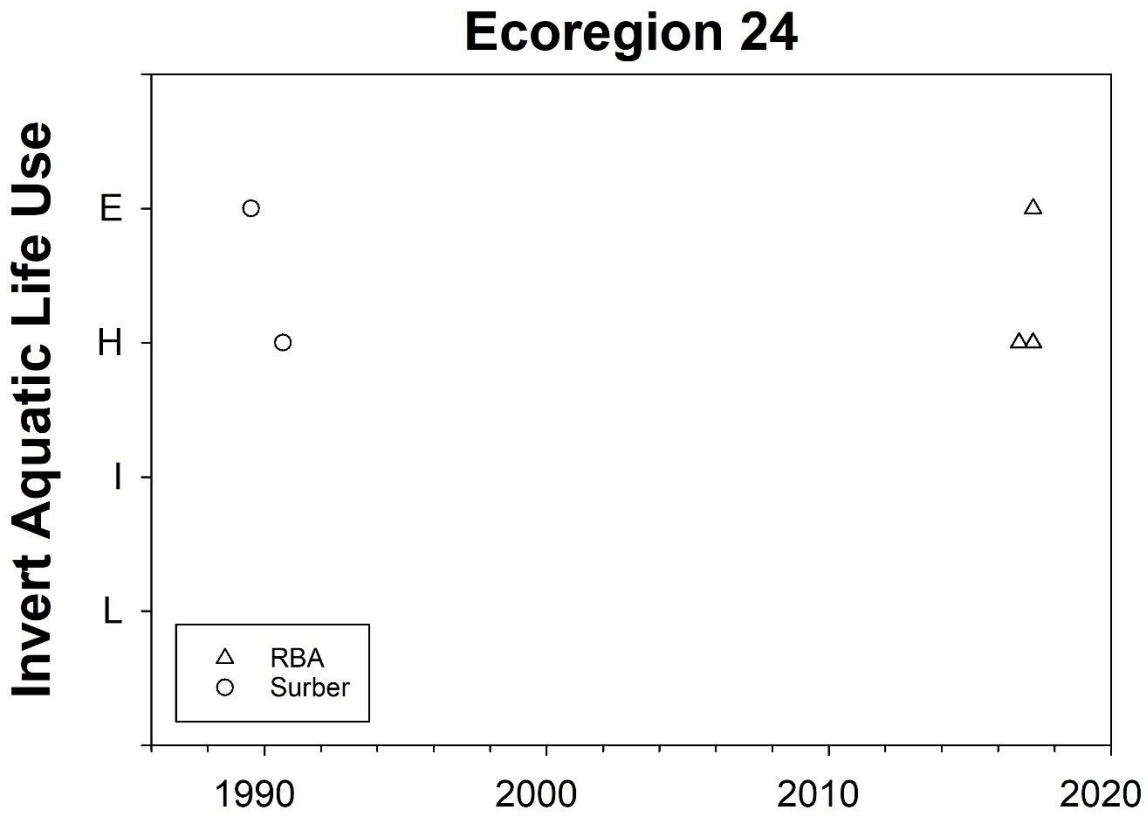

Figure 33. Benthic aquatic life use (ALU) categories through time for all sampling events in Ecoregion 24; Surber ALUs are noted by circles and RBP ALUs are noted by triangles.