WESTSIDE CREEKS ENVIRONMENTAL RESTORATION

Appendix C: Natural Resources

NATURAL RESOURCES APPENDIX

INTRODUCTION

The Natural Resources appendix was developed to provide technical and policy support information utilized in the development of the feasibility report. This appendix provides information that documents historic conditions, future without project conditions, known planning constraints and opportunities to develop plans that would meaningfully restore modern historic ecosystem conditions to the streams and realated riparian habitats of the study area. This appendix describes the estimation of environmental benefits and the plan formulation of the WSC ecosystem restoration study.

Havard (1885) describes the San Antonio River Valley as containing "masses of luxuriant timber spread over the valley, thick shrubbery of various shades of green covers the uplands, and a sward of thin but nutritious grass carpets the ground…Largest and most conspicuous of trees along the river is the lordly pecan, attaining here an enormous size, and the cottonwood." Havard describes an extremely rich and diverse aquatic ecosystem in the San Antonio streams including yellow pond-lily (*Nuphar lutea*), water pennyworts (*Hydrocotyle prolifera, H. umbellata*), Carolina fanwort (*Cabomba caroliana*), watercress (*Nasturtium officinale*), arrow-heads (*Sagittaria lancifolia, S. latifolia*), brookweeds (*Samolus valerandi, S. ebracteatus*), water hemlock (*Cicuta maculata*), monkey-flowers (*Mimulus glabratus, M. luteus*), and several species of pondweed (*Potomogeton* spp.). Beckham (1887) provides further insight into the historic morphology of the San Antonio river and its tributaries writing "These (San Antonio) springs or fountains unite to form a river, which, after winding through the town in a very tortuous course, is joined some distance below by the San Pedro, a large creek having a source of supply similar to that of the river."

The aquatic and terrestrial organisms that depended on the aquatic and riparian habitats were equally diverse. The presence of numerous springs and streams along the Balcones Escarpment and the convergence of the Edwards Plateau, South Texas Brush, and Blackland Prairies ecological regions have long been recognized as providing valuable habitat for many wildlife species in the San Antonio area, particularly birds (Beckham, 1887; Attwater, 1892; Quinlan and Holleman, 1918; Griscom, 1920). The evolutionary 'development' of the Central Flyway along these resources is probably no accident given the immense historic productivity these habitats must have provided.

Although the Westside Creeks aquatic ecosystem had been previously affected by the urbanization of Bexar County and the encroachment on the riparian habitats, the San Antonio Channel Improvements Project (SACIP) constructed between 1957 and1988 by the Corps of Engineers eradicated any semblance of the streams Havard and Beckham described almost 130 years ago. The SACIP straightened approximately 35 miles of the San Antonio River and its tributaries in the San Antonio area and converted the aquatic and riparian habitats to maintained grass-lined channels to reduce flood risk. By straightening the tortuous watercourses, water velocities increased leading to increased erosion and sedimentation downstream, thereby disrupting the substrate composition of the highly impacted aquatic habitats that remained. The homogeneous, shallow pilot channel that replaced the sinuous natural pool, riffle, and run habitats resulted in increased water temperatures and lower dissolved oxygen concentrations. Additionally, the loss of overstory vegetation that once shaded the creeks exasperated these effects resulting in the severe aquatic habitat conditions existing today.

Although the flood risk management measures initiated by the SACIP were a needed response to damaging floods that occurred in San Antonio in the 1940's and 1950's, the actions resulted in unconsidered consequences for fish and wildlife that are dependent on these regionally scarce aquatic and riparian habitats.

The purpose of Civil Works ecosystem restoration is to restore significant ecosystem function, structure, and dynamic processes that have been degraded (USACE, 1999). In an effort to return aquatic and riparian habitat structural and functional benefits to the SACIP riverine ecosystem, San Antonio River Authority (SARA) and the United States Army Corps of Engineers (USACE) have already partnered to restore approximately 9 miles of these habitats with the implementation of Eagleland and Mission Reach projects located on the San Antonio River. This WSC study assesses the benefits of restoring 13 miles of aquatic and riparian habitat along previously channelized tributary streams to the San Antonio River.

EXISTING CONDITIONS

The channelization of the Westside Creeks has caused degradation of the riverine environment resulting in the loss of an aquatic environment supporting native aquatic species. The existing WSC floodways resemble typical trapezoidal shaped floodways with concrete slab and block armoring interspersed throughout. Vegetation is maintained to heights of approximately six inches or less. Linked to the aquatic degradation is the loss of native riparian vegetation species, which in addition to being vital to the aquatic environment, supports native residential and migratory, game and nongame wildlife species. The extent of the degradation is so severe that it is impossible to separate the components of the riverine environment, aquatic versus riparian, to prioritize restoration measures. Virtually no vestige of a natural, complete, native riverine environment remains upon which to add only a few restoration measures and expect significant improvements. The loss of historical native riparian vegetation has resulted in the loss of the necessary components for the life cycle of the numerous insect species, which are the vital cornerstone of the riverine prey base for the native aquatic and riparian-dependent insectivore species. The imbalance in the predator/prey relationship has assisted in the invasion of non-native invasive species into the aquatic and riparian habitats.

Specific details of the WSC existing environmental conditions and potential impacts of the WSC study on these resources are described in the main report (Chapters 2 and 4).

RESOURCE SIGNIFICANCE

In compliance with the Council of Environmental Quality (CEQ) National Environmental Policy Act (NEPA) regulations (40 CFR 1500.1(b), 1501.7(a)(2) and (3), and 1502.2(b)), guidance for USACE ecosystem restoration projects (P&G) require the identification of significant resources and attributes that are likely to be affected by one or more of the alternative plans (U.S. Water Resources Council, 1983). "Significant" is defined as "likely to have a material bearing on the decision-making process" (Apogee Research, Inc., 1996). Resource significance is determined by the importance and non-monetary value of the resource based on institutional, public, and technical recognition in the study area. The P&G defines these significance criteria as:

- **Institutional Recognition**: The importance of the resource or attribute is acknowledged in the laws, adopted plans, and other policy statements of public agencies or private groups.
- **Public Recognition:** The resource or attribute is considered important by some segment of the general public.

- **Technical Recognition:** The importance of the resource or attribute is based on scientific or technical knowledge or judgment of critical resource characteristics.

In January, 2011, the USACE and the Assistant Secretary of the Army (Civil Works)(ASA(CW)) initiated a study to improve the efficiency and effectiveness of the pre-authorization study process (USACE, 2011). The Westside Creeks Ecosystem Restoration study has been designated as one of the pilot programs to assess the efficacy of the new pre-authorization study paradigm. One of the implementation measures identified by the study was the determination of Federal interest and level of Federal investment early in the study process. The new paradigm also requires alternative development and assessment beyond the National Economic Development (NED) and the National Ecosystem Restoration (NER) alternatives and the use of multi-criteria decision analysis in the selection of a “preferred” plan. Therefore, the identification of significant resources in the study area may provide additional criteria to include in a multi-criteria decision making analysis.

INSTITUTIONAL RECOGNITION

Significance based on institutional recognition means that the importance of the environmental resource is acknowledged in the laws, adopted plans, and other policy statements of public agencies or private groups. The institutional recognition of resource significance for the Westside Creeks Study area is demonstrated by the following laws, policies, treaties, plans, and cooperative agreements established for the conservation and protection of these environmental resources.

ENDANGERED SPECIES ACT

The Endangered Species Act of 1973 (ESA), as amended, "provides a means whereby the ecosystems upon which endangered and threatened species depend may be conserved, and to provide a program for the conservation of these species." The Department of the Interior, acting through the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service is responsible for the protection of federally threatened and endangered species in the U.S. The ESA prohibits the take of listed animals and the interstate or international trade in listed plants and animals without a permit. The USFWS also maintains a list of Candidate species consisting of species where there is information that warrants proposing them for listing under ESA, but listing them is precluded due to higher priority species. On October 6, 2011, five mussel species were added to the Federal list of Candidate species, three of which historically occurred in the San Antonio River Basin, but no longer occur within the WSC. The only Federally listed species that may move through the area as an extremely rare transient is the Whooping Crane (Table 1) (USFWS, 2011a; USFWS, 2011b).

TEXAS STATE THREATENED AND ENDANGERED SPECIES

In 1973, the Texas legislature authorized the Texas Parks and Wildlife Department (TPWD) to establish a list of fish and wildlife that are endangered or threatened with statewide extinction. In 1988, the Texas legislature added the authority for TPWD to establish a list of threatened and endangered plant species for the state. TPWD regulations prohibit the taking, possession, transportation, or sale of any state endangered or threatened animal species without the issuance of a permit (TPWD Code §68.015). In addition, the commercial sale, possession for commercial sale, or the sale of all or part of an endangered, threatened, or protected plant from public land is prohibited (TPWD Code §88.008).

Table 1 presents the state-listed rare, threatened, and endangered species that are known to occur in Bexar County (TPWD, 2011a) with the potential of these species to utilize aquatic and riparian habitats within the study area. Table 1 also identifies species of significance that may benefit from the proposed Westside Creeks study.

Table 1. Rare, Threatened, and Endangered Species

Common Name	Scientific Name	State Listing[1]	Utilizes Aquatic/ Riparian Habitats	Habitat within Westside Creeks Study Area
Birds				
American Peregrine Falcon	*Falco peregrines anatum*	ST	Yes	Yes[2]
Arctic Peregrine Falcon	*Falco peregrines tundrius*	SOC	Yes	Yes[2]
Interior Least Tern	*Sterna antillarum athalassos*	SE	Yes	Yes[2]
White-faced Ibis	*Plegadis chihi*	ST	Yes	Yes[2]
Whooping Crane	*Grus americana*	FE/SE	Yes	Yes[2,3]
Wood Stork	*Mycteria americana*	ST	Yes	Yes[2]
Zone-tailed Hawk	*Buteo albonotatus*	ST	Yes	Yes[2]
Mammals				
Cave myotis bat	*Myotis velifer*	SOC	No	Yes[4]
Ghost-faced bat	*Mormoops megalophylla*	SOC	No	Yes[4]
Mollusks				
Creeper (squawfoot)	*Strophitus undulatus*	SOC	Yes	Yes
Golden orb	*Quadrula aurea*	FC/ST	Yes	Yes
Reptiles				
Texas garter snake	*Thamnophis sirtalis annectens*	SOC	Yes	Yes
Texas indigo snake	*Drymarchon melanurus erebennus*	ST	Yes	Yes[3]
Timber/Canebrake rattlesnake	*Crotalus horridus*	ST	Yes	Yes[3]
Plants				
Big red sage	*Salvia pentstemenoides*	SOC	Yes	Yes
Correll's false dragon-head	*Physostegia correllii*	SOC	Yes	Yes

[1]SE – State-listed Endangered; FC –Candidate for Federal Listing; ST – State-listed Threatened; SOC – State Species of Concern
[2]Potential migrant
[3]Study area is at the limits of known range
[4]Potential foraging area

Fish and Wildlife Conservation Act of 1956

The Fish and Wildlife Conservation Act (FWCA) of 1956 encourages all Federal agencies to utilize their statutory and administrative authority to conserve and promote the conservation of nongame fish and wildlife and their habitats.

Fish and Wildlife Coordination Act of 1958

The Fish and Wildlife Coordination Act of 1934, as amended, recognizes the contribution of wildlife resources to the nation. The USFWS and TPWD have committed to dedicate time and resources to coordinate with USACE to develop, refine, and assess a set of measures that will ultimately yield identification of a preferred plan meeting the delivery team objectives for riverine habitat restoration that have significant environmental outputs for fish and wildlife resources. The USFWS and TPWD have previously stated that the Mission Reach segment of the San Antonio Restoration Project is great example of how the two objectives of flood control and habitat restoration can be integrated together, and believe that a similar coordinated effort can be used to accomplish environmental restoration benefits while maintaining the current level of flood protection offered by the existing flood control structures. The habitats that would be restored with implementation of the eventual recommended plan will meet intent and provisions of the Fish and Wildlife Coordination Act by recognizing the vital contribution of wildlife resources to San Antonio, south-central Texas, and the Nation. Institutional significance is demonstrated by the extreme interest, commitment, and recognition given to this study by the USFWS and TPWD. The Act recognizes that incremental losses to flowing waters and their associated riparian habitats have become cumulatively important to nationally recognized resources and that mitigation of those losses is within the national interest. Similarly the restoration of these habitats could be shown to be incrementally nationally significant.

Migratory Bird Treaty Act

The United States has recognized the critical importance of this shared resource by ratifying international, bilateral conventions for the conservation of migratory birds. These migratory bird conventions impose substantive obligations on the U.S. for the conservation of migratory birds and their habitats, and through the Migratory Bird Treaty Act, the U.S. has implemented these migratory bird conventions with respect to the U.S. The Migratory Bird Treaty Act prohibits the taking, possessing, importing/exporting, selling, and transporting of any listed migratory bird, its parts, nest, or eggs. Included in the protection provided by this act are all North American diurnal birds of prey, except bald and golden eagles which are provided protection under the Bald and Golden Eagle Protection Act. A list of bird species known to occur in Bexar County, including migratory birds protected under the Migratory Bird Treaty Act, are presented in Attachment 1.

North American Bird Conservation Initiative

The North American Bird Conservation Initiative (NABCI) is a trinational declaration of intent between the U.S., Canada, and Mexico to strengthen cooperation on the conservation of North American birds throughout their ranges and habitats. The U.S. NABCI Committee is coalition of government agencies, private organizations, and bird initiatives in the United States comprised of representatives from the following entities:

- U.S. Fish and Wildlife Service
- Natural Resources Conservation Service
- Bureau of Land Management

- Department of Defense
- National Park Service
- U.S. Geological Survey
- U.S. Forest Service
- Farm Service Agency
- Wildlife Management Institute
- Association of Fish and Wildlife Agencies
- National Flyway Council
- Partners in Flight
- Association of Joint Venture Management Boards
- National Audubon Society
- The Nature Conservancy
- American Bird Conservancy
- Ducks Unlimited
- Waterbird Conservation for the Americas
- U.S. Shorebird Conservation Plan
- North American Waterfowl Management Plan
- Migratory Shorebird and Upland Game Bird Working Group
- Resident Game Bird Working Group

The NABCI divided North America into 67 ecologically distinct Bird Conservation Regions (BCRs) based on similar bird communities, habitats, and resource management issues. The Westside Creek study area is located near the intersection of three BCRs: Oaks and Prairies (BCR 21), Edwards Plateau (BCR 20), and Tamaulipan Brushlands (BCR 36). Because of the proximity of the study area to each of these BCRs, the avian community and habitats exhibit characteristics of each region.

Oaks and Prairies BCR 21

The Oaks and Prairie BCR encompasses over 45 million acres of Texas and Oklahoma encompassing the Blackland Prairie Ecoregion and the Cross Timbers Ecoregion. These ecoregions represent the southernmost extent of “true” prairies and the westernmost extent of deciduous forest in North America.

Edwards Plateau BCR 20

The Edwards Plateau BCR is demarcated by the Balcones Fault on the south and east boundary of the BCR and grades into the Great Plains and Chihuahuan Desert to the west and north. The Edwards Plateau BCR includes the eastern ranges for more arid, desert species as the region trends to more mesic climes provided in the prairie regions.

Tamaulipan Brushlands BCR 36

The Tamaulipan Brushlands BCR encompasses most of south Texas west of the Gulf Coastal Plains and extends into northeastern Mexico. The BCR provides habitat representing the northernmost extent of several tropical species ranges and the southernmost extent to numerous North American species.

NORTH AMERICAN WATERFOWL MANAGEMENT PLAN

Established in 1986, the North American Waterfowl Management Plan (NAWMP) is an international plan to reverse the downward trend in waterfowl populations. The goal of the plan is to protect, restore, and enhance wetland habitat and increase waterfowl population numbers. An update to the plan in 1998 was signed by the United States, Canada, and Mexico and lists wetland, aquatic systems, grassland, forest, and riparian areas as habitats critical to waterfowl. Thirty-six Important Waterfowl Habitat Areas have been identified by the USFWS, three of which are represented within Texas, and include east Texas, the gulf coast, and the playa lakes region. Central Texas, including the San Antonio area, provides a critical link between the three priority waterfowl habitat areas. The USFWS states that conservation efforts should include national and regional planning for both migratory and endemic waterfowl species. Between 1986 and 2009, $4.5 billion was invested to secure, protect, restore, enhance and manage 15.7 million acres of waterfowl priority landscapes in North America. The NAWMP was updated again in 2004 and NAWMP Science Support Team (NSST) prioritized conservation needs for waterfowl species based on socioeconomic importance of the species, the species population trend, and the vulnerability of the population to decline (NAWMP, 2004). Conservation priority designations in the NAWMP (High, Moderately High, Moderate, and Moderately Low) reflect the conservation need during the breeding and/or nonbreeding seasons. Species that are considered High and Moderately High conservation priorities were included in the Conservation Guild of the Avian IBI. Table 2 identifies waterfowl species known to occur in Bexar County that are considered priority species by the NSST for each BCR in the Westside Creeks study area.

Table 2. Waterfowl Conservation Priority Species (NSST, 2004) Known to Occur in Bexar County (Brierly and Engelman, 2004)

Species	Bird Conservation Region (BCR)		
	Oaks and Prairies	Edwards Plateau[1]	Tamaulipan Brushland
High			
Canada Goose	X		
Moderately High			
American Wigeon	X		
Blue-winged Teal	X		
Bufflehead			
Canvasback	X		
Common Goldeneye	X		
Gadwall	X		X
Green-winged Teal	X		
Northern Shoveler	X		
Redhead	X		X
Ring-necked Duck	X		
Wood Duck	X		

[1]No waterfowl species were listed in the 2004 update of the NAWMP

NORTH AMERICAN WATERBIRD CONSERVATION PLAN

The Waterbird Conservation for the Americas (WCA) initiative was established in 1998 to address threats to waterbirds and their habitats. The goal of the WCA is sustain and restore waterbird populations and breeding, migratory, and nonbreeding habitats in North America, Central America, and the Caribbean. The WCA identified and ranked the conservation concern for waterbird species throughout North America by BCRs as Highly Imperiled, High Concern, Moderate Concern, Low Concern, Not Currently At Risk, and Information Lacking (Kushlan et al., 2002). Species with significant population declines and either low populations or some other high risk factor were designated as Highly Imperiled species. Declining species of High Concern species are declining and have some potential threat as well, and Moderate Concern species are either declining with moderate threats or distributions, stable with known or potential threats and moderate to restricted distributions, or small risk with relatively restricted distributions. Because these three conservation statuses are defined by declining populations, they were included in the Conservation Bird Guild for the Avian IBI.

Table 3. WCA (2002) Conservation Status Waterbirds within BCRs of Bexar County (Brierly and Engelman, 2004)

Species	Bird Conservation Region (BCR)		
	Oaks and Prairies	Edwards Plateau	Tamaulipan Brushland
High Concern			
Black Skimmer			X
Gull-billed Tern			X
Least Tern	X	X	
Little Blue Heron	X	X	X
Snowy Egret	X		X
Tricolored Heron			X
Moderate Concern			
White Pelican			X
Anhinga	X		X
Black-crowned Night-heron	X	X	X
Bonaparte's Gull	X		X
Eared Grebe	X	X	X
Forster's Tern	X		X
Neotropic Cormorant	X		X
Roseate Spoonbill			X
White Ibis			X
Yellow-crowned Night-heron	X		

SHOREBIRD CONSERVATION PLAN

The U.S. Shorebird Conservation Plan is a partnership of state and federal agencies and non-governmental conservation organizations. The Shorebird Conservation Plan developed the plan to protect and restore shorebird populations and their migratory, breeding, and nonbreeding habitats. The plan categorizes the conservation concern and risk for North American shorebirds into five categories: 1) species not at risk, 2) species of low concern, 3) species of moderate concern, 4) species of high concern, and 5) highly imperiled species (Brown et al., 2001). Because the Highly Imperiled, High Concern, and Moderate Concern have declining populations and/or some level of conservation risk identified, they were included in the Conservation Guild in the Avian IBI model. These species are presented in Table 4 for shorebirds that are known to occur in Bexar County.

Table 4. North American Shorebird Conservation Plan Species of Concern (Brown et al., 2001) for BCRs of Bexar County (Brierly and Engelman, 2004)

Species	Bird Conservation Region (BCR)		
	Oaks and Prairies	Edwards Plateau	Tamaulipan Brushland
Highly Imperiled			
Long-billed Curlew			X
Mountain Plover			X
Piping Plover			X
Snowy Plover			X
Species of High Concern			
American Woodcock	X		
Marbled Godwit			X
Red Knot			X
Ruddy Turnstone			X
Sanderling			X

Species	Bird Conservation Region (BCR)		
	Oaks and Prairies	Edwards Plateau	Tamaulipan Brushland
Short-billed Dowitcher			X
Solitary Sandpiper			X
Western Sandpiper	X		
Whimbrel			X
Wilson's Plover			X
Species of Moderate Concern			
American Avocet			X
Black-bellied Plover			X
Dunlin	X		X
Greater Yellowlegs			X
Killdeer	X	X	X
Least Sandpiper	X	X	X
Lesser Yellowlegs			X
Stilt Sandpiper			X
Willet			X

USFWS BIRDS OF CONSERVATION CONCERN

The 1988 amendment to (Public Law 100-653, Title VIII) to the FWCA directs the USFWS to identify migratory nongame bird species, subspecies, and populations that would become candidates for listing under the ESA if additional conservation actions are not implemented. In response to this mandate, the USFWS (2008) compiled a list of Birds of Conservation Concern (BCC) on three scales: the BCRs, USFWS Regions, and a National scale. The USFWS utilized the conservation assessment scores in the Partners in Flight North American Landbird Conservation Plan (Rich et al., 2004), the United States Shorebird Conservation Plan (Brown et al., 2001; USSCP, 2004), and the North American Waterbird Conservation Plan (Kushlan et al., 2002) to identify abundance, population trends, distribution, threats, and the importance of an area to a species to identify Birds of Conservation Concern for each BCR (Table 5).

Table 5. USFWS (2008) Birds of Conservation of Concern and Species Known to Occur Bexar County (Brierly and Engelman, 2004)

Species	Bird Conservation Region (BCR)		
	Oaks and Prairies	Edwards Plateau	Tamaulipan Brushland
Little Blue Heron	X		
Swallow-tailed Kite	X		
Bald Eagle	X(b)	X(b)	
Harris' Hawk			X
Swainson's Hawk			X
Peregrine Falcon	X(b)	X(b)	
Snowy Plover			X(c)
Mountain Plover		X(nb)	X(nb)
Lesser Yellowlegs			X(nb)
Solitary Sandpiper			X(nb)
Upland Sandpiper	X	X(nb)	
Long-billed Curlew	X(nb)	X(nb)	X(nb)
Hudsonian Godwit	X(nb)		
Buff-breasted Sandpiper	X(nb)		
Gull-billed Tern			X
Green Parakeet			X(d)

Species	Bird Conservation Region (BCR)		
	Oaks and Prairies	**Edwards Plateau**	**Tamaulipan Brushland**
Elf Owl			X
Burrowing Owl			X
Buff-bellied Hummingbird			X
Red-headed Woodpecker	X		
Scissor-tailed Flycatcher	X		
Loggerhead Shrike	X		
Bell's Vireo	X(c)		X(c)
Verdin			X
Curve-billed Thrasher			X
Sprague's Pipit	X(nb)		X(nb)
Tropical Parula			X
Swainson's Warbler	X		
Summer Tanager			X
White-collared Seedeater			X
Cassin's Sparrow			X
Rufous-crowned Sparrow		X	
Lark Bunting			X(nb)
Henslow's Sparrow	X(nb)		
Harris' Sparrow	X(nb)	X(nb)	
McCown's Longspur		X(nb)	
Smith's Longspur	X(nb)		
Chestnut-collared Longspur		X(nb)	X(nb)
Varied Bunting			X
Painted Bunting			X
Dickcissel			X
Orchard Oriole	X	X	
Hooded Oriole			X
Altamira Oriole			X
Audubon's Oriole			X

(b) ESA delisted, (c) non-listed subspecies or population of Threatened or Endangered species, (d) MBTA protection uncertain or lacking, (nb) non-breeding in this BCR

PARTNERS IN FLIGHT

Partners in Flight (PIF)is a cooperative partnership between federal, state, and local government agencies, philanthropic foundations, professional organizations, conservation groups, industry, academia, and private individuals. Federal agency partners include the following:

- Federal Agencies
  - U.S. Geological Survey
  - National Park Service
  - Bureau of Land Management
  - U.S. Fish and Wildlife Service
  - Department of Defense
  - U.S. Forest Service
  - U.S. Environmental Protection Agency
  - Natural Resources Conservation Service
  - U.S. Army Corps of Engineers
  - U.S. Department of State

- State Wildlife Resource Agencies
- Non-governmental Organizations
- Private Industry

The goals of PIF are to create a coordinated network of conservation partners to secure sufficient commitment and resources to implement and support scientifically-based landbird conservation plans at multiple scales. In an effort to prioritize conservation needs, PIF assessed the conservation vulnerability for landbird species and assigned a scores to each species based on biological criteria such as population size, breeding distribution, non-breeding distribution, threats to breeding habitats, threats to non-breeding areas, and population trends (Panjabi et al., 2005). In addition to providing conservation scores for each species on a continental scale, scores are also calculated for each BCR. Based on the conservation scores, appropriate conservation action categories are assigned to each species depending on the threat of extinction (Table 6). These conservation actions are required for improving or maintaining the current population status of the species.

Table 6. PIF Conservation Action Categories (Punjab et al. 2005) and Species Known to Occur in Bexar County (Brierly and Engelman, 2004)

Conservation Action Category	Vulnerability Risk	BCR		
		Oaks & Prairies	Edwards Plateau1	Tamaulipan[2]
Critical Recovery	Species subject to very high regional threats. Critical recovery actions are needed to prevent likely extirpation or to reintroduce a species that has been extirpated.	Swallow-tailed Kite Black-capped Vireo Yellow Warbler Golden-cheeked Warbler	Black-capped Vireo Yellow Warbler Golden-cheeked Warbler Common Yellowthroat	Bell's Vireo Common Yellowthroat
Immediate Management	Species subject to high regional threats and large population declines. Conservation action is needed to reverse or stabilize significant, long-term population declines. Lack of action may result in extirpation of species.	Loggerhead Shrike Bell's Vireo	Montezuma Quail Painted Bunting	Scaled Quail Buff-bellied Hummingbird Summer Tanager Painted Bunting Hooded Oriole Bullock's Oriole Audubon's Oriole
Management Attention	Species subject to moderate regional threats and moderate to large declines OR subject to high regional threats but no large decline. Management or other conservation actions are required to reverse or stabilize significant, long-term population declines or mitigate threats.	Northern Bobwhite Yellow-billed Cuckoo Common Nighthawk Chimney Swift Red-headed Woodpecker Great Crested Flycatcher Scissor-tailed Flycatcher Summer Tanager Cassin's Sparrow Field Sparrow Lark Sparrow Painted Bunting Eastern Meadowlark Bullock's Oriole Baltimore Oriole	Northern Bobwhite Harris' Hawk Yellow-billed Cuckoo Bell's Vireo Canyon Wren Cassin's Sparrow Rufous-crowned Sparrow Field Sparrow Lark Sparrow Dickcissel Orchard Oriole	Northern Bobwhite Harris' Hawk Swainson's Hawk White-tailed Hawk Green Parakeet Yellow-billed Cuckoo Golden-fronted Woodpecker Verdin Cactus Wren Curve-billed Thrasher Cassin's Sparrow Lark Sparrow Pyrrhuloxia Dickcissel Orchard Oriole Altamira Oriole
Planning and Responsibility	Species are of continental concern, but not regional concern. Long-term planning actions are required to ensure sustainable populations are maintained.	Swainson's Hawk Inca Dove Purple Martin Carolina Chickadee Prothonotory Warbler Kentucky Warbler Dickcissel	Scaled Quail Black-chinned Hummingbird Black-crested Titmouse Bewick's Wren	Inca Dove Common Ground-dove Greater Roadrunner Eastern Screech-owl Elf Owl Ladder-backed Woodpecker Couch's Kingbird Scissor-tailed Flycatcher Chihuahuan Raven Cave Swallow Long-billed Thrasher Olive Sparrow

[1] Swainson's Warbler has been reported for Bexar County; however, these reports are unconfirmed. Therefore, these species are not included in this analysis.
[2] The Hook-billed Kite, Tropical Parula, White-collared Seedeater, and Varied Bunting have been reported for Bexar County; however, these reports are unconfirmed. Therefore, these species are not included in this analysis.

DoD Partners in Flight

The Department of Defense PIF program consists of a cooperative network of natural resources personnel from military installations across the U.S. DoD PIF works collaboratively with other avian conservation initiatives to conserve migratory and resident bird species and their habitat on DoD lands. In addition, DoD PIF works beyond installation boundaries to facilitate cooperative partnerships, determine the current status of bird populations, and prevent the listing of additional birds as threatened or endangered. In this effort, the DoD PIF has developed a list of species of concern for bird's utilizing DoD lands (Table 7).

Table 7. DoD PIF (2011) Priority Species

Species
Northern Bobwhite
Swallow-tailed Kite
Bald Eagle
Northern Goshawk
Golden Eagle
Prairie Falcon
King Rail
Snowy Plover
Wilson's Plover
Mountain Plover
Upland Sandpiper
Long-billed Curlew
Buff-breasted Sandpiper
Gull-billed Tern
Least Tern
Western Yellow-billed Cuckoo
Burrowing Owl
Common Nighthawk
Chuck-will's-widow
Whip-poor-will
Red-headed Woodpecker
Olive-sided Flycatcher
Loggerhead Shrike
Cactus Wren
Sprague's Pipit
Blue-winged Warbler
Golden-winged Warbler
Prairie Warbler
Cerulean Warbler
Swainson's Warbler
Kentucky Warbler
Grasshopper Sparrow
Baird's Sparrow
Henslow's Sparrow
Harris' Sparrow
Painted Bunting
Dickcissel
Eastern Meadowlark
Rusty Blackbird

NATIONAL AUDUBON SOCIETY AND THE AMERICAN BIRD CONSERVANCY

In 2007, the Audubon Society and the American Bird Conservancy published the Watchlist 2007 (Butcher et al., 2007) documenting a Red-list of bird species in the U.S. that were rapidly declining in numbers and/or had very small populations or limited ranges, and faced major conservation threats and a Yellow-list of bird species that were either declining or rare. Watchlist 2007 includes 15[1] Red-listed species and 39 Yellow-listed species that can be found in Bexar County (Brierly and Engleman, 2004)(Table 8).

Table 8. Bexar County Bird Species on Watchlist 2007

Red-list Species	Yellow-list Species	
Snowy Plover	American Black Duck	Lucifer Hummingbird
Piping Plover	Mottled Duck	Calliope Hummingbird
Mountain Plover	Montezuma Quail	Rufous Hummingbird
Long-billed Curlew	Reddish Egret	Allen’s Hummingbird
Buff-breasted Sandpiper	Harris’ Hawk	Red-headed Woodpecker
Green Parakeet	Swainson’s Hawk	Olive-sided Flycatcher
Bell’s Vireo	Ferruginous Hawk	Willow Flycatcher
Black-capped Vireo	American Golden-plover	Wood Thrush
Sprague’s Pipit	Wilson’s Plover	Curve-billed Thrasher
Golden-winged Warbler	Whimbrel	Blue-winged Warbler
Golden-cheeked Warbler	Hudsonian Godwit	Prairie Warbler
Cerulean Warbler	Marbled Godwit	Bay-breasted Warbler
Baird’s Sparrow	Red Knot	Prothonotory Warbler
Henslow’s Sparrow	Short-billed Dowitcher	Worm-eating Warbler
Audubon’s Oriole	American Woodcock	Kentucky Warbler
	Wilson’s Phalarope	Canada Warbler
	Elf Owl	Painted Bunting
	Short-eared Owl	Dickcissel
	White-throated Swift	Rusty Blackbird
	Buff-bellied Hummingbird	

EXECUTIVE ORDER 13186 (MIGRATORY BIRDS)

The importance of migratory non-game birds to the nation is embodied in numerous laws, executive orders, and partnerships. The Fish and Wildlife Conservation Act demonstrates the Federal commitment to conservation of non-game species. Amendments to the Act adopted in 1988 and 1989 direct the Secretary to undertake activities to research and conserve migratory non-game birds. Executive Order 13186 directs Federal agencies to promote the conservation of migratory bird populations, including restoring and enhancing habitat. Migratory Non-game Birds of Management Concern is a list maintained by the USFWS. The list helps fulfill a primary goal of the USFWS to conserve avian diversity in North America. Additionally, the USFWS' Migratory Bird Plan is a draft strategic plan to strengthen and guide the agency's Migratory Bird Program. The proposed ecosystem restoration would contribute directly to the U.S. Fish and Wildlife Service Migratory Bird Program goals to protect, conserve, and restore migratory bird habitats to ensure long-term sustainability of all migratory bird populations. Rangewide protection, restoration and enhancement of terrestrial and aquatic habitats and landscapes are crucial to maintain and conserve migratory birds (USFWS 2003).

[1] The Whooping Crane, Swainson’s Warbler, and McCown’s Longspur have been reported for Bexar County; however, these reports are unconfirmed. Therefore, these species are not included in this analysis.

Because the Westside Creeks study area support species of concern and their habitats which are addressed in numerous avian joint ventures, conservation organizations, and interagency and international cooperative plans, their institutional significance is recognized from both a regional, national, and international perspective. Aquatic and riparian ecosystem restoration of the Westside Creeks study area would support the goals of each of these plans and cooperative initiatives as the degraded habitat within the study area would increase the quality of breeding, foraging, wintering, and migration habitats for numerous bird species. Institutional significance is further supported as the restored habitats would support many of the species of concern identified in the tables above.

The four following laws and policies further add to the identification of Institutional Significance:

WATER RESOURCES DEVELOPMENT ACT OF 1986

The restored ecosystem functions that would be provided by the eventual recommended plan for the Westside Creeks study can be considered significant by the USACE because the restoration of these functions meet with the spirit of the Water Resources Development Act of 1986.

WATER RESOURCES DEVELOPMENT ACT OF 1990

Section 307(a) of the Water Resources Development Act of 1990 established an interim goal of no overall net loss of wetlands in the U.S. and set a long-term goal to increase the quality wetlands, as defined by acreage and function. The WSC ecosystem restoration study would not result in the loss of wetlands and waters of the U.S. as the proposed study would restore the ecological and hydraulic function to the WSC.

EXECUTIVE ORDER 13112 (INVASIVE SPECIES)

Executive Order 13112 recognizes the significant contribution native species make to the well-being of the Nation's natural environment and directs Federal agencies to take preventive and responsive action to the threat of non-native species invasion and to provide restoration of native species and habitat conditions in ecosystems that have been invaded. As the WSC study would replace non-native vegetation with site-specific native vegetation, it would be in compliance with Executive Order 13112.

TEXAS SENATE BILL 2

In Texas, Senate Bill 2, 77th Legislature of Texas recognizes the San Antonio River basin as a critical fish and wildlife resource. This bill requires the TPWD, the Texas Water Development Board (TWDB), the Texas Commission on Environmental Quality (TCEQ), and other agencies to establish an interagency instream flow program to determine conditions necessary to support a sound ecological environment. TPWD is a stakeholder in the planning of the WSC ecosystem restoration and the WSC ecosystem restoration study would restore fish and wildlife resources associated with the WSC.

PUBLIC RECOGNITION

Significance based on public recognition means that some segment of the general public recognizes the importance of an environmental resource. Public recognition is evidenced by people engaged in activities that reflect an interest in or concern for a particular resource. Recognition of public significance for the Westside Creeks study area can best be demonstrated by the actions of the SARA and the Westside Creeks Oversight Committee (WSCOC). The WSCOC consists of representatives of 20 local community organizations organized in 2008. Building on successes with the San Antonio River Improvements Project, SARA held public workshops between April, 2009 and February, 2010 to seek community participation in the development of a conceptual restoration plan for Westside Creeks (SARA, 2011). During the planning process, stakeholders representing Westside Creek area residents and neighborhood associations, service organizations, elected and government officials, schools and universities participated in the WSCOC, four sub-committees representing each of the four Westside Creek watersheds, and public workshops.

The proposed Westside Creeks Study makes a significant contribution to a larger watershed conservation and restoration effort being implemented by Bexar County, City of San Antonio (CoSA), and SARA. The above entities have made commitments to improving habitat across the entire San Antonio River watershed within Bexar County. The following is a brief listing for some of the recent, current, ongoing, and future projects for the watershed.

- Cibolo Creek, Leon Creek, Salado Creek, Eagleland, and Olmos Creek Studies: partnership studies with USACE to identify ecosystem restoration opportunities within the San Antonio River watershed.
- On-going community input for restoration of other tributaries of the San Antonio River.
- City of San Antonio's Creekways program: $20 million invested in the purchase and preservation the riparian zone of Salado and Leon Creeks.
- City of San Antonio's Proposition 3: Provides funding to purchase lands located in the Edwards Aquifer recharge zone, including creeks and riparian habitats. Approximately $45 million dollars is available for this effort, and thousands of acres have already been purchased.
- Bexar County, SARA, and CoSA spend a great deal for river/creek debris clean-up. CoSA maintains two fulltime crews, and SARA is spending millions to develop water quality models throughout the basin to quantify water quality benefits produced by natural creek systems.
- San Antonio River, Mission Reach: $83.6 million (including $27.5 million in lands, easements, rights-of-way, relocations and disposal areas) was invested in the Mission Reach project by SARA and other non-federal entities in addition to the $121.7 million federal share.

TECHNICAL RECOGNITION

Significance based on technical recognition requires identification of critical resource characteristics such as scarcity, representativeness, status and trends, connectivity, critical habitat, and biodiversity. Therefore, technical recognition of resources varies across geographic areas and spatial scale. The institutional section of this document provides evidence supporting the technical significance of the resources, specifically the scarcity, status, and trends of the resources. Further support for the technical significance of resources in the Westside Creeks Study area is documented in the following sections.

Scarcity. Nationally, the loss of aquatic and riparian habitats is widely recognized. Historically, approximately one percent of the western landscape was comprised of riparian habitats.

Status and Trends. Over the last 100 years, approximately 95-percent of riparian habitat has been converted by river channelization, water impoundments, agricultural practices, and urbanization (Krueper, 1995). As a result, freshwater animal species are disappearing five times faster than terrestrial animals due, partially, to the widespread physical alteration of rivers (Ricciardi and Rasmussen 1999). Of 860,000 river miles within the United States, approximately 24 percent have been impacted by channelization, impoundment, or navigation. The USFWS estimates 70-percent of the riparian habitats nationwide have been lost or altered, and 50-percent of all listed threatened or endangered species depend on rivers and streams for their continued existence. In some geographic areas, loss of natural riparian vegetation is as much as 95-percent indicating that riparian areas are some of the most severely altered landscapes in the country (NRCS 2002). The National Research Council (NRC) has stated that restoration of riparian functions along America's water bodies should be a national goal (NRC 2002). Urban riparian buffers are the framework for healthy streams and water quality and provide greenways that improve the quality of life for citizens (Okay 2000).

Physical, Chemical and Biologic interaction. One of the most important functions of both intermittent and ephemeral headwater streams that have been unaltered and have normal function is the collection and processing of organic material such as leaves, woody debris, and detritus. Microorganisms in the headwater stream systems consume the organic material, converting it into the primary bioavailable food source for aquatic species downstream. Intermittent and ephemeral streams are able to biotransform organic matter more efficiently than perennial streams because larger pieces of organic materials may not be as easily transported downstream at lower or infrequent flows. Therefore, more organic material is retained in the headwater streams extending the time that microorganisms can convert the material to bioavailable carbon and modulating water quality to prevent excess organic matter from degrading downstream systems (Cappiella and Fraley-McNeal, 2007). In addition, headwater streams play a disproportionately large role in the transformation of nitrogen, converting up to 50-percent of the nitrogen introduced from the watershed (Peterson et al., 2001), thereby improving water quality.

Biodiversity. It is because of the intermittent flows of these streams that biodiversity in headwater streams and their associated riparian areas is higher than in perennial systems downstream. This biodiversity includes primary producers (diatoms, cyanobacteria, red algae, and green algae), decomposers (bacteria, and fungi), insects, invertebrates (mollusks, crustaceans, and other invertebrates), fishes, amphibians, reptiles, birds and mammals, some of which are entirely restricted to intermittent streams. Many other species utilize headwater stream habitats seasonally as spawning and nursery areas, foraging areas, refugia habitats from predators and competitors, thermal refuge, and travel corridors (Meyer et al., 2007).

Connectivity. Potential management actions could include the reestablishment of riparian woodland and shrubland habitats, as well as riparian grassland habitats in strategic locations throughout the study area. The establishment of native woody and herbaceous riparian vegetation would provide significant benefit to the movement of aquatic species throughout the study area and would play a role in the aquatic species ability to move into newly restored upstream habitats. During baseflow conditions, fish from the San Antonio River and lower reaches of the Westside Creeks do not have the ability to emigrate up or down long stretches of the creeks. This is the historic condition of the San Pedro Creek and native fish species have adapted to the situation. In addition, the historical riparian habitats along Alazan, Apache, and Martinez Creeks would have maintained stream flows longer into the season than the current conditions allow. During flooding events, fish move along the margins of the creeks, where velocities are slower, in order to migrate up and downstream between the various aquatic habitats. Currently, because of the trapezoidal shape of the channel and the lack of proper riparian vegetational structure, velocities along the margins of the river can be too swift for fish movement during floods. Riparian trees serve many purposes when inundated including slowing the flood waters along the margins, which makes fish movement possible and provides a velocity refugia from the higher velocity water. Additionally, the structure added by the trees and the woody and herbaceous understory provides cover from predation during movement up and downstream. It is important that the riparian corridor be continuous from the water's edge to the top of the channel banks in order to maximize the benefits provided with respect to cover and migration along floodwater margins.

Typical of arid and semiarid areas in the western U.S., the mean monthly and annual evaporation rates exceed the highly variable precipitation rates in the San Antonio area (Table 9). As the ratio of precipitation to evaporation decreases, the contrast between the mesic riparian habitats associated with perennial flow and the adjacent upland habitats increases. For intermittent streams, this contrast decreases from the perennial end of the water availability continuum to the ephemeral until eventually blending into the upland end of the continuum. This relationship underscores the importance of arid and semiarid riparian ecosystems compared to riparian ecosystems in wetter or more humid climates where the distinction between upland and riparian habitats may be less defined.

Table 9. Mean Precipitation and Evaporation Rates for Bexar County (TWDB, 2011)

Month	Mean Precipitation (in)	Mean Evaporation (in)
January	1.78	2.19
February	2.05	2.53
March	1.96	3.84
April	2.72	4.55
May	3.76	4.98
June	3.49	6.42
July	2.22	7.33
August	2.47	7.11
September	3.59	5.42
October	3.44	4.45
November	2.22	2.99
December	1.84	2.25
Annual	**31.53**	**54.05**

Although riparian habitats comprise a relatively small portion of the overall landscape in arid and semiarid regions, riparian ecosystems substantially influence hydrologic, geomorphic, and ecological processes (Shaw and Cooper, 2008). Because soils in riparian habitats adjacent to intermittent and ephemeral streams have higher moisture content, they support more abundant vegetation than adjacent uplands. This vegetation provides breeding, nesting, and foraging habitat, cover, and wildlife travel corridors that are not available in adjacent upland habitats. Parameters influencing migrant passerine bird use in riparian habitats include habitat preferences of the bird, niche diversity and plant species composition, location and accessibility of habitat, and quality of adjacent habitat (Stevens et al., 1977). Avian species, in particular, are more dependent on riparian habitats in semiarid environments than other organisms (Levick et al., 2008). In fact, riparian bird populations may not be significantly affected by the impacts of urbanization as long as the riparian ecosystem remains in good condition (Oneal and Rotenberry, 2009).

Based on an analysis of more than 21,000 plant and animal species, the Nature Conservancy ranked biodiversity within the 50 states and the District of Columbia (Stein, 2002). According to the Nature Conservancy, four states exhibit exceptional levels of biodiversity, with Texas ranked 2nd overall and ranked 1st for diversity of birds and reptiles. Unfortunately, Texas ranks 4th in the number of extinctions, and is ranked 11th overall for the number of species at risk. Following is a listing of Texas rankings (out of 51) for the percentage of species at risk. Those listings in bold type are significant to the recommended ecosystem restoration of the San Antonio River.

- Bird Diversity at Risk 6th
- Amphibian Diversity at Risk 7th
- Freshwater Fish Diversity at Risk 8th

- Mammal Diversity at Risk 9th
- Reptile Diversity at Risk 9th
- Vascular Plant Diversity at Risk 11th

TPWD released the Texas Conservation Action Plan (TPWD, 2011b) for comment in June 2011 identifying Species of Greatest Conservation Need (SGCN) for ecoregions throughout the state, including the Blackland Prairie, Edwards Plateau, and South Texas ecoregions (Attachment 2). Included in the list of SGCN for these ecoregions are several species that would benefit from aquatic and riparian ecosystem restoration measures within the Westside Creeks Study Area (Table 10). Aquatic species such as spiny softshell turtle, slider, Texas shiner, alligator gar, and blue sucker would benefit from the reconnection of fragmented aquatic habitats. Riparian SGCN such as the swamp rabbit, Strecker's chorus frogs Bell's Vireo, Louisiana Waterthrush would also benefit from the restoration of riparian grassland, shrubland, and woodland habitats. In addition, species that rely on riparian corridors for foraging habitat, including bat SGCN such as the Brazilian free-tailed bat and ghost-faced bat, would benefit from the improved habitat for forage species.

Table 10. TPWD Species of Greatest Conservation Need

Species	Scientific Name	Global/State Ranking	Blackland Prairies	Edwards Plateau	South Texas Plains
Birds					
Wood Stork	*Mycteria americana*	G4/SHB,S2N	X		
Northern Harrier	*Circus cyaneus*	G5/S2B,S3N	X	X	X
Common Black-hawk	*Buteogallus anthracinus*	G4G5/S2B		X	X
Harris's Hawk	*Parabuteo unicinctus*	G5/S3B		X	X
Zone-tailed Hawk	*Buteo albonotatus*	G4/S3B		X	
Golden Eagle	*Aquila chrysaetos*	G5/S3B		X	
American Golden-plover	*Pluvialis dominica*	G5,S3	X		
Mountain Plover	*Charadrius montanus*	G3/S2	X		X
American Woodcock	*Scolopax minor*	G5/S2B,S3N	X		
Chuck-will's-widow	*Caprimulgus carolinensis*	G5/S3S4B	X	X	
Red-headed Woodpecker	*Melanerpes erythrocephalus*	G5/S3B	X		
Scissor-tailed Flycatcher	*Tyrannus forficatus*	G5/S3B	X	X	X
Loggerhead Shrike	*Lanius ludovicianus*	G4/S4B	X	X	X
Bell's Vireo	*Vireo bellii*	G5/S3B	X	X	X
Sprague's Pipet	*Anthus spragueii*	G4/S3N	X	X	X
Kentucky Warbler	*Oporornis formosus*	G5/S3B	X		
Grasshopper Sparrow	*Ammodramus savannarum*	G5/S3B	X	X	X
Henslow's Sparrow	*Ammodramus henslowii*	G4/S2S3N,SXB	X		
Amphibians and Reptiles					
Texas indigo snake	*Drymarchon melanurus erebennus*	G4/S3		X	X
Cagle's map turtle	*Graptemys caglei*	G3/S1	X	X	
Alligator snapping turtle	*Macrochelys temminckii*	G3G4/S3	X		
Strecker's chorus frog	*Pseudacris streckeri*	G5/S3	X	X	
Texas garter snake	*Thamnophis sirtalis annectans*	G5/S2	X	X	
Fish					
Blue sucker	*Cycleptus elongates*	G3G4/S3	X		
Headwater catfish	*Ictalurus lupus*	G3/S2		X	X

[1]Global Conservation Ranking/State Conservation Ranking

GX/SX – Presumed Extinct; not located despite intensive searches and virtually no likelihood of discovery
GH/SH – Missing; known from only historical occurrences but still some hope of discovery
G1/S1 – Critically Imperiled; At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, 0r other factors
G2/S2 – Imperiled; At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors
G3/S3 – Vulnerable; At moderate risk of extinction due to restricted range , relatively few populations (often 80 or fewer), recent and widespread declines, or other factors
G4/S4 – Apparently Secure; Uncommon but not rare; some cause for long-term concern due to declines or other factors
G5/S5 – Secure; Common, widespread and abundant
G#G#/S#S# - Range Rank; A numeric range rank (e.g. G2G3/S2S3) is used to indicate the range of uncertainty in the status of a species.
B – Breeding; Conservation status referes to the breeding population of the species
N – Nonbreeding; Conservation status refers to the non-breeding population of the species

The national and state trend for habitat loss is even more pronounced within Bexar County and the study area. An analysis of tree cover within the San Antonio region reveals tree loss trends in three distinct analysis areas. As might be expected, the most dramatic loss of tree cover occurs within the City of San Antonio. The city has had its heavy tree cover (areas with greater than 50-percent canopy) decline by nearly 39 percent from 63,522 acres in 1985 to 38,753 acres in 2001. The greater San Antonio Area, including Bexar County and surrounding suburbs saw its heavy tree cover drop from 26 percent to 20 percent; areas with medium density canopy (20-49-percent) had the most significant percentage change, from 6 percent in 1985 to 3 percent by 2001 – a loss of approximately 43 percent; areas with light tree canopy (less than 20-percent tree cover) expanded from 69 percent in 1985 to 77 percent in 2001 (American Forests, 2002). Further, the introduction of exotic plant and animal species has had a substantial effect on riparian areas, leading to displacement of native species and the subsequent alteration of ecosystem properties (NRC 2002). Problematic non-native woody and herbaceous plant species are found throughout the study area. Local elimination of these species has been recommended by the USFWS (2004). This *trend* in the loss of habitat and species is expected to continue unless proactive restoration measures are taken. Between 2000 and 2020, the Bexar County population is projected to grow up to 49-percent. Of all the attributes of natural land in south Texas, wildlife habitat is the most endangered by human growth pressures.

The species benefiting from the restoration are also significant for a number of reasons. First, the restored aquatic habitat provides the opportunity for native fish populations to return to the Westside Creeks within the study area. Fish assemblages are strongly influenced by instream habitat, which in turn is strongly influenced by the riparian zone (Paller, et al. 2000). Annual fish surveys conducted by SARA between 1998 and 2003 of the San Antonio River below the study area show that the percentage of non-native species is consistently 200-300 percent higher (15-57 percent non-native) than below the floodway (2-17 percent non-native). A fish survey conducted for the San Antonio River Mission Reach segment by the U.S. Army Corps of Engineers, Engineering and Research Design Center (ERDC) found 25 percent of the total number identified species were non-native. Sixty-four percent of the native species component of the Mission Reach aquatic community was tolerant of degraded habitat. Therefore, 89 percent of the fishes surveyed within the Mission Reach project area are comprised of introduced species or native species tolerant of degraded conditions.

It has been demonstrated that habitat is the limiting factor in the return of native fish to the study area. As water quality in the river has improved through better wastewater treatment, an increase in the number of pollution-intolerant fish species such as stone rollers and longear sunfish in the San Antonio River downstream of the study area has been observed. The resource agencies believe the number of native fish will increase throughout the study area after implementation of the restoration project.

As evidenced by the numerous conservation and management cooperatives established to address adverse impacts to avian populations in North America, migratory birds are of great ecological value and contribute immensely to biological diversity. Bexar County provides essential feeding and resting habitat for migratory birds and is located in the heart of the Central Flyway. Over 300 species of birds are listed as Nearctic-Neotropical migrants in North America, and over 98-percent of those have been recorded in Texas. Therefore, of the more than 600 species of birds documented in Texas, 54-percent are neotropical species which depend on Texas to provide nesting or migration habitats. Many of these species are specifically dependent on south central Texas riparian areas. Neotropical migratory birds have been declining in numbers for several decades. Initially, the focus of conservation for this important group of birds was focused on breeding habitat and wintering grounds; however, recently it has been recognized that the loss, fragmentation, and degradation of migratory stop-over habitat is potentially the greatest threat to the survival and conservation of neotropical birds. In arid areas of the United States, stop-over sites are restricted to small defined habitats along shelter belts, hedgerows, desert oases and riparian corridors. The riparian corridors of south central Texas provide an opportunity for the birds to replenish fat reserves, provide shelter from predators and water for re-hydration prior to continuing, what is for most neotropicals, a trip of over 1000 miles one-way. During the fall migration, the San Antonio area is located towards the end of the long flight, and therefore, provides the vital link between having enough fat reserves to complete the trip or perish.

The Oak and Prairies BCR supports over 25-percent of the global breeding population of Painted Buntings and Scissor-tailed Flycatchers. In addition, the riverine and riparian habitats in the BCR provide habitat for numerous other bird species including Bell's Vireo and the Red-headed Woodpecker (TPWD, 2007).

Conservation priorities identified by the Oak and Prairies and Rio Grande Joint Ventures (TPWD, 2006; TPWD, 2007) that are applicable to the study area include:

- Riparian corridors, especially where above-ground stream flow occurs;
- Habitat fragmentation;
- Alteration of hydrologic regimes;
- Invasive plants;
- Urban development; and
- Limited water resources.

Desirable habitat for migratory waterfowl and neotropical migrants is limited in the San Antonio Area. A high percentage of all neotropical migrant species require woodlands of various densities and structure. Woodland habitats in San Antonio are primarily limited to only those that occur along waterways. In addition, many species of waterfowl require riparian grassland and parkland areas for foraging, cover, and nesting habitats. Potential restoration measures would increase riverine habitat (riparian and aquatic) required by many bird species living in or migrating through Bexar County, including many of the bird species of concern noted in the previous tables.

The study area is centrally located between two areas where migratory birds, including migratory waterfowl are heavily concentrated, Mitchell Lake and Brackenridge Park. The Mitchell Lake Wildlife Refuge, located approximately 9.5 miles from the southern end of the study area, has had over 300 species of birds recorded, many of which are migratory waterfowl, and is one of the most heavily birded locations in Bexar County. The other area of heavy use is located just 6 miles from the northern end of the study area is Brackenridge Park. In Brackenridge Park, there is a small remnant of quality riparian habitat along the San Antonio River. This area has also recorded a large number of neotropical migrant species and represents the other heavily birded locations in Bexar County. In addition, previously constructed ecosystem restoration projects at the Mission Reach and Eagleland reaches of the San Antonio River have increased the quantity and quality of migratory bird habitat near the study area (Lee Marlowe, personal communication). During site surveys of the Westside Creeks study area, several migratory species were observed, including great egret, belted kingfisher, great blue heron, double-crested cormorant, mallard, white-winged dove, and others. The Westside Creeks Restoration Study, which connects to the Mission Reach segment of the San Antonio River and is located to the west of Mitchell Lake and Brackenridge Park migratory bird habitats, would increase the amount of highly used, but scarce habitat along a proven migratory bird stop-over corridor.

Aquatic and riparian habitats are dynamic and relatively rare systems in South Texas, most of which are defined by highly variable and intermittent flows. The number of naturally functioning aquatic and riparian habitats are decreasing nationwide, and the loss of these habitats is much more significant in South Texas due to the limited availability of aquatic and riparian habitats in the region. The effect of the loss of aquatic and riparian habitats in South Texas is especially significant for migrating birds utilizing the Central Flyway which are dependent on these habitats. Potentially compounding the loss of riparian habitats in the immediate future, are the number of Conservation Reserve Program lands throughout the Great Plains in the Central Flyway that will be coming out of the program and will potentially be converted back to croplands.

Bird migration is a physically demanding activity that places extreme energy demands on birds. Compounding these energy requirements, the migration bookends the breeding and reproduction season of the birds where the energy demands approach those needed for migration. Energy reserves may be severely depleted for many bird species as they have flown non-stop over the Gulf of Mexico. In order to fuel migration energy demands, productive foraging and resting stop over habitats must be found along the migration corridor. Aquatic and riparian habitats are some of the most productive and diverse ecosystems in North America, especially in the arid southwest, and therefore are heavily utilized by migrating birds. Historically, the aquatic and riparian habitats in the San Antonio area would have been one of the first productive stopover habitats for northbound migratory birds after the Texas coast along the southeastern side of the arid South Texas plains.

The WSC study will analyze the benefits of restoring the structure and function of aquatic and riparian habitats within the study area. The benefits analyzed will be those associated with the energy resources that are provided by these types of habitat that are needed for migrating birds as well as benefits for wintering and resident birds. As the energy reserves for the birds can encompass all taxa, one may consider the birds as a biomarker of the true health of the aquatic and riparian ecosystem in the San Antonio area.

HABITAT EVALUATIONS

Aquatic and riparian habitat assessments were conducted to assess existing habitat conditions and to base future net benefits to the riverine habitat resulting from the proposed ecosystem restoration measures. Aquatic habitat structure, water quality, and fish community parameters were collected to compare the WSC with the reference streams (Medio Creek and the Medina River) that were utilized in the Avian point count surveys. The Avian point count surveys were conducted to assess the utilization of the WSC habitats by migratory birds (breeding, wintering, and migrating) compared to the reference streams. By modeling avian community and habitat parameters as they are influenced by the level of human disturbances inherent in the WSC and Medio Creek compared to the more pristine Medina River, we can quantify the habitat benefits realized by the implementation of the proposed restoration measures.

AQUATIC HABITAT ASSESSMENT

Fish community sampling efforts were made at 15 locations: Alazan Creek (2), Apache Creek (3), Martinez Creek (2), San Pedro Creek (3), Medio Creek (3), and the Medina River (2). At each stream, 2-3 stations per location with 1-4 habitats (pool, riffle, run, or glide) were sampled at each station for a total of 34 fish community samples. Twenty-eight sites were sampled by seine once during the period 11-12 April 2012. Six units were also sampled by electrofishing. A detailed description of each sample station and general sampling conditions is provided inAttachment 3.

EXISTING HABITAT CONDITIONS

Of the 34 samples from representative macrohabitat units were taken at 15 the stations, 2,955 individuals representing 23 species of fishes were captured. The number of species documented varied across stations, gear types and between habitats. Seining efforts, both sizes combined, documented 1-9 species per unit ($\bar{x}$ (mean) = 3.7 species) with two units (pool and riffle) at Apache Creek yielding no catch. Electrofishing efforts produced 2-9 species ($\bar{x}$= 3.9) per sampled unit. The number of species varied between waterbodies with combined efforts on Alazan Creek yielding 2 species ($\bar{x}$ = 2); San Pedro Creek, 1-4 species ($\bar{x}$ = 2.2), Apache Creek, 2-5 species ($\bar{x}$ = 2.3); Martinez Creek, 1-4 species ($\bar{x}$ = 2.7); Medina River, 3-9 species ($\bar{x}$ = 5.9) and Medio Creek, 4-9 species ($\bar{x}$ = 6.4). Combined sampling efforts by macrohabitat unit varied as well with pool units yielding 2-5 species ($\bar{x}$ = 2.75) followed by riffle, 1-9 species ($\bar{x}$ = 3.7); glide, 1-7 species ($\bar{x}$ = 3.7); run, 1-9 species ($\bar{x}$ = 4.5) and backwater, 6-7 species ($\bar{x}$ = 6.7).

Species diversity between habitat types was differed by waterbody where total number of species was typically lower at Westside Creek stations. Indicators of urban stream conditions include a flashier hydrograph, elevated concentrations of nutrients and contaminants, altered channel morphology, and reduced biotic richness, with increased dominance of tolerant species (Walsh et al. 2005). Water quality analyses reflect these types of symptoms in Westside Creeks, but comparison to the Reference streams indicates that restoration will provide benefits. Fish assemblages associated with Westside Creeks were correlated with reduced structural variables (vegetation, overstory), larger substrates including rip-rap, higher water temperatures, and shallower water (reduced depth and wetted perimeter). The type of fish assemblage (tolerant and more invasive species) reflects these degraded habitat conditions. Reference streams suggest that restoration measures will have a positive benefit to native fishes as the restoration would increase habitat diversity and cover for food items required to support a greater diversity of fishes. Additionally, increasing overstory and stream riparian cover, along with greater depths and water velocity, were shown to result in higher richness and diversity of the fish assemblage. The fisheries, instream, and stream bank habitat analysis indicates that restoration of habitat conditions of Westside Creek would provide ecological benefits to the overall aquatic community including fish and wildlife species that make up the interrelated food web of the stream basins.

RIPARIAN HABITAT ASSESSMENT

Frey (1977) defined biotic integrity as "…the capability of supporting and maintaining a balanced integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region." Assessing the health and monitoring changes of habitats due to anthropogenic activities in an effort to evaluate the biotic integrity of each component of the ecosystem can be complex and unwieldy. However, by identifying biological indicators of habitat quality and their community level response over a range of anthropogenic and natural stressors, we can infer a level of biotic integrity to the system as a whole. Karr (1981) developed an Index of Biotic Integrity (IBI) to assess the ecosystem integrity of streams using a multimetric fish community model. The IBI approach to assessing ecosystem health has since been applied on six continents and with freshwater, marine, and terrestrial organisms (Karr, 2005; Crewe and Timmermans, 2005).

The composition and structure of the avian community has been used as an indicator of anthropogenic impacts and habitat quality of forests and riparian habitats (Adamus, 1995; Brooks et al., 1998; Bryce et al., 2002; Larsen et al., 2010; Larsen et al., 2012; O'Connell et al. 2000). Methods for applying the IBI process to avian communities in an effort to assess and monitor riparian ecosystems in response to anthropogenic activities have been proposed (U.S. EPA, 2002) and tested (Crewe and Timmermans, 2005; Guilfoyle et al., 2009; Wakeley et al., 2003; Wakeley et al. 2004). The Westside Creeks Avian IBI model expands off the work of Wakeley et al. and Guilfoyle et al. in an effort to characterize the existing biotic integrity of the Westside Creeks and project future biotic integrity of the creeks resulting from different combinations of ecosystem restoration measures for the Westside Creeks Ecosystem Restoration study.

The purpose of the Avian IBI model is to quantify the effects of human alterations to avian habitats. By correlating an anthropogenic index, or Index of Human Disturbance (IHD), to an avian diversity metric, the Avian IBI can model existing conditions over a range of habitat disturbances. The resulting model can be used to predict the potential future conditions and benefits resulting from proposed habitat restoration measures on the Westside Creeks. The Avian IBI model has been approved for the San Antonio River Basin .

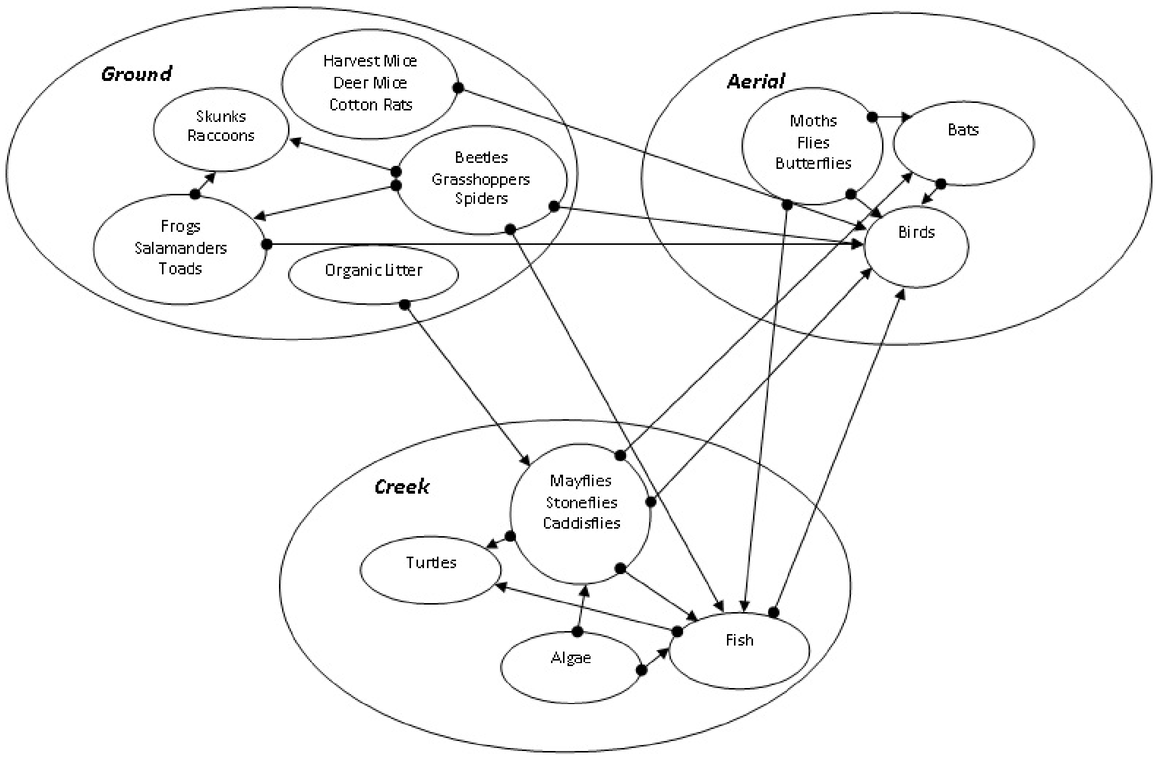

Figure 1. Food Web for Riverine Systems

Other ecological benefits not recognized by the Avian IBI model such as increased invertebrate, amphibian, fish, and mammal diversity can be used to provide further justification for determining a tentatively selected plan. When examining the trophic pyramid in Figure 2. Ecological Trophic Levels, the Avian IBI model is primarily looking at the increase of diversity on the tertiary and secondary consumers, i.e. the top of the pyramid. The benefits attribute to the aquatic and riparian ecosystem components with the largest diversity and biomass are unrecognized. Because the interpolation of benefits to primary producers and consumers is not linear, the benefits of the restoration measures affect exponentially more organisms than the Avian IBI alone accounts for. Therefore, the Avian IBI is used as a habitat quality metric to develop habitat inputs into the IWR Planning Suite's Cost Effective/Incremental Cost Analysis software and the qualitative indicators of biomass and foodweb interactions will be used to assess the justification of the costs of one alternative to the next.

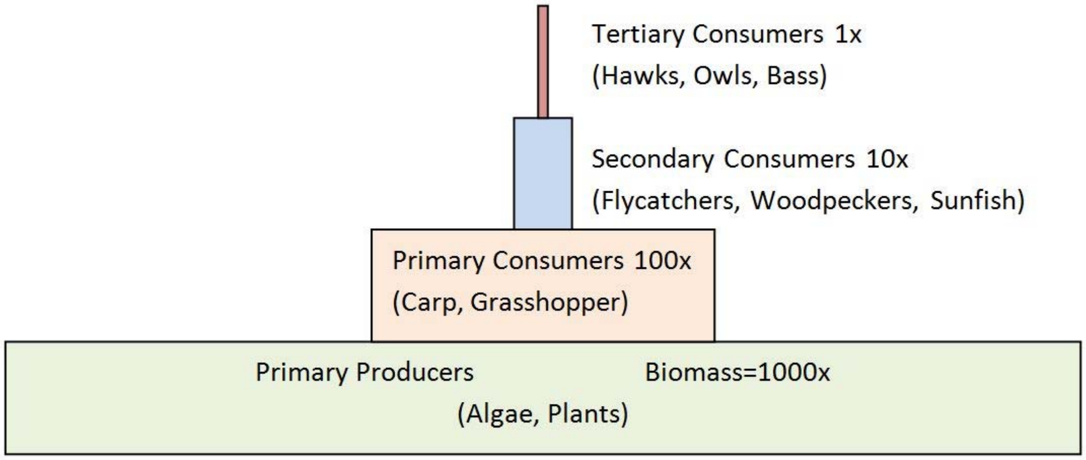

Figure 2. Ecological Trophic Levels

PROCEDURES

SARA, TPWD, and USACE biologists and local birding experts conducted avian point count following Hamel et al., 1996 with one modification; birds were spatially categorized with respect to the creek, floodway and neighborhood instead of with respect to specified radii from the point.

Six permanent avian point count survey stations were established on each of the four Westside Creeks and the two reference reaches (Figure 3 and Figure 4). Each point count station was marked with a lathe stake and the GPS location was recorded.

Each avian point count station was sampled bi-weekly from 22 February to 31 May 2012 and from 13 August to 7 October 2012. Each sampling session began at sunrise and was completed within five hours of sunrise. Sampling sessions were scheduled for days when weather forecasts predicted no precipitation and wind speeds below 15 miles per hour. Three teams of two each sampled two creeks each sampling session. Each team was comprised of a birder with specific expertise on central Texas bird species (Attachment 3) and a data recorder. Each point count station was sampled for seven minutes with notations on the datasheet designating whether the bird was first seen within the first three minutes, the next two minutes, or the last two minutes. Flushed birds were recorded if it was determined that the birds flushed in response to the team approaching the point count station.

The number of birds seen and/or heard during each sampling session was recorded by species and the location of the bird in relation to the creek was documented. Each bird was documented as utilizing the creek habitat, floodway/floodplain habitat, the neighborhood or areas outside of the floodplain, or was documented as a flyover. Birds were tracked on field datasheets with a schematic of the floodway/floodplain enabling the recorder to track the location of each bird identified to minimize the double counting of a bird (Attachment 4). At the end of the sampling session, the data from the field data sheets were reviewed and transcribed to data summary sheets immediately upon the return from the field.

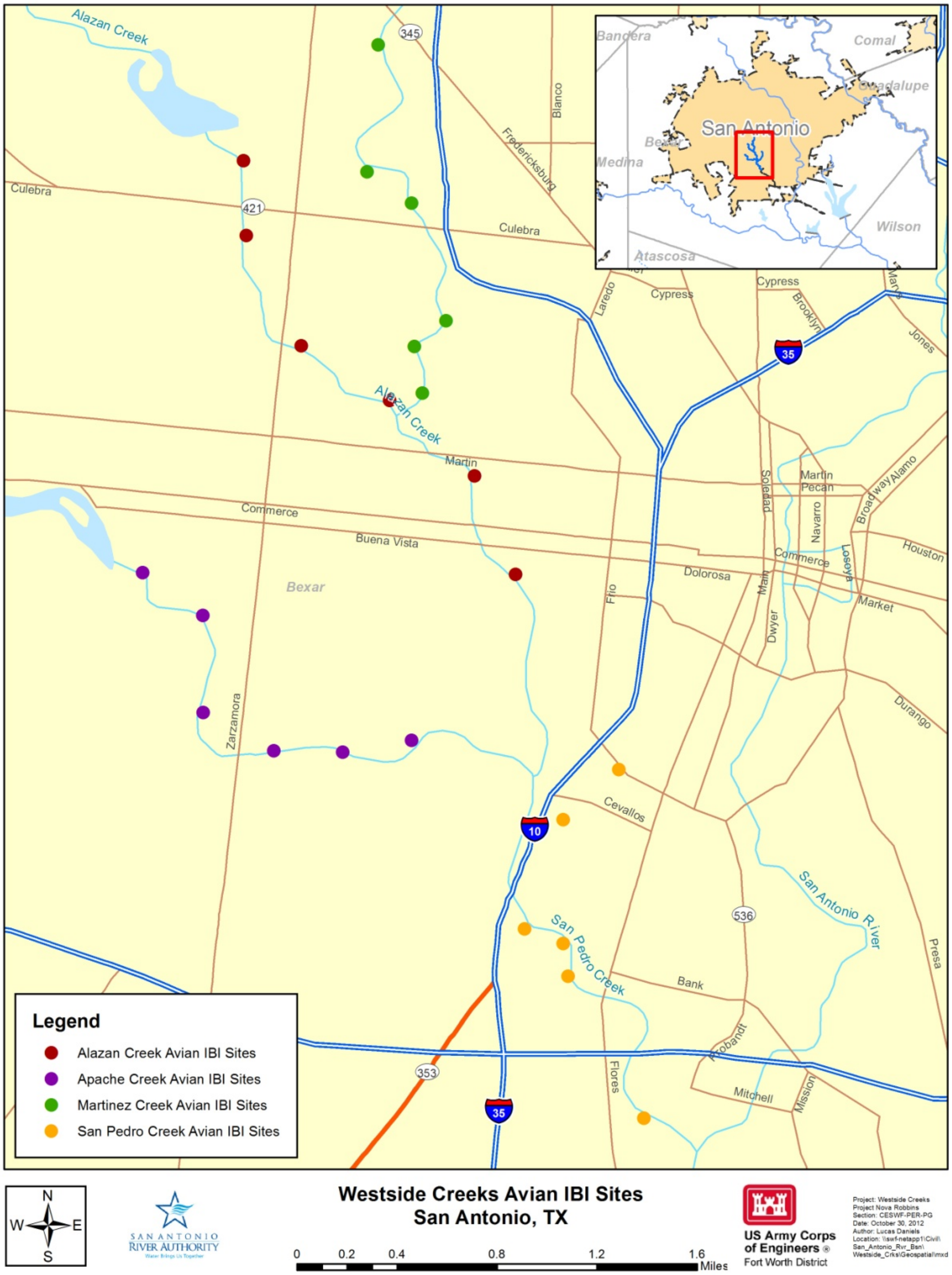

Figure 3: Avian IBI Sites for the Westside Creeks

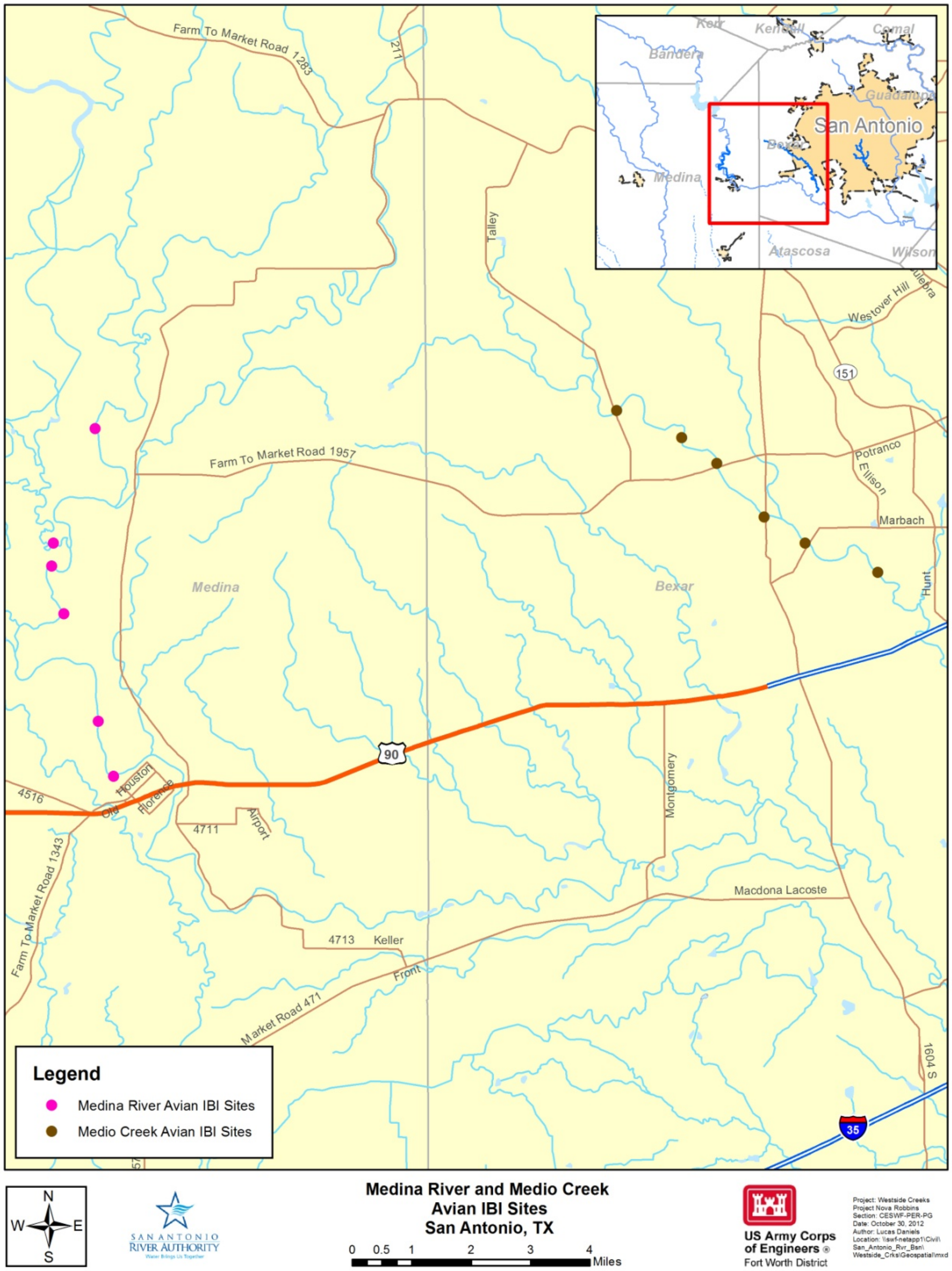

Figure 4: Avian IBI Sites for the Reference Reaches

At each avian point count station, habitat conditions were assessed over three scales: at a site specific, creek, and watershed level. The vegetation structure, species composition, and anthropogenic development of each site were characterized to calculate the site specific component of the IHD. For each creek, the level of human disturbance (channelization, concrete armoring, etc.) was quantified to calculate the creek component of the IHD. Finally, the USGS North American Land Use Cover GIS data for Bexar and Medina Counties were used to quantify a watershed scale estimate of human disturbance as the third component of the IHD for each site.

Details of the avian community and IHD calculations and derivation of the Avian IBI is described in more detail in the WSC Avian IBI model certification documentation.

EXISTING HABITAT CONDITIONS

To quantify the value of the existing habitat conditions, the Avian IBI will be used to quantify the diversity of the avian community within the WSC study area. The Avian IBI will utilize habitat-specific features that can be incorporated into measures to improve avian habitat within WSC. Due to the multiple coefficients used to calculate the the lowest score for the Avian IBI, attributable to absolutely no usable avian habitat, is 0.0. Due to the urban land uses and hydraulic constraints, the highest Avian IBI score possible for the WSC is 3.4.

Table 11. Avian IBI Scores for Westside Creeks

Point Count Station	Avian IBI	Mean Avian IBI for Creek
Alazan		**0.919491**
1	0.956594	
2	0.995982	
3	0.861292	
4	0.921665	
5	0.897996	
6	0.883416	
Apache		**0.939846**
2	1.079253	
3	0.953086	
4	0.971056	
5	0.883244	
6	0.927655	
7	0.824784	
Martinez		**0.920196**
1	0.885287	
2	0.839975	
3	0.916872	
4	0.918972	
5	1.056488	
6	0.903579	
San Pedro		**0.913683**
1	0.772167	
2	0.947887	
3	0.993473	
4	0.892162	
5	0.897693	
6	0.978719	

The avian IBI was then multiplied by the acreage of the study area for each creek to obtain the existing condition avian community units (ACU) of each creek (Table 12).

Table 12: Existing Avian Community Units for the WSC Study Area

Creek	Acres	Avian IBI	Avian Community Units
San Pedro	67.35	0.9137	61.54
Apache	34.02	0.9398	31.97
Alazan	70.35	0.9195	64.69
Martinez	50.26	0.9202	46.53

FUTURE WITHOUT PROJECT CONDITIONS

Because the WSC study area is located within the existing SACIP project area, the future without-project condition for aquatic and riparian habitat would continue to be equivalent to the existing conditions. As continued mowing and maintenance of the floodway would continue to minimize the habitat value of the floodway, the Index of Human Disturbance and Avian IBI scores would fluctuate with yearly rainfall and management actions but on average remain the unchanged over the next 75 years. In order to maintain the existing flood protection, any woody vegetation invading the floodway would have to be removed and the invasive non-native Bermudagrass and Johnsongrass would continue to dominate the herbaceous vegetation. Sedimentation and erosion problems would also persist throughout the next 75 years, requiring frequent maintenance to keep flood conveyance within existing expected conditions.

ALTERNATIVE DEVELOPMENT

USACE only participates in detailed analysis of ecosystem restoration alternatives for areas that show a probable federal interest and fall within the USACE authorized mission. Because of this constraint, the WSC study area is smaller in size than the construction limits of the SACIP as follows:

- San Pedro Creek –The study area is bounded by Camp St, just downstream of the San Pedro tunnel outlet and continues to the confluence with the San Antonio River.
- Apache Creek – The upstream end of the study area is at the dam at Elmendorf Lake, and extends downstream to the confluence with San Pedro Creek.
- Alazán Creek – The upstream study area limit is set at the dam for Woodlawn Lake, and continues downstream to the confluence with Apache Creek.
- Martinez Creek – The upstream end of the study area is set at Hildebrand Avenue, and continues downstream to the confluence with Alazán Creek.

Bridge modifications were considered to increase conveyance and allow for concrete removal to provide additional opportunities for restoration measures. The PDT determined early that full scale removal and reconstruction of bridges represented an unacceptable cost in relationship to the scale of potential benefits. A sensitivity analysis was conducted to determine the rough order of magnitude change in water surface elevation that might result from modifying only the bridge abutments. Through the analysis the PDT determined the change in water surface elevation (0.1-0.2 feet) was not sufficient to allow for the increased roughness and slower velocities that would result from concrete removal. Furthermore, there are geotechnical risks associated with altering the existing abutments which the PDT found to be unacceptable. The alteration of the abutments would necessitate increased costs for geotechnical remediation, raising the same concerns as full scale removal and replacement of bridges; therefore, costs would not be proportionate to the potential benefits.

This study area is highly urbanized, making acquisition of additional right-of-way (ROW) relatively expensive. The result is a general desire to stay within the existing ROW to keep costs scaled relative to the achievable restoration benefits. However, some publicly owned lands, which typically cost less to acquire, were considered for ROW expansion. These lands are adjacent to the creeks, and include public parks and/or excavated lands acquired between 2002-2004 by FEMA in response to the October 1998 flood event. The public lands considered include:

- Portions of Mario-Farias Park at the confluence of Martinez and Alazán;
- City property adjacent to Elmendorf Lake downstream of General McMullen, evacuated as part of the FEMA VAP;
- Portions of Amistad Park on Apache, downstream of Navidad; and
- City property adjacent to Martinez Creek, between Magnolia and Craig Place, evacuated as part of the FEMA VAP.

Considerations regarding topography, surrounding land use, and hydraulics resulted in dropping all but the city property adjacent to Martinez Creek from further formulation efforts. The ROW expansion adjacent to Martinez Creek, because of the low floodway banks in this area, is deemed to be a suitable location for a small scale off channel wetland area.

Major portions of Apache are currently reinforced with concrete. It would be extremely costly to excavate and complete the geotechnical remediation necessary to remove the concrete, while maintaining hydraulic neutrality and geotechnical stability needed to ensure the continued performance of the existing FRM project. The team briefly considered abandoning all efforts to restore the pilot channel on this creek, however, the addition of a pilot channel to Apache Creek is important when considering the study area and watershed as a connected ecosystem. Analyses were completed to determine the sensitivity of the water surface elevations to removal of lesser sections of concrete. The areas for concrete removal were further refined to occur only in areas of low risk for geotechnical stability issues. Ultimately the project delivery team (PDT) determined the most acceptable way to implement the pilot channel on Apache was to limit the continuous pilot channel measure to the lower third (0.8 miles) of Apache Creek. This results in the Apache Creek pilot channel being the shortest of the four pilot creek increments but still provides a system approach to the pilot channel network.

After the screening process discussed above, a final list of potential management measures was developed for each creek. These are the measures which will be carried forward for input into the IWR Planning Suite to be compared as standalone alternatives or in combination with other measures in a cost-effective incremental cost analysis (CE/ICA). Each of the measures below was evaluated against the Avian Index of Biotic Integrity to determine the level of benefit that might be derived, as well as the cost to implement each measure. The cost and benefit evaluation values for each individual measure and/or combination of measures to be compared in the CE/ICA were established. Below is a brief discussion of the cost elements for each measure and how each measure addresses the ecosystem restoration objective for WSC. Unless otherwise noted, each measure is implementable on each creek independent of whether implemented on the other creeks.

No Action: The no action measure would result in no additional costs beyond the current annual expenditure for regular operation and maintenance of the existing FRM channel features. The

WSC floodway would continue to be maintained using the existing maintenance and management plans. The no action measure does not address the ecosystem restoration objective, but is included during the comparison of action measures.

Riparian Meadow (RM): The change from non-native herbaceous vegetation to a restored native riparian meadow and aquatic vegetation would be a hydraulically neutral action. The riparian meadow measure can be implemented as a standalone alternative. Restoration of the riparian meadow and aquatic vegetation would partially address the restoration objective for WSC by providing some increased vertical structure diversity in the aquatic and riparian habitat, some increased insect biomass production, and some increased allochthonous material input to the aquatic habitat. Cost components for establishment of a native riparian meadow and aquatic vegetation include: 1) removal of top 6 inches of existing soil to remove the non-native seed bank; 2) ripping to a depth of 12-18 inches to reduce compaction and provide an acceptable strata for deep root growth; 3) incorporation of compost material into the top 2-4 inches to promote germination and sustained growth; 4) planting a diverse mix of native riparian meadow seeds; 5) the planting of aquatic, wetland, and riparian seedlings, and; 6) provisions for short-term watering to aid in quick establishment of ground cover of the exposed floodway slopes. As riparian meadow was historically a principle component of the riverine system of the WSC and the foundation of aquatic and riparian habitats, the riparian meadow management measure was determined to be the first increment of restoration.

Pilot Channel (PC): The pilot channel measure supports the ecosystem restoration objective by addressing the problems associated the increased bed slope and loss of aquatic habitat structures which occurred as a direct result of the channelization for flood risk management purposes. Specifically, the pilot channel measure would restore a balanced sediment transport function to the aquatic system as well as restore pool-riffle complexes within the creek. The restored sediment transport function in combination with restored habitat structure results in riffle and pool habitats with appropriate substrates to support the historic aquatic functions of the riverine system. Cost components for establishment of the pilot channel include: excavation, grading, rock constructed in-channel features, armoring, and utility relocation. The pilot channel measure will require a larger amount of excavation and ground disturbing activity. Since re-establishment of ground cover will be required due to the extensive ground disturbance, it seems logical that native plants would be utilized. Therefore, it was assumed that the pilot channel measure would be implemented in combination with the riparian meadow measure.

Riparian Woodland (30, 70): The riparian woodland measure supports the ecosystem restoration objective by addressing the problems of lack of aquatic shading, reduced allochthonous material inputs, lack of stratification of vertical structure, lack of terrestrial shading, and lack of soft and hard mast diversity which occurred as a direct result of the channelization for flood risk management purposes. Specifically, the riparian woodland measure would restore shading and provide the necessary organic inputs to drive the function of the riverine ecosystem. Cost components for the establishment of the riparian woodlands include: 1) spot treatment herbicide to remove herbaceous competition in the immediate area around the seedling; 2) purchase of seedlings in a diverse mix of native riparian woodland species; 3) planting of seedlings, and; 4) provisions for short term watering to aid in quick establishment. Implementation of the riparian woodland measure requires that hydraulic capacity within the floodway be increased to accommodate the added hydraulic roughness of trees. Implementation of the pilot channel measure would gain some hydraulic capacity through the required excavation to implement that measure. Therefore, it was determined that implementation of the riparian woodland measure would be dependent upon implementation of the pilot channel measure first.

Slackwater (SW): The slackwater measure supports the ecosystem restoration objective by addressing the loss of aquatic habitat structure resulting from channelization. Slackwater areas will include the addition small embayment features to the natural stream design channel increasing the heterogeneity of the physical habitat structure of the pilot channel. This measure would restore natural velocity refugia and increase length of the shoreline boundary, facilitating the accumulation of organic materials and restoring vital micro-habitats necessary for the function of the riverine ecosystem. Cost components for the establishment of slackwater include excavation, grading, armoring, and utility relocation. Implementation of the slackwater measure would require mobilization of equipment and staging sites for each location. Since the measure is so similar in nature to that of the pilot channel, which is continuous, requiring singular mobilization but multiple staging sites, significant cost reduction for this measure would be experienced by combining the slackwater work with the pilot channel work.

Wetland (WL): The wetland measure supports the ecosystem restoration objective by addressing the loss of aquatic habitat structure resulting from channelization. The measure would restore uniquely productive microhabitats through the accumulation of organic materials. Cost components for the establishment of wetland include real estate acquisition, excavation, grading, armoring, planting a diverse mixture of wetland vegetation, and provisions for short term actions to aide in establishment. Implementation of the wetland measure would require ensuring a consistent if intermittent source of water. The nearest source is Martinez Creek, but modifications to the existing channel would be required. For this reason the team determined the wetland measure would only implemented in combination with the pilot channel measure.

Utilizing the list of final management measures above, a set of incrementally combined plans for each creek was developed. By projecting future herbaceous, shrub, and overstory percent canopy cover and channel conditions for the acreage of restored habitats under each alternative, Avian IBI scores were calculated for each measure over a period of 75 years, with indexes estimated for 1 year following construction; 15 years following construction, 25 years following construction, 50 years following construction, and 75 years following construction. A period of 75 years was chosen to allow the maturing of the riparian woody vegetation so that full benefits can be captured. The respective Avian IBI scores were then multiplied by acreage to get the Avian Community Units for each measure in each of the reference years. Tables 13 through 17 show the calculation of these Avian Community Units. Using the annualizer module in the IWR Planning Suite software, these environmental outputs were annualized. By utilizing a 75-year period, the project benefits can be modeled as plateauing around the 50-year time period thereby accounting for the time required for the woody vegetation to mature. Table 18. Average Annual ABI, shows the data entered into the annualizer module and the resulting average annual avian community units for each measure. In performing the annualization, linear interpolation was used for the calculation (Table 19).

Table 13. Calculation of Total Avian Community Units for Year 1

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
San Pedro Creek	Riparian Meadow	1.11	67.35	74.77										74.77
	Riparian Meadow + Pilot Channel	1.16	67.35	78.18										78.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.16	50.24	58.32	1.16	17.11	19.86							78.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.16	50.24	58.32	1.16	9.14	10.61	1.16	7.97	9.25				78.18
	Riparian Meadow + Pilot Channel + Slackwater	1.21	67.35	81.59										81.59
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.21	50.24	60.9	1.21	17.11	20.73							81.59
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.21	50.24	60.9	1.21	9.14	11.07	1.21	7.97	9.66				81.59
Alazán Creek	Riparian Meadow	1.15	70.35	80.82										80.82
	Riparian Meadow + Pilot Channel	1.20	70.35	84.39										84.39
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	58.02	69.60	1.20	12.33	14.79							84.39
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	58.02	69.60	1.20	7.86	9.42	1.20	4.47	5.36				84.39
	Riparian Meadow + Pilot Channel + Slackwater	1.25	70.35	87.95										87.95
	Riparian Meadow + Pilot Channel + Woody Vegetaion (30 stems per acre) + Slackwater	1.25	58.02	72.54	1.25	12.33	15.41							87.95
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	58.02	72.54	1.25	7.86	9.83	1.25	4.47	5.59				87.95
Martinez Creek	Riparian Meadow	1.15	50.56	58.08										58.08
	Riparian Meadow + Pilot Channel	1.20	50.56	60.64										60.64
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	41.77	50.10	1.20	8.79	10.54							60.64
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	41.77	50.10	1.20	5.03	6.03	1.20	3.76	4.51				60.64

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
	Riparian Meadow + Pilot Channel + Slackwater	1.25	50.56	63.20										63.20
	Riparian Meadow + Pilot Channel + Wetland	1.20	50.56	60.64							1.45	5.20	7.54	68.18
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	1.25	50.56	63.20							1.45	5.20	7.54	70.74
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.25	41.77	52.21	1.25	8.79	10.99							63.20
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	41.77	52.21	1.25	5.03	6.29	1.25	3.76	4.70				63.20
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	1.20	41.77	50.10	1.20	8.79	10.54			0.00	1.45	5.20	7.54	68.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	1.20	41.77	50.10	1.20	5.03	6.03	1.20	3.76	4.51	1.45	5.20	7.54	68.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	1.25	8.79	10.99			0.00	1.45	5.20	7.54	70.74
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	1.25	5.03	6.29	1.25	3.76	4.70	1.45	5.20	7.54	70.74
Apache Creek	Riparian Meadow	1.09	34.02	37.20										37.20
	Riparian Meadow + Pilot Channel	1.11	34.02	37.73										37.73
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.11	27.22	30.19	1.11	6.80	7.54							37.73
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.11	27.22	30.19	1.11	2.00	2.22	1.11	4.80	5.32				37.73
	Riparian Meadow + Pilot Channel + Slackwater	1.13	34.02	38.27										38.27
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.13	27.22	30.62	1.13	6.80	7.65							38.27
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.13	27.22	30.62	1.13	2.00	2.25	1.13	4.80	5.40				38.27

Table 14. Calculation of Total Avian Community Units for Year 15

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
San Pedro Creek	Riparian Meadow	1.11	67.35	74.77										74.77
	Riparian Meadow + Pilot Channel	1.16	67.35	78.18										78.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.16	50.24	58.31	1.65	17.11	28.17							86.49
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.16	50.24	58.31	1.65	9.14	15.04	2.00	7.97	15.95				89.31
	Riparian Meadow + Pilot Channel + Slackwater	1.21	67.35	81.59										81.59
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.21	50.24	60.86	1.70	17.11	29..04							89.90
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.21	50.24	60.86	1.70	9.14	15.51	2.05	7.97	16.35				92.73
Alazán Creek	Riparian Meadow	1.15	70.35	80.82										80.82
	Riparian Meadow + Pilot Channel	1.20	70.35	84.39										84.38
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	58.02	69.60	1.69	12.33	20.78							90.38
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	58.02	69.60	1.69	7.86	13.25	2.04	4.47	9.12				91.96
	Riparian Meadow + Pilot Channel + Slackwater	1.25	70.35	87.95										87.95
	Riparian Meadow + Pilot Channel + Woody Vegetaion (30 stems per acre) + Slackwater	1.25	58.02	72.54	1.74	12.33	21.40							93.94
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	58.02	72.54	1.74	7.86	13.64	2.04	4.47	9.12				95.30
Martinez Creek	Riparian Meadow	1.15	50.56	58.08										58.08
	Riparian Meadow + Pilot Channel	1.20	50.56	60.64										60.64
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	41.77	50.09	1.69	8.79	14.81							64.91
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	41.77	50.09	1.69	5.03	8.48	2.04	3.76	7.67				66.24

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
	Riparian Meadow + Pilot Channel + Slackwater	1.25	50.56	63.20										63.20
	Riparian Meadow + Pilot Channel + Wetland	1.20	50.56	60.64							1.45	5.20	7.54	68.18
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	1.25	50.56	63.20							1.45	5.20	7.54	70.74
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.25	41.77	52.21	1.74	8.79	15.26							67.47
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	41.77	52.21	1.74	5.03	8.73	2.09	3.76	7.86				68.80
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	1.20	41.77	50.09	1.69	8.79	14.81				1.45	5.20	7.54	72.44
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	1.20	41.77	50.09	1.69	5.03	8.48	2.04	3.76	7.67	1.45	5.20	7.54	73.78
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	1.74	8.79	15.26				1.45	5.20	7.54	75.01
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	1.74	5.03	8.73	2.09	3.76	7.86	1.45	5.20	7.54	76.34
Apache Creek	Riparian Meadow	1.09	34.02	37.20										37.20
	Riparian Meadow + Pilot Channel	1.11	34.02	37.73										37.73
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.11	27.22	30.19	1.59	6.80	10.85							41.04
	Riparian Meadow + Pilot Channel + Woody Vegetation 70 stems per acre)	1.11	27.22	30.19	1.59	2.00	3.19	1.95	4.80	9.36				42.74
	Riparian Meadow + Pilot Channel + Slackwater	1.13	34.02	38.27										38.27
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.13	27.22	30.63	1.61	6.80	10.95							41.58
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.13	27.22	30.63	1.61	2.00	3.22	1.97	4.80	9.43				43.28

Table 15. Calculation of Total Avian Community Units for Year 25

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
San Pedro Creek	Riparian Meadow	1.11	67.35	74.77										74.77
	Riparian Meadow + Pilot Channel	1.16	67.35	78.18										78.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.16	50.24	58.32	2.01	17.11	34.35							92.67
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.16	50.24	58.32	2.01	9.14	18.35	2.48	7.97	19.77				96.44
	Riparian Meadow + Pilot Channel + Slackwater	1.21	67.35	81.59										81.59
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.21	50.24	60.86	2.06	17.11	35.21							96.08
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.21	50.24	60.86	2.06	9.14	18.81	2.53	7.97	20.17				99.85
Alazán Creek	Riparian Meadow	1.15	70.35	80.82										80.82
	Riparian Meadow + Pilot Channel	1.20	70.35	84.39										84.39
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	58.02	69.59	2.05	12.33	25.23							94.83
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	58.02	69.59	2.05	7.86	16.08	2.52	4.47	11.26				96.94
	Riparian Meadow + Pilot Channel + Slackwater	1.25	70.35	87.95										87.95
	Riparian Meadow + Pilot Channel + Woody Vegetaion (30 stems per acre) + Slackwater	1.25	58.02	72.54	2.10	12.33	25.86							98.39
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	58.02	72.54	2.10	5.86	16.48	2.57	4.47	11.49				100.50
Martinez Creek	Riparian Meadow	1.15	50.56	58.08										58.08
	Riparian Meadow + Pilot Channel	1.20	50.56	60.64										60.64
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	41.77	50.10	2.05	8.79	17.98							68.08
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	41.77	50.10	2.05	5.03	10.29	2.52	3.76	9.47				69.86
	Riparian Meadow + Pilot Channel + Slackwater	1.25	50.56	63.20										63.20

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
	Riparian Meadow + Pilot Channel + Wetland	1.20	50.56	60.64							1.45	5.20	7.54	68.17
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	1.25	50.56	63.20							1.45	5.20	7.54	70.74
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.25	41.77	52.21	2.10	8.79	18..43							70.65
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	41.77	52.21	2.10	5.03	10.55	2.57	3.76	9.66				72.42
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	1.20	41.77	50.09	2.05	8.79	17.99				1.45	5.20	7.54	75.62
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	1.20	41.77	50.09	2.05	5.03	10.29	2.52	3.76	9.47	1.45	5.20	7.54	77.40
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	2.10	8.79	18.43				1.45	5.20	7.54	78.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	2.10	5.03	10.55	2.57	3.76	9.66	1.45	5.20	7.54	79.96
Apache Creek	Riparian Meadow	1.09	34.02	37.20										37.20
	Riparian Meadow + Pilot Channel	1.11	34.02	37.73										37.73
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.11	27.22	30.19	1.96	6.80	13.30							43.49
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.11	27.22	30.19	1.96	2.00	3.91	2.43	4.80	11.66				45.76
	Riparian Meadow + Pilot Channel + Slackwater	1.13	34.02	38.27										38.27
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.13	27.22	30.62	1.97	6.80	13.41							44.03
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.13	27.22	30.62	1.97	2.00	3.94	2.44	4.80	11.73				46.30

Table 16. Calculation of Total Avian Community Units for Year 50

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
San Pedro Creek	Riparian Meadow	1.11	67.35	74.77										74.77
	Riparian Meadow + Pilot Channel	1.16	67.35	78.18										78.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.16	50.24	58.32	2.48	17.11	42.44							100.76
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.16	50.24	58.32	2.48	9.14	22.67	3.02	7.97	24.03				105.02
	Riparian Meadow + Pilot Channel + Slackwater	1.21	67.35	81.59										81.59
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.21	50.24	60.86	2.53	17.11	43.31							104.17
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.21	50.24	60.86	2.53	9.14	23.13	3.07	7.97	24.44				108.43
Alazán Creek	Riparian Meadow	1.15	70.35	80.82										80.82
	Riparian Meadow + Pilot Channel	1.20	70.35	84.39										84.39
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	58.02	69.60	2.52	12.33	31.06							100.66
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	58.02	69.60	2.52	7.86	19.80	3.05	4.47	13.65				103.05
	Riparian Meadow + Pilot Channel + Slackwater	1.25	70.35	87.95										87.95
	Riparian Meadow + Pilot Channel + Woody Vegetaion (30 stems per acre) + Slackwater	1.25	58.02	72.54	2.57	12.33	31.69							104.22
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	58.02	72.54	2.57	7.86	20.20	3.10	4.47	13.88				106.61
Martinez Creek	Riparian Meadow	1.15	50.56	58.08										58.08
	Riparian Meadow + Pilot Channel	1.20	50.56	60.64										60.64
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	41.77	50.10	2.52	8.79	22.14							72.24
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	41.77	50.10	2.52	5.03	12.67	3.05	3.76	11.48				74.25
	Riparian Meadow + Pilot Channel + Slackwater	1.25	50.56	63.20										63.20
	Riparian Meadow + Pilot Channel + Wetland	1.20	50.56	60.64							1.45	5.20	7.54	68.18
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	1.25	50.56	63.20							1.45	5.20	7.54	70.74
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.25	41.77	52.21	2.57	8.79	22.59							74.80
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	41.77	52.21	2.57	5.03	12.93	3.10	3.76	11.67				76.81

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	1.20	41.77	50.10	2.52	8.79	22.14				1.45	5.20	7.54	79.78
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	1.20	41.77	50.10	2.52	5.03	12.67	3.05	3.76	11.48	1.45	5.20	7.54	81.79
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	2.57	8.79	22.59				1.45	5.20	7.54	82.33
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	2.57	5.03	12.93	3.10	3.76	11.67	1.45	5.20	7.54	84.35
Apache Creek	Riparian Meadow	1.09	34.02	37.20										37.20
	Riparian Meadow + Pilot Channel	1.11	34.02	37.73										37.73
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.11	27.22	30.19	2.43	6.82	16.52							46.71
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.11	27.22	30.19	2.43	2.00	4.86	2.96	4.80	14.23				49.28
	Riparian Meadow + Pilot Channel + Slackwater	1.13	34.02	38.27										38.27
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.13	27.22	30.62	2.44	6.82	16.62							47.24
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.13	27.22	30.62	2.44	2.00	4.89	2.98	4.80	14.30				49.82

Table 17. Calculation of Total Avian Community Units for Year 75

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
San Pedro Creek	Riparian Meadow	1.11	67.35	74.77										74.77
	Riparian Meadow + Pilot Channel	1.16	67.35	78.18										78.18
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.16	50.24	58.32	2.48	17.11	42.44							100.76
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.16	50.24	58.32	2.48	9.14	22.67	3.02	7.97	24.03				105.02
	Riparian Meadow + Pilot Channel + Slackwater	1.21	67.35	81.59										81.59
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.21	50.24	60.86	2.53	17.11	43.31							104.17
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.21	50.24	60.86	2.53	9.14	23.13	3.07	7.97	24.44				108.43
Alazán Creek	Riparian Meadow	1.15	70.35	80.82										80.82
	Riparian Meadow + Pilot Channel	1.20	70.35	84.39										84.39
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	58.02	69.60	2.52	12.33	31.06							100.66
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	58.02	69.60	2.52	7.86	19.80	3.05	4.47	13.65				103.05
	Riparian Meadow + Pilot Channel + Slackwater	1.25	70.35	87.95										87.95
	Riparian Meadow + Pilot Channel + Woody Vegetaion (30 stems per acre) + Slackwater	1.25	58.02	72.54	2.57	12.33	31.69							104.22
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	58.02	72.54	2.57	7.86	20.20	3.10	4.47	13.88				106.61
Martinez Creek	Riparian Meadow	1.15	50.56	58.08										58.08
	Riparian Meadow + Pilot Channel	1.20	50.56	60.64										60.64
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.20	41.77	50.09	2.52	8.79	22.14							72.24
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.20	41.77	50.09	2.52	5.03	12.67	3.05	3.76	11.48				74.25
	Riparian Meadow + Pilot Channel + Slackwater	1.25	50.56	63.20										63.20
	Riparian Meadow + Pilot Channel + Wetland	1.20	50.56	60.64							1.45	5.20	7.54	68.18

Stream	Plan	Non Woody Vegetation Avian IBI (Riparian Meadow, Pilot Channel, Slackwater)	Non Woody Vegetation Acres	Non Woody Vegetation Avian Community Units	Avian IBI for 30 Stems per Acre	Total Acreage for 30 Stems per Acre	Avian Community Units for 30 Stems per Acre	Avian IBI for 70 Stems per Acre	Acreage for 70 Stems per Acre	Avian Community Units for 70 Stems per Acre	Avian IBI for Wetlands	Acreage for Wetlands	Avian Community Units for Wetlands	Total Avian Community Units
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	1.25	50.56	63.20							1.45	5.20	7.54	70.74
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.25	41.77	52.21	2.57	8.79	22.59							74.80
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.25	41.77	52.21	2.57	5.03	12.93	3.10	3.76	11.67				76.81
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	1.20	41.77	50.09	2.52	8.79	22.14				1.45	5.20	7.54	79.78
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	1.20	41.77	50.09	2.52	5.03	12.67	3.05	3.76	11.48	1.45	5.20	7.54	81.79
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	2.57	8.79	22.59				1.45	5.20	7.54	82.34
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	1.25	41.77	52.21	2.57	5.03	12.93	3.10	3.76	11.67	1.45	5.20	7.54	84.35
Apache Creek	Riparian Meadow	1.09	34.02	37.20										37.20
	Riparian Meadow + Pilot Channel	1.11	34.02	37.73										37.73
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	1.11	27.22	30.19	2.43	6.80	16.52							46.71
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	1.11	27.22	30.19	2.43	2.00	4..86	2.96	4.80	14.23				49.28
	Riparian Meadow + Pilot Channel + Slackwater	1.13	34.02	38.27										38.27
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	1.13	27.22	30.62	2.44	6.80	16.62							47.25
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	1.13	27.22	30.62	2.44	2.00	4.89	2.98	4.80	14.30				49.82

Table 18. Average Annual ABI

Stream	Measure	Year						Average Annual Avian Community Units
		0	1	15	25	50	75	
San Pedro Creek	Riparian Meadow	61.54	74.77	74.77	74.77	74.77	74.77	74.27
	Riparian Meadow + Pilot Channel	61.54	78.18	78.18	78.18	78.18	78.18	77.66
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	61.54	78.18	86.49	92.67	100.76	100.76	93.66
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	61.54	78.18	89.32	96.44	105.02	105.02	97.12
	Riparian Meadow + Pilot Channel + Slackwater	61.54	81.59	81.59	81.59	81.59	81.59	81.05
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	61.54	81.59	89.90	96.08	104.17	104.17	97.05
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	61.54	81.59	92.73	99.85	108.43	108.43	100.51
Alazán Creek	Riparian Meadow	64.69	80.82	80.82	80.82	80.82	80.82	80.28
	Riparian Meadow + Pilot Channel	64.69	84.39	84.39	84.39	84.39	84.39	83.83
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	64.69	84.39	90.38	94.83	100.66	100.66	95.35
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	64.69	84.39	91.96	96.94	103.05	103.05	97.30
	Riparian Meadow + Pilot Channel + Slackwater	64.69	87.95	87.95	87.95	87.95	87.95	87.36
	Riparian Meadow + Pilot Channel + Woody Vegetaion (30 stems per acre) + Slackwater	64.69	87.95	93.94	98.39	104.22	104.22	98.89
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	64.69	87.95	95.30	100.50	106.61	106.61	100.80
Martinez Creek	Riparian Meadow	46.53	58.08	58.08	58.08	58.08	58.08	57.69
	Riparian Meadow + Pilot Channel	46.53	60.64	60.64	60.64	60.64	60.64	60.24
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	46.53	60.64	64.91	68.08	72.24	72.24	68.46
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	46.53	60.64	66.24	69.86	74.25	74.25	70.09
	Riparian Meadow + Pilot Channel + Slackwater	46.53	63.20	63.20	63.20	63.20	63.20	62.78
	Riparian Meadow + Pilot Channel + Wetland	46.53	68.18	68.18	68.18	68.18	68.18	67.73
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	46.53	70.74	70.74	70.74	70.74	70.74	70.27
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	46.53	63.20	67.47	70.65	74.80	74.80	71.00
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	46.53	63.20	68.80	72.42	76.81	76.81	72.63
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	46.53	68.18	72.45	75.62	79.78	79.78	75.94
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	46.53	68.18	73.78	77.40	81.79	81.79	77.58
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	46.53	70.74	75.01	78.18	82.34	82.34	78.49
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	46.53	70.74	76.34	79.96	84.35	84.35	80.12
Apache Creek	Riparian Meadow	31.97	37.20	37.20	37.20	37.20	37.20	36.92
	Riparian Meadow + Pilot Channel	31.97	37.73	37.73	37.73	37.73	37.73	37.48
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	31.97	37.73	41.04	43.49	46.71	46.71	43.84
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	31.97	37.73	42.74	45.76	49.28	49.28	45.93
	Riparian Meadow + Pilot Channel + Slackwater	31.97	38.27	38.27	38.27	38.27	38.27	38.02
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	31.97	38.27	41.58	44.03	47.25	47.25	44.38
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	31.97	38.27	43.28	46.30	49.82	49.82	46.46

Environmental restoration benefits are calculated by subtracting the future without-project avian community units from the with-project average annual avian community units. The resulting benefits are then used, along with annual costs, to identify cost effective plans and perform incremental cost analysis. The calculation of benefits (outputs) is shown in Table 19.

Table 19: Calculation of Ecological Benefits by Creek and Measure

		Future Without Project			Future With Project		
Stream	**Plan**	**Avian IBI**	**Acres**	**Avian Community Unit**	**Acres**	**Average Annual Avian Community Unit**	**Benefits Average Annual Avian Community Units (Output)**
San Pedro Creek	Riparian Meadow	0.913683	67.35	61.53655	67.35	74.27136	12.73481
	Riparian Meadow + Pilot Channel	0.913683	67.35	61.53655	67.35	77.65872	16.12217
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	0.913683	67.35	61.53655	67.35	93.65845	32.1219
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	0.913683	67.35	61.53655	67.35	97.12074	35.58419
	Riparian Meadow + Pilot Channel + Slackwater	0.913683	67.35	61.53655	67.35	81.04609	19.50954
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	0.913683	67.35	61.53655	67.35	97.04702	35.51047
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	0.913683	67.35	61.53655	67.35	100.5093	38.97276
Alazán Creek	Riparian Meadow	0.919491	70.35	64.68619	70.35	80.28135	15.59516
	Riparian Meadow + Pilot Channel	0.919491	70.35	64.68619	70.35	83.82717	19.14098
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	0.919491	70.35	64.68619	70.35	95.35475	30.66856
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	0.919491	70.35	64.68619	70.35	97.29697	32.61078
	Riparian Meadow + Pilot Channel + Slackwater	0.919491	70.35	64.68619	70.35	87.36366	22.67746
	Riparian Meadow + Pilot Channel + Woody Vegetaion (30 stems per acre) + Slackwater	0.919491	70.35	64.68619	70.35	98.89363	34.20744
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	0.919491	70.35	64.68619	70.35	100.799	36.11277
Martinez Creek	Riparian Meadow	0.920196	50.56	46.52511	50.56	57.69275	11.16764
	Riparian Meadow + Pilot Channel	0.920196	50.56	46.52511	50.56	60.23575	13.71064
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	0.920196	50.56	46.52511	50.56	68.45646	21.93135
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	0.920196	50.56	46.52511	50.56	70.08925	23.56414
	Riparian Meadow + Pilot Channel + Slackwater	0.920196	50.56	46.52511	50.56	62.77875	16.25364
	Riparian Meadow + Pilot Channel + Wetland	0.920196	50.56	46.52511	55.76	67.72526	21.20015

Stream	Plan	Future Without Project			Future With Project		
		Avian IBI	Acres	Avian Community Unit	Acres	Average Annual Avian Community Unit	Benefits Average Annual Avian Community Units (Output)
	Riparian Meadow + Pilot Channel + Slackwater + Wetland	0.920196	50.56	46.52511	55.76	70.26826	23.74315
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	0.920196	50.56	46.52511	50.56	70.99986	24.47475
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	0.920196	50.56	46.52511	50.56	72.63278	26.10767
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Wetlands	0.920196	50.56	46.52511	55.76	75.9433	29.41819
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Wetlands	0.920196	50.56	46.52511	55.76	77.57538	31.05027
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater+Wetlands	0.920196	50.56	46.52511	55.76	78.48657	31.96146
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater+Wetlands	0.920196	50.56	46.52511	55.76	80.12042	33.59531
Apache Creek	Riparian Meadow	0.939846	34.02	31.97356	34.02	36.92178	4.948216
	Riparian Meadow + Pilot Channel	0.939846	34.02	31.97356	34.02	37.47876	5.505194
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre)	0.939846	34.02	31.97356	34.02	43.84279	11.86922
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre)	0.939846	34.02	31.97356	34.02	45.92924	13.95568
	Riparian Meadow + Pilot Channel + Slackwater	0.939846	34.02	31.97356	34.02	38.01507	6.041507
	Riparian Meadow + Pilot Channel + Woody Vegetation (30 stems per acre) + Slackwater	0.939846	34.02	31.97356	34.02	44.37816	12.4046
	Riparian Meadow + Pilot Channel + Woody Vegetation (70 stems per acre) + Slackwater	0.939846	34.02	31.97356	34.02	46.46449	14.49093

To conduct the CE/ICA analysis, these environmental restoration benefits (increase in with-project average annual avian community units) and annual costs (expressed in thousands of dollars) were entered into IWR Planning Suite, resulting in an an array of Best Buy Plans for the study that provide ecological benefits to migratory birds and other biotic components utilizing the WSC.

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ATTACHMENT 1: BIRD SPECIES OCCURRING IN BEXAR COUNTY (BRIERLY AND ENGELMAN, 2004)

Common Name	Scientific Name	Season				Breeding Habitat[1]
		Spring	Summer	Fall	Winter	
Anatidae						
Black-bellied Whistling Duck	*Dendrocygna autumnalis*	C	C	C	C	X
Fulvous Whistling Duck	*Dendrocygna bicolor*	R	V	V	V	
Greater White-fronted Goose	*Anser albifrons*	V		R	R	
Snow Goose	*Chen caerulescens*	R		R	R	
Ross' Goose	*Chen rossii*				R	
Canada Goose	*Branta canadensis*	R		U	U	
Tundra Swan	*Cygnus columbianus*				V	
Wood Duck	*Aix sponsa*	F	F	F	F	X
Gadwall	*Anas strepera*	C	R	C	C	X
American Wigeon	*Anas Americana*	C	R	C	C	
American Black Duck	*Anas rubripes*				V	
Mallard	*Anas platyrhynchos*	U	U	U	U	X
Mottled Duck	*Anas fulvigula*	R	R	R	R	
Blue-winged Teal	*Anas discors*	C	R	C	F	X
Cinnamon Teal	*Anas cyanoptera*	U	V	U	U	X
Northern Shoveler	*Anas clypeata*	C	R	C	C	X
Northern Pintail	*Anas acuta*	C	R	C	C	
Green-winged Teal	*Anas crecca*	C	R	C	C	
Canvasback	*Aythya valisineria*	U	V	U	U	
Redhead	*Aythya americana*	U	R	U	U	
Ring-necked Duck	*Aythya collaris*	U	R	U	F	
Greater Scaup	*Aythya marila*	V	V	R	R	
Lesser Scaup	*Aythya affinis*	C	R	C	C	
Surf Scoter	*Melanitta perspicillata*			V	V	
White-winged Scoter	*Melanitta fusca*	V		V	V	
Black Scoter[2]	*Melanitta americana*				V	
Long-tailed Duck	*Clangula hyemalis*			V	V	
Bufflehead	*Bucephala albeola*	C	V	C	C	
Common Goldeneye	*Bucephala clangula*	V		R	R	
Hooded Merganser	*Lophodytes cucullatus*	R		F	F	
Common Merganser	*Mergus merganser*				V	
Red-breasted Merganser	*Mergus serrator*	V		R	R	
Masked Duck	*Nomonyx dominicus*	V				
Ruddy Duck	*Oxyura jamaicensis*	C	R	C	C	X
Odontophoridae						
Scaled Quail	*Callipepla squamata*	V	V	V	V	X[3]
Northern Bobwhite	*Colinus virginianus*	F	C	F	U	X
Montezuma Quail	*Cyrtonyx montezumae*		V		V	X[3]
Phasianidae						
Wild Turkey	*Meleagris gallopavo*	R	R	R	R	X
Gaviidae						
Red-throated Loon[2]	*Gavia stellata*			V	V	

Common Name	Scientific Name	Season: Spring	Summer	Fall	Winter	Breeding Habitat[1]
Pacific Loon[2]	*Gavia pacifica*			V	V	
Common Loon	*Gavia immer*	V	V	R	R	
Podicipedidae						
Least Grebe	*Tachybaptus dominicus*	U	R	U	F	X
Pied-billed Grebe	*Podilymbus podiceps*	C	C	C	C	X
Horned Grebe	*Podiceps auritus*			R	R	
Red-necked Grebe	*Podiceps grisegena*				V	
Eared Grebe	*Podiceps nigricollis*	C	R	C	C	X[3]
Western Grebe	*Aechmophorus occidentalis*	R	V	V	R	
Hydrobatidae						
Band-rumped Storm-petrel	*Oceanodroma castro*		V			
Ciconiidae						
Wood Stork	*Mycteria americana*	V	R	R		
Fregatidae						
Magnificent Frigatebird	*Fregata magnificens*		V	V		
Phalacrocoracidae						
Neotropic Cormorant	*Phalacrocorax brasilianus*	U	C	C	U	
Double-crested Cormorant	*Phalacrocorax auritus*	C	R	C	C	
Anhingidae						
Anhinga	*Anhinga anhinga*	R	R	R	R	X[3]
Pelecanidae						
American White Pelican	*Pelecanus erythrorhynchos*	C	C	C	C	
Brown Pelican	*Pelecanus occidentalis*	R	R	R	R	
Ardeidae						
American Bittern	*Botaurus lentiginosus*	R		R	R	
Least Bittern[4]	*Ixobrychus exilis*	U	U	U		X
Great Blue Heron	*Ardea Herodias*	C	U	C	C	
Great Egret	*Ardea alba*	C	C	C	C	X
Snowy Egret	*Egretta thula*	F	C	F	U	X
Little Blue Heron	*Egretta caerulea*	F	F	F	R	X
Tricolored Heron	*Egretta tricolor*	R	F	F	R	
Reddish Egret	*Egretta rufescens*		V	V		
Cattle Egret	*Bubulcus ibis*	C	C	C	U	X
Green Heron	*Butorides virescens*	C	C	C	R	X
Black-crowned Night-heron	*Nycticorax nycticorax*	C	F	C	C	X
Yellow-crowned Night-heron	*Nyctanassa violacea*	C	C	C	R	X
Threskiornithidae						
White Ibis	*Eudocimus albus*	R	R	R	V	
Glossy Ibis	*Plegadis falcinellus*	V	V			
White-faced Ibis	*Plegadis chihi*	F	U	F	R	X[3]
Roseate Spoonbill	*Platalea ajaja*	R	U	U	R	
Cathartidae						
Black Vulture	*Coragyps atratus*	C	C	C	C	X
Turkey Vulture	*Cathartes aura*	C	C	C	C	X
Pandionidae						
Osprey[4]	*Pandion haliaetus*	F	U	U	F	

Common Name	Scientific Name	Season: Spring	Season: Summer	Season: Fall	Season: Winter	Breeding Habitat[1]
Accipitridae						
Hook-billed Kite[2]	*Chondrohierax uncinatus*			V		
Swallow-tailed Kite	*Elanoides forficatus*	V	V	V		
White-tailed Kite	*Elanus leucurus*	V	R	R	V	
Mississippi Kite	*Ictinia mississippiensis*	U	R	U		
Bald Eagle	*Haliaeetus leucocephalus*	V		V	R	
Northern Harrier	*Circus cyaneus*	C	V	C	C	
Sharp-shinned Hawk	*Accipiter striatus*	F	V	F	F	
Cooper’s Hawk	*Accipiter cooperii*	F	V	F	F	X
Northern Goshawk	*Accipiter gentilis*		V		V	
Common Black-hawk	*Buteogallus anthracinus*			V	V	
Harris’ Hawk	*Parabuteo unicinctus*	U	U	U	U	X
Red-shouldered Hawk	*Buteo lineatus*	F	F	F	F	X
Broad-winged Hawk	*Buteo platypterus*	U		R		
Swainson’s Hawk[4]	*Buteo swainsoni*	F	U	F	V	X
White-tailed Hawk	*Buteo albicaudatus*	V	V	V	V	
Zone-tailed Hawk	*Buteo albonotatus*	R		R	R	X[3]
Red-tailed Hawk	*Buteo jamaicensis*	C	F	C	C	X
Ferruginous Hawk	*Buteo regalis*	R		R	U	
Rough-legged Hawk	*Buteo lagopus*	V		V	R	
Golden Eagle	*Aquila chrysaetos*	R		R	R	
Falconidae						
Crested Caracara	*Caracara cheriway*	F	F	F	F	X
American Kestrel	*Falco sparverius*	C	R	C	C	
Merlin	*Falco columbiarius*	R		R	R	
Peregrine Falcon	*Falco peregrines*	R		R	R	
Prairie Falcon	*Falco mexicanus*	V			V	
Rallidae						
King Rail	*Rallus elegans*	V	V		V	X[3]
Virginia Rail	*Rallus limicola*	V		V	R	
Sora[4]	*Porzana carolina*	U		U	F	
Purple Gallinule	*Porphyrio martinica*	R	R	R		X
Common Gallinule[4]	*Gallinula galeata*	F	C	F	F	X
American Coot	*Fulica americana*	C	U	C	C	X
Gruidae						
Sandhill Crane	*Grus canadensis*	R	V	R	R	
Whooping Crane[2]	*Grus americana*			V		
Charadriidae						
Black-bellied Plover	*Pluvialis squatarola*	R	V	R	V	
American Golden-plover	*Pluvialis dominica*	R	V	R	R	
Snowy Plover	*Charadrius nivosus*	R	R	R	V	
Wilson’s Plover	*Charadrius wilsonia*		V	V		
Semipalmated Plover	*Charadrius semipalmatus*	U	U	U	R	
Piping Plover	*Charadrius melodus*	V	V	R	V	
Killdeer	*Charadrius vociferous*	C	C	C	C	X
Mountain Plover	*Charadrius montanus*	V		V	V	
Recurvirostridae						

Common Name	Scientific Name	Season: Spring	Season: Summer	Season: Fall	Season: Winter	Breeding Habitat[1]
Black-necked Stilt	*Himantopus mexicanus*	C	C	C	R	X
American Avocet	*Recurvirostra americana*	C	U	U	R	X
Jacanidae						
Northern Jacana	*Jacana spinosa*		V			X
Scolopacidae						
Spotted Sandpiper	*Actitis macularius*	C	U	C	C	
Solitary Sandpiper	*Tringa solitaria*	U	U	U	U	
Greater Yellowlegs	*Tringa melanoleuca*	C	U	C	U	
Willet	*Tringa semipalmata*	R	V	R		
Lesser Yellowlegs	*Tringa flavipes*	C	U	C	U	
Upland Sandpiper	*Bartramia longicauda*	U	R	U		
Whimbrel	*Numenius phaeopus*	R	V	V		
Long-billed Curlew	*Numenius americanus*	R	V	R		
Hudsonian Godwit	*Limosa haemastica*	R	V			
Marbled Godwit	*Limosa fedoa*	V	R	V		
Ruddy Turnstone	*Arenaria interpres*	R	R	R		
Red Knot	*Calidris canutus*	V				
Sanderling	*Calidris alba*	R	R	R		
Semipalmated Sandpiper	*Calidris pusilla*	U	U	U		
Western Sandpiper	*Calidris mauri*	C	U	C	R	
Least Sandpiper	*Calidris minutilla*	C	F	C	C	
White-rumped Sandpiper	*Calidris fuscicollis*	U	V	U		
Baird’s Sandpiper	*Calidris bairdii*	C	V	C	V	
Pectoral Sandpiper	*Calidris melanotos*	F	U	F	V	
Dunlin	*Calidris alpina*	R	V	R	R	
Curlew Sandpiper[2]	*Calidris ferruginea*	V				
Stilt Sandpiper	*Calidris himantopus*	F	V	F	R	
Buff-breasted Sandpiper	*Tryngites subruficollis*	R	R	R	R	
Ruff	*Philomachus pugnax*	V	V	V	V	
Short-billed Dowitcher	*Limnodromus griseus*	R	V	R		
Long-billed Dowitcher	*Limnodromus scolopaceus*	C	F	C	U	
Wilson’s Snipe	*Gallinago delicata*	C	V	C	C	
American Woodcock	*Scolopax minor*	V			R	
Wilson’s Phalarope	*Phalaropus tricolor*	C	U	C	R	
Red-necked Phalarope	*Phalaropus lobatus*	V	V	V		
Laridae						
Black-legged Kittiwake	*Rissa tridactyla*			V	R	
Sabine’s Gull	*Xema sabini*			V		
Bonaparte’s Gull	*Chroicocephalus philadelphia*	R		R	C	
Little Gull[2]	*Hydrocoloeus minutes*				V	
Laughing Gull	*Leucophaeus atricilla*	R	R	R	R	
Franklin’s Gull	*Leucophaeus pipixcan*	F	R	F	V	
Mew Gull[2]	*Larus canus*				V	
Ring-billed Gull	*Larus delawarensis*	C	R	C	C	
California Gull	*Larus californicus*	V		V	V	
Herring Gull	*Larus argentatus*	R	V	R	U	
Lesser Black-backed Gull[2]	*Larus fuscus*				V	
Glaucous Gull[2]	*Larus hyperboreus*				V	

Common Name	Scientific Name	Season				Breeding Habitat[1]
		Spring	Summer	Fall	Winter	
Sooty Tern	*Onychoprion fuscatus*		V	V		
Bridled Tern[2]	*Onychoprion anaethetus*		V			
Least Tern	*Sternula antillarum*	R	R	R		
Gull-billed Tern	*Gelochelidon nilotica*	V		V		
Caspian Tern	*Hydroprogne caspia*	R	V	R	V	
Black Tern	*Chlidonias niger*	U	U	U		
Common Tern	*Sterna hirundo*	R	V	R		
Forster’s Tern	*Sterna forsteri*	C	R	U	C	
Royal Tern	*Thalasseus maximus*		V	V		
Black Skimmer	*Rynchops niger*	R	R	R	V	
Stercorariidae						
Parasitic Jaeger	*Stercorarius parasiticus*		V	V		
Long-tailed Jaeger	*Stercorarius longicaudus*		V			
Columbidae						
Rock Pigeon[5]	*Columbia livia*	C	C	C	C	X
Eurasian Collared-dove[5]	*Streptopelia decaocto*	R	R	R	R	
White-winged Dove	*Zenaida asiatica*	C	C	C	C	X
Mourning Dove	*Zenaida macroura*	C	C	C	C	X
Inca Dove	*Columbina inca*	C	C	C	C	X
Common Ground-dove	*Columbina passerina*	F	F	F	U	X
Psittacidae						
Monk Parakeet[4,5]	*Myiopsitta monachus*	R	R	R	R	X
Green Parakeet	*Aratinga holochlora*	V	V	V	V	
Cuculidae						
Yellow-billed Cuckoo	*Coccyzus americanus*	C	C	C	V	
Black-billed Cuckoo	*Coccyzus erythropthalmus*	R	V	R		
Greater Roadrunner	*Geococcyx californianus*	F	F	F	F	
Groove-billed Ani[4]	*Crotophaga sulcirostris*	R	U	U		
Tytonidae						
Barn Owl	*Tyto alba*	U	U	U	U	X
Strigidae						
Western Screech-owl[2]	*Megascops kennicottii*				V	
Eastern Screech-owl	*Megascops asio*	U	U	U	U	X
Great Horned Owl	*Bubo virginianus*	U	U	U	U	X
Snowy Owl[2]	*Bubo scandiacus*				V	
Elf Owl	*Micrathene whitneyi*	V	V			
Burrowing Owl	*Athene cunicularia*	V		V	R	
Barred Owl	*Strix varia*	U	U	U	U	X
Long-eared Owl	*Asio otus*	R		V	R	
Short-eared Owl	*Asio flammeus*	R		R	R	
Caprimulgidae						
Lesser Nighthawk	*Chordeiles acutipennis*	U	U	U		X
Common Nighthawk	*Chordeiles minor*	C	C	C		X
Common Pauraque[2]	*Nyctidromus albicollis*				V	
Common Poorwill	*Phalaenoptilus nuttallii*	R	V	R	V	X
Chuck-will’s-widow	*Caprimulgus carolinensis*	F	F	F		X
Whip-poor-will	*Caprimulgus vociferus*	U		R	V	

Common Name	Scientific Name	Season				Breeding Habitat[1]
		Spring	Summer	Fall	Winter	
Apodidae						
Chimney Swift	*Chaetura pelagica*	C	C	C	V	X
White-throated Swift	*Aeronautes saxatalis*				V	
Trochilidae						
Green Violet-ear	*Colibri thalassinus*	V				
Broad-billed Hummingbird[2]	*Cyananthus latirostris*	V				
Buff-bellied Hummingbird	*Amazilia yucatanensis*	V	V	R	V	
Magnificent Hummingbird[2]	*Eugenes fulgens*	V				
Lucifer Hummingbird	*Calothorax Lucifer*		V			
Ruby-throated Hummingbird	*Archilochus colubris*	C	R	C	V	
Black-chinned Hummingbird	*Archilochus alexandri*	C	C	C	V	X
Anna's Hummingbird	*Calypte anna*			R	R	
Calliope Hummingbird	*Stellula calliope*	V	V			
Broad-tailed Hummingbird	*Selasphorus platycercus*	R	V	R		
Rufous Hummingbird	*Selasphorus rufus*	R	R	U	U	
Allen's Hummingbird	*Selasphorus sasin*		V	V	V	
Alcedinidae						
Ringed Kingfisher	*Megaceryle torquata*			V	V	
Belted Kingfisher	*Megaceryle alcyon*	C	U	C	C	X[3]
Green Kingfisher	*Chloroceryle americana*	U	U	U	U	X
Picidae						
Red-headed Woodpecker	*Melanerpes lewis*	V	V	R	R	X[3]
Golden-fronted Woodpecker	*Melanerpes aurifrons*	C	C	C	C	X
Red-bellied Woodpecker	*Melanerpes carolinus*	V			V	
Yellow-bellied Woodpecker	*Sphyrapicus varius*	U		U	U	
Red-naped Sapsucker[2]	*Sphyrapicus nuchalis*			V		
Ladder-backed Woodpecker	*Picoides scalaris*	C	C	C	C	X
Downy Woodpecker	*Picoides pubescens*	R	R	R	R	X
Hairy Woodpecker[2]	*Picoides villosus*				V	
Northern Flicker	*Colaptes punctigula*	F		F	F	
Pileated Woodpecker	*Dryocopus pileatus*		V			X[3]
Tyranidae						
Olive-sided Flycatcher	*Contopus cooperi*	U	R	U		
Greater Pewee	*Contopus pertinax*				V	
Western Wood-Pewee	*Contopus sordidulus*	R		R		
Eastern Wood-Pewee	*Contopus virens*	C	U	U		X
Yellow-bellied Flycatcher	*Empidonax flaviventris*	U	R	U		
Acadian Flycatcher	*Empidonax virescens*	C	F	F		X[3]
Alder Flycatcher	*Empidonax alnorum*	U	R	U		
Willow Flycatcher	*Empidonax traillii*	U	R	U		
Least Flycatcher	*Empidonax minimus*	C	R	U		
Cordilleran Flycatcher	*Empidonax occidentalis*		V			
Black Phoebe	*Sayornis nigricans*	V		V	R	
Eastern Phoebe	*Sayornis phoebe*	C	U	C	C	X
Say's Phoebe	*Sayornis saya*	R		R	F	
Vermilion Flycatcher[4]	*Pyrocephalus rubinus*	F	R	F	C	X[3]
Ash-throated Flycatcher	*Myiarchus cinerascens*	C	F	U	F	X
Great Crested Flycatcher	*Myiarchus crinitus*	C	C	F		X

Common Name	Scientific Name	Season				Breeding Habitat[1]
		Spring	Summer	Fall	Winter	
Brown-crested Flycatcher	*Myiarchus tyrannulus*	U	U	R		X
Great Kiskadee	*Pitangus sulphuratus*			V		
Couch's Kingbird	*Tyrannus couchii*	U	U	U	U	X
Cassin's Kingbird[2]	*Tyrannus vociferans*			V		
Western Kingbird	*Tyrannus verticalis*	C	C	F	V	X
Eastern Kingbird	*Tyrannus tyrannus*	F	R	R		X[3]
Scissor-tailed Flycatcher	*Tyrranus forficatus*	C	C	C	V	X
Laniidae						
Loggerhead Shrike	*Lanius ludovicianus*	C	F	C	C	X
Vireonidae						
White-eyed Vireo	*Vireo griseus*	C	C	C	F	X
Bell's Vireo	*Vireo bellii*	F	F	U	V	X
Black-capped Vireo	*Vireo atricapilla*	R	R			X
Yellow-throated Vireo	*Vireo flavifrons*	R	R	R	V	X[3]
Plumbeous Vireo	*Vireo plumbeus*	V	V			
Blue-headed Vireo	*Vireo solitaries*	C		C	U	
Hutton's Vireo[4]	*Vireo huttoni*	R	R	R	R	X
Warbling Vireo	*Vireo gilvus*	U		U		
Philadelphia Vireo	*Vireo philadelphicus*	U	V	U		
Red-eyed Vireo	*Vireo olivaceus*	F	R	R		X
Corvidae						
Green Jay	*Cyanocorax yncas*	V	V	V	V	X[3]
Blue Jay	*Cyanocitta cristata*	C	C	C	C	X
Western Scrub-jay	*Aphelocoma californica*	C	C	C	C	X
American Crow	*Corvus brachyrhynchos*	C	C	C	C	X
Chihuahuan Raven	*Corvus cryptoleucus*		V			
Common Raven	*Corvus corax*	U	U	U	U	X
Alaudidae						
Horned Lark	*Eremophila alpestris*		V	R	R	
Hirundinidae						
Purple Martin	*Progne subis*	C	C	U	V	X
Tree Swallow	*Tachycineta bicolor*	F	U	F	R	X[3]
Violet-green Swallow[2]	*Tachycineta thalassina*			V		
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	F	U	F	V	X
Bank Swallow	*Riparia riparia*	U	U	U	V	
Cliff Swallow	*Petrochelidon pyrrhonota*	C	C	C	V	X
Cave Swallow	*Petrochelidon fulva*	C	C	C	C	X
Barn Swallow	*Hirundo rustica*	C	C	C	R	X
Paridae						
Carolina Chickadee	*Poecile carolinensis*	C	C	C	C	X
Tufted Titmouse	*Baeolophus bicolor*				V	
Black-crested Titmouse	*Baeolophus atricristatus*	C	C	C	C	X
Remizidae						
Verdin	*Auriparus flaviceps*	F	F	F	F	X
Aegithalidae						
Bushtit	*Psaltriparus minimus*	R	R	R	R	X
Sittidae						

Common Name	Scientific Name	Season				Breeding Habitat[1]
		Spring	Summer	Fall	Winter	
Red-breasted Nuthatch	*Sitta canadensis*	R		R	R	
White-breasted Nuthatch	*Sitta carolinensis*	V			R	
Certhidae						
Brown Creeper	*Certhia americana*	R		R	R	
Troglodytidae						
Cactus Wren	*Campylorhynchus brunneicapillus*	U	U	U	U	X
Rock Wren	*Salpinctes obsoletus*	R	R	R	R	X[3]
Canyon Wren	*Catherpes mexicanus*	U	U	U	U	X
Carolina Wren	*Thryothorus ludovicianus*	C	C	C	C	X
Bewick's Wren	*Thryomanes bewickii*	C	C	C	C	X
House Wren	*Troglodytes aedon*	C		C	C	
Winter Wren	*Troglodytes hiemalis*	R		R	R	
Sedge Wren	*Cistothorus platensis*			R	R	
Marsh Wren	*Cistothorus palustris*	F		F	F	
Polioptilidae						
Blue-gray Gnatcatcher	*Polioptila caerulea*	C	U	F	F	X
Black-tailed Gnatcatcher	*Polioptila melanura*	V		V	V	
Regulidae						
Golden-crowned Kinglet	*Regulus satrapa*	R		R	R	
Ruby-crowned Kinglet	*Regulus calendula*	C		C	C	
Turdidae						
Eastern Bluebird	*Sialia sialis*	U	R	U	F	X
Western Bluebird	*Sialia mexicana*			V	V	
Mountain Bluebird	*Sialia currucoides*	V			V	
Townsend's Solitaire	*Myadestes townsendi*	V			V	
Veery	*Catharus fuscescens*	R		V	V	
Gray-cheeked Thrush	*Catharus minimus*	R		V	V	
Swainson's Thrush	*Catharus ustulatus*	F	V	U	R	
Hermit Thrush	*Catharus guttatus*	F		F	F	
Wood Thrush	*Hylocichla mustelina*	U		U	R	
American Robin	*Turdus migratorius*	F	R	F	F	X
Mimidae						
Gray Catbird	*Dumetella carolinensis*	F		U	R	
Northern Mockingbird	*Mimus polyglottos*	C	C	C	C	X
Sage Thrasher	*Oreoscoptes montanus*	V		V	R	
Brown Thrasher	*Toxostoma rufum*	U		U	U	
Long-billed Thrasher	*Toxostoma longirostre*	F	F	F	F	X
Curve-billed Thrasher	*Toxostoma curvirostre*	F	F	F	F	X
Sturnidae						
European Starling[5]	*Sturnus vulgaris*	C	C	C	C	X
Motacillidae						
American Pipit	*Anthus rubescens*	C	V	F	C	
Sprague's Pipit	*Anthus spragueii*	R		V	U	
Bombycillidae						
Bohemian Waxwing[2]	*Bombycilla garrulous*				V	
Cedar Waxwing	*Bombycilla cedrorum*	C		R	C	

Common Name	Scientific Name	Season				Breeding Habitat[1]
		Spring	Summer	Fall	Winter	
Ptilogonatidae						
Phainopepla	*Phainopepla nitens*	V		V		X[3]
Calcariidae						
Lapland Longspur	*Calcarius lapponicus*				F	
Chestnut-collared Longspur	*Calcarius ornatus*	V		V	R	
Smith's Longspur[2]	*Calcarius pictus*				V	
McCown's Longspur[2]	*Rhynchophanes mccownii*	V		V	R	
Parulidae						
Ovenbird	*Seiurus aurocapilla*	U		R	V	
Worm-eating Warbler	*Helmitheros vermivorum*	R		V		
Louisiana Waterthrush	*Parkesia motacilla*	U	V	R		
Northern Waterthrush	*Parkesia noveboracensis*	F	V	R	V	
Golden-winged Warbler	*Vermivora chrysoptera*	R		V		
Blue-winged Warbler	*Vermivora cyanoptera*	R		V		
Black-and-white Warbler	*Mniotilta varia*	C	U	F	U	X
Prothonotory Warbler	*Protonotaria citrea*	U	R	V		
Swainson's Warbler[2]	*Limnothlypis swainsonii*	V				
Tennessee Warbler	*Oreothlypis peregrine*	U		R		
Orange-crowned Warbler	*Oreothlypis celata*	C		C	C	
Nashville Warbler	*Oreothlypis ruficapilla*	C		C	R	
Connecticut Warbler	*Oporornis agilis*	V		V		
MacGillivray's Warbler	*Geothlypis tolmiei*	U	V	R		
Mourning Warbler	*Geothlypis philadelphia*	U	R	R		
Kentucky Warbler	*Geothlypis formosa*	U	V	V	V	X[3]
Common Yellowthroat	*Geothlypis trichas*	C		C	C	
Hooded Warbler	*Setophaga citrina*	U		R	V	
American Redstart	*Setophaga ruticilla*	F	V	U	V	
Cape May Warbler	*Setophaga tigrina*	V		V		
Cerulean Warbler	*Setophaga cerulea*	R		V		
Northern Parula	*Setophaga americana*	U	V	V	V	X
Tropical Parula[2]	*Setophaga pitiayumi*		V			
Magnolia Warbler	*Setophaga magnolia*	C	V	R		
Bay-breasted Warbler	*Setophaga castanea*	U		R		
Blackburnian Warbler	*Setophaga fusca*	F	V	R		
Yellow Warbler	*Setophaga petechia*	F	V	F	V	X[3]
Chestnut-sided Warbler	*Setophaga pensylvanica*	U	V	R	V	
Blackpoll Warbler	*Setophaga striata*	R				
Black-throated Blue Warbler	*Setophaga caerulescens*	V		V	V	
Palm Warbler	*Setophaga palmarum*	V		R	R	
Pine Warbler	*Setophaga pinus*	R		R	U	
Yellow-rumped Warbler	*Setophaga coronata*	C		C	C	
Yellow-throated Warbler	*Setophaga dominica*	R		V	V	
Prairie Warbler	*Setophaga discolor*			V		
Black-throated Gray Warbler	*Setophaga nigrescens*	V		V	V	
Townsend's Warbler	*Setophaga townsendi*			V	V	
Golden-cheeked Warbler	*Setophaga chrysoparia*	F	F			X
Black-throated Green Warbler	*Setophaga virens*	C	V	F	R	
Rufous-capped Warbler[2]	*Basileuterus rufifrons*				V	

Common Name	Scientific Name	Season				Breeding Habitat[1]
		Spring	Summer	Fall	Winter	
Canada Warbler	*Cardellina canadensis*	U		R	V	
Wilson's Warbler	*Cardellina pusilla*	C	V	F	R	
Yellow-breasted Chat	*Icteria virens*	C	U	U	V	X
Emberizidae						
White-collared Seedeater[2]	*Sporophila torqueola*				V	
Olive Sparrow	*Arremonops rufivirgatus*	R	R	R	R	
Green-tailed Towhee	*Pipilo chlorurus*	R		R	R	
Spotted Towhee	*Pipilo maculatus*	C		C	C	
Eastern Towhee	*Pipilo erythrophthalmus*	R		R	U	
Rufous-crowned Sparrow	*Aimophila ruficeps*	F	F	F	U	X
Canyon Towhee[2]	*Melozone fusca*	R	R	R		X[3]
Cassin's Sparrow	*Peucaea cassinii*	F	R	R	R	X
American Tree Sparrow[2]	*Spizella arborea*				V	
Chipping Sparrow	*Spizella passerina*	C	R	U	C	X
Clay-colored Sparrow	*Spizella pallida*	F		F	R	
Field Sparrow	*Spizella pusilla*	C	R	U	C	X
Vesper Sparrow	*Pooecetes gramineus*	C		C	C	
Lark Sparrow	*Chondestes grammacus*	F	F	F	F	X
Black-throated Sparrow	*Amphispiza bilineata*	U	U	U	U	X[3]
Lark Bunting	*Calamospiza melanocorys*	R	V	R	U	
Savannah Sparrow	*Passerculus sandwichensis*	C	V	C	C	
Grasshopper Sparrow	*Ammodramus savannarum*	F	U	U	F	X
Baird's Sparrow	*Ammodramus bairdii*	V			V	
Henslow's Sparrow	*Ammodramus henslowii*	V			V	
Le Conte's Sparrow	*Ammodramus leconteii*	V		V	R	
Fox Sparrow	*Passerella iliaca*	R		R	U	
Song Sparrow	*Melospiza melodia*	F		F	C	
Lincoln's Sparrow	*Melospiza lincolnii*	C	V	C	C	
Swamp Sparrow	*Melospiza Georgiana*	U		U	F	
White-throated Sparrow	*Zonotrichia albicollis*	C		F	C	
Harris' Sparrow	*Zonotrichia querula*	R		R	U	
White-crowned Sparrow	*Zonotrichia leucophrys*	C		C	C	
Golden-crowned Sparrow[2]	*Zonotrichia atricapilla*				V	
Dark-eyed Junco	*Junco hyemalis*	U		R	U	
Cardinalidae						
Hepatic Tanager	*Piranga flava*	V	V	V	V	
Summer Tanager	*Piranga rubra*	F	F	U	R	
Scarlet Tanager	*Piranga olivacea*	U		V		
Western Tanager	*Piranga ludoviciana*	R		R	V	
Northern Cardinal	*Cardinalis cardinalis*	C	C	C	C	X
Pyrrhuloxia	*Cardinalis sinuatus*	F	F	F	F	X
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	U		R	V	
Black-headed Grosbeak	*Pheucticus melanocephalus*	R	V	R	R	
Blue Grosbeak	*Passerina caerulea*	C	F	U	V	X
Lazuli Bunting	*Passerina amoena*	R		V	V	
Indigo Bunting	*Passerina cyanea*	F	U	F	V	X
Varied Bunting[2]	*Passerina versicolor*	V				
Painted Bunting	*Passerina ciris*	C	C	U	V	X

Common Name	Scientific Name	Season				Breeding Habitat[1]
		Spring	Summer	Fall	Winter	
Dickcissel	*Spiza americana*	C	F	R	V	X
Icteridae						
Bobolink	*Dolichonyx oryzivorus*	V		V		
Red-winged Blackbird	*Agelaius phoeniceus*	C	C	C	C	X
Eastern Meadowlark	*Sturnella magna*	C	F	C	C	X
Western Meadowlark	*Sturnella neglecta*	R		R	F	
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	U	R	U	R	
Rusty Blackbird	*Euphagus carolinus*	R			R	
Brewer's Blackbird[4]	*Euphagus cyanocephalus*	U		U	C	
Common Grackle	*Quiscalus quiscula*	U	V	U	F	X[3]
Great-tailed Grackle	*Quiscalus mexicanus*	C	C	C	C	X
Bronzed Cowbird	*Molothrus aeneus*	U	U	U	R	X
Brown-headed Cowbird	*Molothrus ater*	C	C	C	C	X
Orchard Oriole	*Icterus spurious*	F	F	U		X
Hooded Oriole	*Icterus cucullatus*	R	R	R	V	
Bullock's Oriole	*Icterus bullockii*	C	C	U	R	X
Altamira Oriole	*Icterus gularis*		V	V	V	
Audubon's Oriole	*Icterus graduacauda*	V			V	
Baltimore Oriole	*Icterus galbula*	C	U	U	R	
Scott's Oriole	*Icterus parisorum*	R	R	R	V	X
Fringillidae						
Purple Finch	*Carpodacus purpureus*	R		R	R	
House Finch	*Carpodacus mexicanus*	C	C	C	C	X
Red Crossbill	*Loxia curvirostra*	V		V	V	
Pine Siskin	*Spinus pinus*	R		R	R	
Lesser Goldfinch	*Spinus psaltria*	U	U	U	U	X
American Goldfinch	*Spinus tristus*	C		C	C	
Evening Grosbeak	*Coccothraustes vespertinus*	V			V	
Passeridae						
House Sparrow[5]	*Passer domesticus*	C	C	C	C	X

C-Common; F-Fairly Common; U-Uncommon; R-Rare; V-Very Rare
[1]Documented breeding in Bexar County
[2]Status uncertain, siting not independently verified
[3]Historical breeding record
[4]Localized populations
[5]Non-native species

ATTACHMENT 2: TPWD SPECIES OF CONCERN

Species	Specific Epithet	Global/State Ranking	Blackland Prairies	Edwards Plateau	South Texas Plains
Mammals					
Pallid bat	*Antrozous pallidus*	G5/S5		X	X
Elliot's short-tailed shrew	*Blarina hylophaga plumblea*	G5T1Q/S1	X		
Nelson's pocket mouse	*Chaetodipus nelsoni*	G5/S?			X
Hog-nosed skunk	*Conepatus leuconotus*	G5/S4		X	X
Townsend's big-eared bat	*Corynorhinus townsendii*	G4T4/S3S4?		X	
Black-tailed prairie dog	*Cynomys ludovicianus*	G5T3/S3		X	
Ord's kangaroo rat	*Dipodomys ordii parvabullatus*	G5/S4			X
Big brown bat	*Eptesicus fuscus*	G5/S5		X	
Attwater's pocket gopher	*Geomys attwateri*	G4/S4	X		X
Texas pocket gopher	*Geomys personatus davisi*	G4T2/S2			X
Strecker's pocket gopher	*Geomys streckeri*	G4T1/S1			X
Frio pocket gopher	*Geomys texensis bakeri*	G2QT2/S2		X	X
Llano pocket gopher	*Geomys texensis texensis*	G3T2/S2		X	
Jaguarundi	*Herpailurus yaguarondi*	G4/S1			X
Southern yellow bat	*Lasiurus ega*	G5/S1			X
Ocelot	*Ocelot*	G4/S1			X
River Otter	*Lutra canadensis*	G5/S4	X	X	
Ghost-faced bat	*Mormoops megalophylla*	G4/S2		X	X
Long-tailed weasel	*Mustela frenata*	G5/S5	X	X	X
Black-footed ferret	*Mustela nigripes*	G1/SH		X	
Southeastern myotis	*Myotis austroriparius*	G3G4/S3	X		
Cave myotis	*Myotis velifer*	G5/S4	X	X	X
White-nosed coati	*Nasua narica*	G5/S2?		X	X
Mink	*Neovision vison*	G5/S4			X
Desert shrew	*Notiosorex crawfordii*	G5/S4			X
Big free-tailed bat	*Nyctinomops macrotis*	G5/S3			X
Coues rice rat	*Oryzomys couesi aquaticus*	G5T3?/S2			X
Canyon bat	*Parastrellus hesperus*	G5/S5		X	
Tricolored bat	*Perimyotis subflavus*	G5/S5		X	
Mountain lion	*Puma concolor*	G5/S2	X	X	X
Eastern mole	*Scalopus aquaticus*	G5/S5			X
Western spotted skunk	*Spilogale gracilis*	G5/S5		X	X
Eastern spotted skunk	*Spilogale putorius*	G4T/S4	X	X	X
Swamp rabbit	*Sylvilagus aquaticus*	G5/S5	X	X	
Brazilian free-tailed bat	*Tadarida brasiliensis*	G5/S5	X	X	X
American badger	*Taxidea taxus*	G5/S5	X	X	X
Black bear	*Ursus americanus*	G5/S3	X	X	
Swift fox	*Vulpes velox*	G3/S3?		X	
Birds					
Mottled Duck	*Anas fulvigula*	G4/S4B			X
Northern Pintail	*Anas acuta*	G5/S3B,S5N	X		X
Scaled Quail	*Callipepla squamata*	G5/S4B			X
Northern Bobwhite	*Colinus virginianus*	G5/S4B	X	X	X
Montezuma Quail	*Cyrtonyx montezumae*	G4G5/S3B		X	
Greater Prairie-chicken	*Tympanicus cupido*	G4/S1B	X		
Wild Turkey	*Meleagris gallopavo*	G5/S5B	X	X	X
Least Bittern	*Ixobrychus exilis*	G5/S4B	X		
Snowy Egret	*Egretta thula*	G5/S5B	X		
Little Blue Heron	*Egretta caerulea*	G5/S5B	X		
Green Heron	*Butorides virescens*	G5/S5B	X		
Wood Stork	*Mycteria americana*	G4/SHB,S2N	X		

Species	Specific Epithet	Global/State Ranking	Blackland Prairies	Edwards Plateau	South Texas Plains
Mississippi Kite	*Ictinia mississippiensis*	G5/S4B	X		
Hook-billed Kite	*Chondrohierax uncinatus*	G4/S2			X
Bald Eagle	*Haliaeetus leucocephalus*	G5/S3B,S3N	X		
Northern Harrier	*Circus cyaneus*	G5/S2B,S3N	X	X	X
Common Black-hawk	*Buteogallus anthracinus*	G4G5/S2B		X	X
Harris's Hawk	*Parabuteo unicinctus*	G5/S3B		X	X
Red-shouldered Hawk	*Buteo lineatus*	G5/S4B	X	X	X
Gray Hawk	*Buteo nitidus*	G5/S2B			X
Swainson's Hawk	*Buteo swainsoni*	G5/S4B			X
Zone-tailed Hawk	*Buteo albonotatus*	G4/S3B		X	
Golden Eagle	*Aquila chrysaetos*	G5/S3B		X	
American Golden-plover	*Pluvialis dominica*	G5,S3	X		
Mountain Plover	*Charadrius montanus*	G3/S2	X		X
American Woodcock	*Scolopax minor*	G5/S2B,S3N	X		
Least Tern	*Sternula antillarum*	G4/S3B	X		X
Green Parakeet	*Aratinga holochlora*	G3/S3			X
Red-crowned Parrot	*Amazona viridigenalis*	G2/S2			X
Ferruginous Pygmy-owl	*Glaucidium brasilianum*	G5/S3B			X
Burrowing Owl	*Athene cunicularia*	G4/S3B			X
Short-eared Owl	*Asio flammeus*	G5/S4N	X		
Chuck-will's-widow	*Caprimulgus carolinensis*	G5/S3S4B	X	X	
Red-headed Woodpecker	*Melanerpes erythrocephalus*	G5/S3B	X		
Pileated Woodpecker	*Dryocopus pileatus*	G5/S4B	X		
Northern Beardless-tyrannulet	*Camptostoma imberbe*	G5/S3B			X
Scissor-tailed Flycatcher	*Tyrannus forficatus*	G5/S3B	X	X	X
Loggerhead Shrike	*Lanius ludovicianus*	G4/S4B	X	X	X
Bell's Vireo	*Vireo bellii*	G5/S3B	X	X	X
Black-capped Vireo	*Vireo atricapilla*	G3/S2B		X	
Carolina Chickadee	*Poecile carolinensis*	G5/S5B	X	X	
Bewick's Wren	*Thryomanes bewickii*	G5/S5B	X		
Sedge Wren	*Cistothorus platensis*	G5/S4	X		
Wood Thrush	*Hylocichla mustelina*	G5/S4B	X		
Sprague's Pipet	*Anthus spragueii*	G4/S3N	X	X	X
Tropical Parula	*Parula pitiayumi*	G5/S3B		X	X
Golden-cheeked Warbler	*Dendroica chrysoparia*	G2/S2B		X	
Yellow-throated Warbler	*Dendroica dominica*	G5/S4B	X	X	
Prothonotory Warbler	*Protonotaria citrea*	G5/S5B	X		
Swainson's Warbler	*Limnothlypis swainsonii*	G5/S4	X		
Louisiana Waterthrush	*Seiurus motacilla*	G5/S4B	X	X	
Kentucky Warbler	*Oporornis formosus*	G5/S3B	X		
Cassin's Sparrow	*Aimophila cassinii*	G5/S4B		X	X
Rufous-crowned Sparrow	*Aimophila ruficeps*	G5/S4B		X	
Field Sparrow	*Spizella pusilla*	G5/S5B	X	X	
Grasshopper Sparrow	*Ammodramus savannarum*	G5/S3B	X	X	X
Lark Sparrow	*Chondestes grammacus*	G5/S4B	X	X	X
Henslow's Sparrow	*Ammodramus henslowii*	G4/S2S3N,SXB	X		
Le Conte's Sparrow	*Ammodramus leconteii*	X	X	X	
Harris's Sparrow	*Zonotricha querula*	G5S4	X	X	
McCown's Longspur	*Calcarius mccownii*	G5/S4	X		
Smith's Longspur	*Calcarius pictus*	X	X		
Summer Tanager	*Piranga rubra*	G5/S5B	X	X	X

Species	Specific Epithet	Global/State Ranking	Blackland Prairies	Edwards Plateau	South Texas Plains
Painted Bunting	*Passerina ciris*	G5/S4B	X	X	X
Dickcissel	*Spiza americana*	G5/S4B	X	X	X
Eastern Meadowlark	*Sturnella magna*	G5/S5B	X	X	X
Rusty Blackbird	*Euphagus carolinus*	G4/S3	X		
Orchard Oriole	*Icterus spurious*	G5S4B	X	X	X
Amphibians & Reptiles					
Woodhouse's toad	*Anaxyrus woodhousii*	G5/SU	X	X	
Smooth softshell turtle	*Apalone mutica*	X	X	X	
Spiny softshell turtle	*Apalone spinifera*	X	X	X	X
Common snapping turtle	*Cheylydra serpentine*	X	X	X	
Black-striped snake	*Coniophanes imperialis*				X
Western diamondback rattlesnake	*Crotalus atrox*	S4	X	X	X
Timber rattlesnake	*Crotalus horridus*	G4/S4	X		
Reticulate collared lizard	*Crotaphytus reticulatus*	G3/S2			X
Texas indigo snake	*Drymarchon melanurus erebennus*	G4/S3		X	X
Cascade Caverns salamander	*Eurycea latitans*	G3/S1		X	
San Marcos salamander	*Eurycea nana*	G1/S1		X	
Georgetown salamader	*Eurycea naufragia*	G1/S1		X	
Texas salamander	*Eurycea neotenes*	G1/S2		X	
Blanco River Springs salamander	*Eurycea pterophila*	G2/S2		X	
Texas blind salamander	*Eurycea rathbuni*	G1/S1		X	
Blanco blind salamander	*Eurycea robusta*	G1Q/S1		X	
Barton Springs salamander	*Eurycea sosorum*	G1/S1		X	
Jollyville Plateau salamander	*Eurycea tonkawae*	G1/S2S3		X	
Comal blind salamander	*Eurycea tridentifera*	G1/S1		X	
Austin blind salamander	*Eurycea waterlooensis*	G1/S1		X	
Texas tortoise	*Gopherus berlandieri*	G4/S2*		X	X
Cagle's map turtle	*Graptemys caglei*	G3/S1	X	X	
Texas map turtle	*Graptemys versa*	G4/SU	X	X	
Western hognosed snake	*Heterodon nasicus*	X	X	X	X
Plateau earless lizard	*Holbrookia lacerata lacerata*	S2		X	
Southern earless lizard	*Holbrookia lacerata subcaudalis*	X			X
Northern earless lizard	*Holbrookia propinqua propinqua*	SX			X
Sheep frog	*Hypopachus variolosus*	G5/S2			X
White-lipped frog	*Leptodactylus variolosus*	G5/S1			X
Northern cat-eyed snake	*Leptodeira septentrionalis septentrionalis*	G5T5/S2			X
Concho water snake	*Nerodia paucimaculata*	G2/S2		X	
Black-spotted newt	*Notophthalmus meridionalis*	G1/S1 or S2?			X
Alligator snapping turtle	*Macrochelys temminckii*	G3G4/S3	X		
Western slender glass lizard	*Ophisaurus attenuates*	X	X	X	
Texas horned lizard	*Phrynosoma cornutum*	G4G5/S4	X	X	X
Strecker's chorus frog	*Pseudacris streckeri*	G5/S3	X	X	
Rio Grande cooter	*Pseudemys gorzugi*	S2			X
Texas blind snake	*Rena dulcis*	X			X

Species	Specific Epithet	Global/State Ranking	Blackland Prairies	Edwards Plateau	South Texas Plains
Mexican burrowing toad	*Rhinophrynus dorsalis*	G5/S2			X
Rio Grande siren (large form)	*Siren sp.*	GNRQ/S2			X
Massasagua	*Sistrurus catenatus*	X	X	X	X
Mexican blackhead snake	*Tantilla atriceps*	X			X
Eastern box turtle	*Terrapene carolina*	G5/S3	X	X	
Ornate box turtle	*Terrapene ornate*	G5/S3	X	X	X
Texas garter snake	*Thamnophis sirtalis annectans*	G5/S2	X	X	
Red-eared slider	*Trachemys scripta*	X	X	X	X
Freshwater Fishes					
American eel	*Anguilla rostrata*	G4/S5	X	X	X
Alligator gar	*Atractosteus spatula*	X	X		X
Blue sucker	*Cycleptus elongates*	G3G4/S3	X		
Rio Grande blue sucker	*Cycleptus sp.*	X			X
Plateau shiner	*Cyprinella lepida*	G1G2/S1S2		X	X
Proserpine shiner	*Cyprinella proserpina*	G3/S2		X	X
Nueces River shiner	*Cyprinella sp.*	G1G2Q/S1S2		X	X
Devils River pupfish	*Cyprinodon eximius ssp.*	X		X	X
Manantial roundnose minnow	*Dionda argentosa*	G2/S2		X	X
Devil's River minnow	*Dionda diaboli*	G1/S1		X	X
Guadalupe roundnose minnow	*Dionda nigrotaeniata*	G4/S4		X	
Nueces roundnose minnow	*Dionda serena*	G2/S2		X	X
Fountain darter	*Etheostoma fonticola*	G1/S1	X		
Rio Grande darter	*Etheostoma grahami*	G2G3/S2		X	X
San Felipe gambusia	*Gambusia clarkhubbsi*	G1/S1			X
Clear Creek gambusia	*Gambusia heterochir*	G1/S1		X	
Blotched gambusia	*Gambusia senilis*	G3G4/SX			X
Rio Grande silvery minnow	*Hybognathus amarus*	G1G2/SX			X
Headwater catfish	*Ictalurus lupus*	G3/S2		X	X
Silver chub	*Macryhbopsis storeriana*	X	X		
Guadalupe bass	*Micropterus treculii*	G3/S3	X	X	
Texas shiner	*Notropis amarus*	X			X
Blackspot shiner	*Notropis atrocaudalis*	X	X		
Red River shiner	*Notropis bairdi*	X	X		
Tamaulipas shiner	*Notropis braytoni*	X			X
Small-eye shiner	*Notropis buccula*	G2Q/S2	X		
Ironcolor shiner	*Notropis chalybaeus*	X	X		
Rio Grande shiner	*Notropis jemezanus*	X			X
Sharpnose shiner	*Notropis oxyrhynchus*	G3/S3	X		
Chub shiner	*Notropis potteri*	G4/S3	X		
Silverband shiner	*Notropis shumardi*	X	X		
Guadalupe darter	*Percina apristis*	X	X	X	
Paddlefish	*Polyodon spathula*	G4/S3	X		
Longnose dace	*Rhinichthys cataractae*	X			X
Widemouth blindcat	*Satan eurystomus*	G1/S1	X		
Toothless blindcat	*Trogloglanis pattersoni*	G1/S1	X		
Invertebrates					
A cave obligate amphipod	*Allotexiweckelia hirsuta*	G2G3/S2?*		X	
An aquatic mite	*Almuerzothyas n. sp.*	G1*/S1*		X	
A katydid	*Amblycorypha uhleri*	G2G3*/S2?*		X	
A mining bee	*Andrena scotoptera*	G1*S1*			X
Rio Grande gold	*Aphonopelma moderatum*	G2G3*/S2?*			X

Species	Specific Epithet	Global/State Ranking	Blackland Prairies	Edwards Plateau	South Texas Plains
tarantula					
A cave obligate pseudoscorpion	*Apocheiridium reddelli*	G1G2/S1*		X	
A katydid	*Arethaea ambulator*	G2G3*/S2?*		X	
Rio Grande thread-legged katydid	*Arethaea phantasma*	G2?*/S2?*			X
Golden-winged dancer	*Argia rhoadsi*	G2G3/S2?*		X	
An aquatic mite	*Arrenurus n. sp.*	XG1*/S1*		X	
A cave obligate amphipod	*Artesia subterranean*	G1G2/S1?*		X	
Texas Austrotinodes caddisfly	*Austrotinodes texensis*	G2/S2		X	X
A mayfly	*Baetodes alleni*	G1G2/S1?*		X	
Balcones ghostsnail	*Balconorbis uvaldensis*	G1G2/S1*		X	
A cave obligate beetle	*Batrisodes cryptotexanus*	G1G2/S1*		X	
A cave obligate beetle	*Batrisodes dentifrons*	G2*/S1*		X	
A cave obligate beetle	*Batrisodes fanti*	G1G2*/S1*		X	
A cave obligate beetle	*Batrisodes feminiclypeus*	G1G2*/S1*		X	
A cave obligate beetle	*Batrisodes gravesi*	G2*/S2*		X	
A cave obligate beetle	*Batrisodes grubbsi*	G1G2/S1*		X	
A cave obligate beetle	*Batrisodes incisipes*	G1G2*/S1*		X	
A cave obligate beetle	*Batrisodes pekinsi*	G1G2*/S1*		X	
A cave obligate beetle	*Batrisodes reyesi*	G2G3/S2*		X	
A cave obligate beetle	*Batrisodes shadeae*	G1G2*/S1*		X	
A cave obligate beetle	*Batrisodes texanus*	G1G2/S1		X	
A cave obligate beetle	*Batrisodes venyivi*	G1G2/S1		X	
A cave obligate beetle	*Batrisodes wartoni*	G1G2*/S1		X	
American bumblebee	*Bombus pensylvanicus*	GU/SU*	X	X	X
Sonoran bumblebee	*Bombus sonorus*	GU/SU*		X	X
Variable cuckoo bumblebee	*Bombus variabilis*	GU/SU*		X	
A cave obligate isopod	*Brackenridgia reddelli*	G2G3/S2?*		X	
A mayfly	*Caenis arwini*	G1G3/S2?*		X	X
A cave obligate shrimp	*Calathaemon holthuisi*	G1G2/S1?*		X	
Holzenthal's Philopotamid caddisfly	*Chimarra holzenthali*	G1G2/S1	X		
A cave obligate pseudoscorpion	*Chitrella elliotti*	G1G2/S1*		X	
A cave obligate spider	*Cicurina bandera*	G2G3/S2*		X	
Bandit Cave spider	*Cicurina bandida*	G1G2/S1		X	
Robber Baron Cave meshweaver	*Cicurina baronia*	G1G2/S1		X	
A cave obligate spider	*Cicurina barri*	G1G2/S1*		X	
A cave obligate spider	*Cicurina browni*	G1G2/S1*		X	
A cave obligate spider	*Cicurina caliga*	G1G2*/S1*		X	
A cave obligate spider	*Cicurina cavern*	G1G2/S1*		X	
A cave obligate spider	*Cicurina coryelli*	G1G2/S1*		X	
A cave obligate spider	*Cicurina elliotti*	G2G3/S2*		X	
A cave obligate spider	*Cicurina ezelli*	G1G2/S1*		X	
A cave obligate spider	*Cicurina gruta*	G1G2/S1*		X	
A cave obligate spider	*Cicurina holsingeri*	G1G2/S1*		X	
A cave obligate spider	*Cicurina hoodensis*	G1G2*/S1*		X	
A cave obligate spider	*Cicurina machete*	G1G2/S1*		X	
Madla Cave meshweaver	*Cicurina madla*	G1G2/S1		X	
A cave obligate spider	*Cicurina mckenziei*	G1G2/S1*		X	
A cave obligate spider	*Cicurina medina*	G1G2/S1*		X	
A cave obligate spider	*Cicurina menardia*	G1G2/S1*		X	
A cave obligate spider	*Cicurina mixmaster*	G1G2*/S1*		X	

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A cave obligate spider	*Cicurina obscura*	G1G2/S1*		X	
A cave obligate spider	*Cicurina orellia*	G1G2/S1*		X	
A cave obligate spider	*Cicurina pablo*	G1G2/S1*		X	
A cave obligate spider	*Cicurina pastura*	G1G2/S1*		X	
A cave obligate spider	*Cicurina patei*	G1G2/S1*		X	
A cave obligate spider	*Cicurina porter*	G1G2/S1*		X	
A cave obligate spider	*Cicurina puentecilla*	G1G2/S1*		X	
A cave obligate spider	*Cicurina rainesi*	G1G2/S1*		X	
A cave obligate spider	*Cicurina reclusa*	G1G2/S1*		X	
A cave obligate spider	*Cicurina reddelli*	G1G2/S1*		X	
A cave obligate spider	*Cicurina russelli*	G1G2/S1*		X	
A cave obligate spider	*Cicurina sansaba*	G1G2/S1*		X	
A cave obligate spider	*Cicurina selecta*	G1G2/S1*		X	
A cave obligate spider	*Cicurina serena*	G1G2/S1*		X	
A cave obligate spider	*Cicurina sheari*	G1G2/S1*		X	
A cave obligate spider	*Cicurina sprousei*	G1G2/S1*		X	
A cave obligate spider	*Cicurina stowersi*	G1G2/S1*		X	
A cave obligate spider	*Cicurina suttoni*	G1G2/S1*		X	
A cave obligate spider	*Cicurina travisae*	G1G2/S1*		X	
A cave obligate spider	*Cicurina troglobia*	G1G2/S1*		X	
A cave obligate spider	*Cicurina ubicki*	G1G2/S1*		X	
A cave obligate spider	*Cicurina uvalde*	G1G2/S1*		X	
A cave obligate spider	*Cicurina venefica*	G1G2/S1*		X	
Braken Canyon Bat Cave meshweaver	*Cicurina venii*	G1G2/S1		X	
Government Canyon Bat Cave meshweaver	*Cicurina vespera*	G1G2/S1		X	
A cave obligate spider	*Cicurina vibora*	G1G2/S1*		X	
Warton Cave meshweaver	*Cicurina wartoni*	G1/S1		X	
A cave obligate spider	*Cicurina waters*	G1G2/S1*		X	
Cazier's tiger beetle	*Cincindela cazieri*	G2/S2		X	
A bee	*Coelioxys piercei*	G1*/S1*		X	
A lichen moth	*Cisthene conjuncta*	G1Q/S1Q*		X	
A cellophane bee	*Colletes bumeliae*	G1*/S1*		X	
A cellophane bee	*Colletes saritensis*	G1*/S1*		X	
Comal Springs diving beetle	*Comaldessus stygius*	G1/S1		X	
Brownsville meadow katydid	*Conocephalus resacensis*	G2?*/S2?*			X
A scarab beetle	*Cotinus boylei*	G2*/S2*	X		
Horseshoe liptooth	*Daedalochila hippocrepis*	G1/S1		X	
Percosius skipper	*Decinea percosius*	G1G3/S1S3*			X
Acacia fairy shrimp	*Dendrocephalus acacioidea*	G1/S1*			X
A katydid	*Dichopetala catinata*	G1?*/S1?*		X	
Gladiator short-winged katydid	*Dichopetala gladiator*	G2?*/S2?*			X
A katydid	*Dichopetala seeversi*	G1*/S1*		X	
A cave obligate pseudoscorpion	*Dinocheirus cavicolus*	G2G3/S2*		X	
A cave obligate spider	*Eidmennella nastuta*	G2G3/S2*		X	
A cave obligate spider	*Eidmennella reclusa*	G1G2/S1*		X	
A cave obligate copepod	*Elaphoidella n. sp.*	G1*/S1*		X	
Glossy wolfsnail	*Euglandina texasiana*	G1G2/S1S2*			X
Tamaulipan clubtail	*Gomphus gonzalezi*	G2/S2*			X
Edwards Aquifer diving beetle	*Haideoporus texanus*	G1G2/S1		X	
Comal Springs riffle	*Heterelmis comalensis*	G1/S1		X	

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beetle					
Fern Bank Springs riffle beetle	*Heterelmis sp.*	G1*/S1*		X	
Fessenden Springs riffle beetle	*Heterelmis sp.*	G1*/S1*		X	
Devils River Springs riffle beetle	*Heterelmis sp.*	G1*/S1*		X	X
A cuckoo bee	*Holcopasites jerryozeni*	G1*/S1*		X	
New Braunfels Holospira	*Holospira goldfussi*	G2G3/S2?*		X	
A cave obligate amphipod	*Holsingerius samacos*	G1G2/S1?*		X	
Clear Creek amphipod	*Hyalella texana*	G1/S1		X	
A caddisfly	*Hydroptila melia*	G2G3/S2?*		X	
A cave obligate amphipod	*Ingofiella n. sp.*	G1G2*/S1*		X	
Texas fatmucket	*Lampsilis bracteata*	G1/S1*		X	
A mayfly	*Latineosus cibola*	G1G2/S1?*			X
A cave obligate pseudoscorpion	*Leucohya texana*	G1G2/S1*		X	
A cave obligate isopod	*Lirceolus bisetus*	G1G2/S1*		X	
A cave obligate isopod	*Lirceolus hardeni*	G2G3/S2?*		X	
A cave obligate isopod	*Lirceolus pilus*	G2G3/S2?		X	
Texas troglobitic water slater	*Lirceolus smithii*	G1G2/S1		X	
A cave obligate beetle	*Lymantes nadineae*	G1*/S1*		X	
A mining bee	*Macrotera parkeri*	G1G2*/S1S2 *		X	
A mining bee	*Macrotera robertsi*	G1*/S1*		X	
Comal siltsnail	*Marstonia comalensis*	G1/S1		X	
A leaf-cutting beetle	*Megachile parksi*	G1*/S1*			X
A cave obligate isopod	*Mexistenasellus coahuila*	G2G3/S2?*		X	
A cave obligate amphipod	*Mexiweckelia hardeni*	G2G3/S2?*		X	
Texas angle-wing	*Microcentrum minus*	G1?*/S1?*			X
Texas urocoptid	*Microceramus texanus*	G2/S2*		X	
Edwards Plateau liptooth	*Millerelix gracilis*	G2G3/S2?*		X	
A narrow-waisted bark beetle	*Myrmecoderus laevipennis*	G1*/S1*		X	
A caddisfly	*Nectopsyche texana*	G1G3/S2?*		X	
Texas minute moss beetle	*Neocylloepus boeseli*	G1G2*/S1*			X
A cave obligate spider	*Neoleptoneta anopica*	G1G2/S1*		X	
A cave obligate spider	*Neoleptoneta bullis*	G1G2*/S1*		X	
A cave obligate spider	*Neoleptoneta concinna*	G1G2/S1*		X	
A cave obligate spider	*Neoleptoneta devia*	G1G2/S1*		X	
Government Canyon Bat Cave spider	*Neoleptoneta microps*	G1G2/S1		X	
Tooth Cave spider	*Neoleptoneta myopica*	G1G2/S1		X	
A cave obligate spider	*Neoleptoneta valverde*	G1G2/S1*		X	
A caddisfly	*Neotrichia juani*	G1/S1*		X	
American burying beetle	*Nicrophorus americanus*	G1/S1	X		
A cave obligate copepod	*Nitocrellopsis texana*	G1*/S1*		X	
A cave obligate springtail	*Oncopodura fenestra*	G2G3/S2?*		X	
A snout moth	*Oxyelophila callista*	G1?*/S1?*		X	

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A caddisfly	*Oxyethira ulmeri*	G2G3/S2?*		X	
A cave obligate shrimp	*Palaemonetes antrorum*	G2G3/S2?*		X	
Texas river shrimp	*Palaemonetes texanaus*	G1G2*/S1?*		X	
A cave obligate amphipod	*Parabogidiella americana*	G2G3/S2?*		X	
A cave obligate amphipod	*Paraholsingerius smaragdinus*	G2G3/S2?*		X	
Pointytop finger clam shrimp	*Paralimnetis texana*	G1/S1*		X	
A cave obligate amphipod	*Paramexiweckelia ruffoi*	G1G2/S1?*		X	
Pedernales oval	*Patera leatherwoodi*	G1/S1*		X	
Daedelus sheildback katydid	*Pediodectes daedelus*	G1?*/S1?*			X
Mitchell's shieldback katydid	*Pediodectes mitchelli*	G1?*/S1?*			X
Pratt's shieldback katydid	*Pediodectes pratti*	G1?*/S1?*			X
A mining bee	*Perdita dolanensis*	G1*/S1*		X	
A mining bee	*Perdita fraticincta*	G1*/S1*			X
A mining bee	*Perdita tricincta*	G1*/S1*			X
A snout moth	*Petrophila daemonalis*	G1?*/S1?*		X	
Hueco cavesnail	*Phreatodrobia conica*	G1/S1*		X	
Mimic cavesnail	*Phreatodrobia imitata*	G1/S1		X	
Flattened cavesnail	*Phreatodrobia micra*	G2G3/S2S3		X	
Nymph trumpet	*Phreatodrobia nugax*	G1G2/S1*		X	
Disc cavesnail	*Phreatodrobia plana*	G2/S2*		X	
High-hat cavesnail	*Phreatodrobia punctata*	G2/S2*		X	
Beaked cavesnail	*Phreatodrobia rotunda*	G1G2/S1*		X	
A mayfly	*Plauditus texanus*	G2G3/S1?*		X	
Comanche harvester ant	*Pogonomyrmex comanche*	G2G3*/S2*		X	
Texas hornshell	*Popenaias popeii*	G1/S1			X
Texas heelsplitter	*Potamilus amphichaenus*	G1G2/S1	X		
Salina mucket	*Potamilus metnecktayi*	G1/S1			X
White scrubsnail	*Praticolella candida*	G2/S2*			X
Hidalgo scrubsnail	*Praticolella trimatris*	G2/S2*			X
Nueces crayfish	*Procambarus nueces*	G1/S1			X
Regal burrowing crayfish	*Procambarus regalis*	G2G3/S2?*	X		
Parkhill prairie crayfish	*Procambarus steigmani*	G1G2/S1S2*	X		
A mayfly	*Procloeon distinctum*	G1G3/S2?*		X	
A mining bee	*Protandrena maurula*	G1G2*/S1S2*		X	
A caddisfly	*Protoptila arca*	G1/S1		X	
A mayfly	*Pseudocentroptiloides morihari*	G2G3/S2?*	X		
A tiger moth	*Pygarctia lorula*	G2G3/S2?*		X	
Golden orb	*Quadrula aurea*	G1/S2*		X	X
Smooth pimpleback	*Quadrula houstonensis*	G2/S1S2*		X	
False spike	*Quadrula mitchelli*	GH/SH		X	
Texas pimpleback	*Quadrula petrina*	G2/S1*		X	
A cave obligate beetle	*Rhadine austinica*	G1G2/S1*		X	
A cave obligate beetle	*Rhadine bullis*	G2*/S2		X	
A cave obligate beetle	*Rhadine exilis*	G1/S1		X	
A cave obligate beetle	*Rhadine infernalis*	G2G3/S1		X	
A cave obligate beetle	*Rhadine insolata*	G1G2/S1*		X	
A cave obligate beetle	*Rhadine noctivaga*	G1G2/S1*		X	
A cave obligate beetle	*Rhadine persephone*	G1G2/S1		X	
A cave obligate beetle	*Rhadine reyesi*	G1G2*/S1S2*		X	

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A cave obligate beetle	*Rhadine russelli*	G1G2/S1*		X	
A cave obligate beetle	*Rhadine speca*	G2*/S2*		X	
A cave obligate beetle	*Rhadine subterranea*	G2*/S2*		X	
A cave obligate amphipod	*Seborgia relicta*	G2G3/S2?*		X	
A cave obligate isopod	*Speocirolana hardeni*	G2G3/S2?*		X	
A cave obligate millipede	*Speodesmus echinourus*	G2G3/S2?*		X	
A cave obligate millipede	*Speodesmus falcatus*	G2*/S2*		X	
A cave obligate millipede	*Speodesmus ivyi*	G2*/S2*		X	
A cave obligate millipede	*Speodesmus reddelli*	G2*/S2*		X	
Sage sphinx	*Sphinx eremitoides*	G1G2/S1?*	X	X	
Manfreda giant-skipper	*Stallingsia maculosus*	G1G2/S1S2			X
Spinyfinger fairy shrimp	*Streptocephalus linderi*	G2/S2*		X	
A cave obligate amphipod	*Stygobromus balconis*	G2G3/S1		X	
Cascade Cave amphipod	*Stygobromus dejectus*	G1G2/S1		X	
Ezell's Cave amphipod	*Stygobromus flagellatus*	G2G3/S1		X	
Devil's Sinkhole amphipod	*Stygobromus hadenoecus*	G1G2/S1		X	
Border Cave amphipod	*Stygobromus limbus*	G1G2/S1*		X	
Long-legged Cave amphipod	*Stygobromus longipes*	G2G3/S1		X	
Neel's Cave amphipod	*Stygobromus n. sp.*	G1G2*/S1*		X	
Devil's River Cave amphipod	*Stygobromus n. sp.*	G1G2*/S1*		X	
Fessenden Cave amphipod	*Stygobromus n. sp.*	G1G2*/S1*		X	
Lost Maples Cave amphipod	*Stygobromus n. sp.*	G1G2*/S1*		X	
San Gabriel Cave amphipod	*Stygobromus n. sp.*	G1G2*/S1*		X	
Peck's Cave amphipod	*Stygobromus pecki*	G1G2/S1		X	
Reddell stygobromid	*Stygobromus reddelli*	G1G2/S1		X	
A cave obligate amphipod	*Stygobromus russelli*	G1G2*/S1*		X	
Comal Springs dryopid beetle	*Stygopamus comalensis*	G1G2/S1		X	
Barton cavesnail	*Stygopyrgus bartonensis*	G1/S1		X	
A mayfly	*Susperatus tonkawa*	G1/S1*	X		
A cave obligate pseudoscorpion	*Tartarocreagris altimana*	G1G2*/S1*		X	
A cave obligate pseudoscorpion	*Tartarocreagris amblyopa*	G1G2*/S1*		X	
A cave obligate pseudoscorpion	*Tartarocreagris attenuata*	G1G2*/S1*		X	
A cave obligate pseudoscorpion	*Tartarocreagris domina*	G1G2*/S1*		X	
A cave obligate pseudoscorpion	*Tartarocreagris grubbsi*	G1G2*/S1*		X	
A cave obligate pseudoscorpion	*Tartarocreagris hoodensis*	G1G2*/S1*		X	
A cave obligate pseudoscorpion	*Tartarocreagris infernalis*	G2G3/S2?*		X	

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A cave obligate pseudoscorpion	*Tartarocreagris intermedia*	G1G2/S1*		X	
A cave obligate pseudoscorpion	*Tartarocreagris proserpina*	G1G2*/S1*		X	
A cave obligate pseudoscorpion	*Tartarocreagris reddelli*	G1G2*/S1*		X	
A cave obligate pseudoscorpion	*Tartarocreagris reyesi*	G1G2*/S1*		X	
Tooth Cave pseudoscorpion	*Tartarocreagris texana*	G1G2/S1		X	
A cave obligate crustacean	*Tethysbaena texana*	G2G3/S2?*		X	
Kretschmarr Cave mold beetle	*Texamaurops reddelli*	G2G3/S1		X	
A bathynellid	*Texanobathynella bowmani*	G2G3/S2?*		X	
Striated hydrobe	*Texapyrgus longleyi*	G1/S1		X	
A cave obligate harvestman	*Texella brevidenta*	G1G2/S1*		X	
A cave obligate harvestman	*Texella brevistyla*	G1G2/S1*		X	
Cokendolpher Cave harvestman	*Texella cokendolpheri*	G1G2/S1		X	
A cave obligate harvestman	*Texella diplospina*	G1G2/S1*		X	
A cave obligate harvestman	*Texella grubbsi*	G1G2/S1*		X	
A cave obligate harvestman	*Texella hardeni*	G1G2/S1*		X	
A cave obligate harvestman	*Texella mulaiki*	G2G3/S2*		X	
Reddell harvestman	*Texella reddelli*	G2G3/S2*		X	
A cave obligate harvestman	*Texella renkesae*	G1G2/S1*		X	
Bone Cave harvestman	*Texella reyesi*	G2G3/S2*		X	
A cave obligate harvestman	*Texella spinoperca*	G1G2*/S1*		X	
A cave obligate amphipod	*Texiweckelia texensis*	G2G3/S2?*		X	
Texas fawnsfoot	*Truncilla macrodon*	G2Q/S1*		X	
A cave obligate pseudoscorpion	*Tyrannochthonius muchmoreorum*	X		X	
A cave obligate pseudoscorpion	*Tyrannochthonius troglodytes*	G1G2/S1*		X	
A caddisfly	*Xiphocentron messapus*	G1G3/S2?*		X	
Plants					
Texas trumpets	*Acleisanthes crassifolia*	G2/S2			X
Wright's trumpets	*Acleisanthes wrightii*	G2/S2			X
Vasey's adelia	*Adelia vaseyi*	G3/S3			X
Osage Plains false foxglove	*Agalinis densiflora*	G3/S2	X	X	
Texas amorpha	*Amorpha roemeriana*	G3/S3		X	
Silvery wild-mercury	*Argythamnia argyraea*	G2/S2			X
Prostrate milkweed	*Asclepias prostrata*	G1G2/S1S2			X
Cory's woolly locoweed	*Astragalus mollissimus var. coryi*	G5T3/S3		X	
Texas milkvetch	*Astragalus reflexus*	G3/S3	X	X	X
Wright's milkvetch	*Astragalus wrightii*	G3/S3		X	
Star cactus	*Astrophytum asterias*	G2/S1S2			X
Kleberg saltbush	*Atriplex klebergorum*	G2/S2			X

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Anacacho orchid	*Bauhinia lunarioides*	G3/S1		X	X
Texas barberry	*Berberis swaseyi*	G3/S3		X	
Enquist's sandmint	*Brazoria enquistii*	G2/S2		X	
Gravelbar brickellbush	*Brickellia dentata*	G3G4/S3S4		X	
Narrowleaf brickellbush	*Brickellia eupatorioides var. gracillima*	G5T3/S3		X	
South Texas rushpea	*Caesalpinia phyllanthoides*	G2/S1			X
Two-flower stick-pea	*Calliandra biflora*	G3/S3			X
Oklahoma grass pink	*Calopogon oklahomensis*	G3/S1S2	X		
Basin bellflower	*Campanula reverchonii*	G2/S2		X	
Texas largeseed bittercress	*Cardamine macrocarpa var. texana*	G3T2/S2		X	
Chihuahuan balloon-vine	*Cardiospermum dissectum*	G2G3/S3			X
Canyon sedge	*Carex edwardsiana*	G3G4/S3S4	X	X	
Shinner's sedge	*Carex shinnersii*	G3?/S2	X		
Spreading leastdaisy	*Chaetopappa effusa*	G3G4/S3S4		X	
Scarlet leather-flower	*Clematis texensis*	G3G4/S3S4		X	
Comal snakewood	*Colubrina stricta*	G2/S1		X	
Crown tickseed	*Coreopsis nuecensis*	G3/S3			X
Runyon's cory cactus	*Coryphantha macromeris var. runyonii*	G5T2T3/S2S3			X
Nickel's cory cactus	*Coryphantha nickelsiae*	G2/SH			X
Dallas hawthorn	*Crataegus dallasiana*	G3Q/S3	X		
Turners' hawthorn	*Crataegus turnerorum*	G3Q/S3		X	
Texabama croton	*Croton alabamensis var. texensis*	G3T2/S2		X	
Tree dodder	*Cuscuta exaltata*	G3/S3	X	X	X
Hall's prairie-clover	*Dalea hallii*	G3/S3	X	X	
Sabinal prairie-clover	*Dalea sabinalis*	GH/SH		X	
Net-leaf bundleflower	*Desmanthus reticulates*	G3/S3		X	X
Lindheimer's tickseed	*Desmodium lindheimeri*	G3G4/S1		X	
Don Richard's spring moss	*Donrichardsia macroneuron*	G1/S1		X	
Topeka purple-coneflower	*Echinacea atrorubens*	G3/S3	X		
Texas claret-cup cactus	*Echinocereus coccineus var. paucispinus*	G5T3/S3		X	
Yellow-flowered alicoche	*Echinocereus papillosus*	G3/S3			X
Fitch's hedgehog cactus	*Echinocereus reichenbachii ssp. fitchii*	G5T3/S3			X
Black lace cactus	*Echinocereus reichenbachii var. albertii*	G5T1Q/S1			X
Cory's ephedra	*Ephedra coryi*	G3/S3		X	
Small-headed pipewort	*Eriocaulon koernickianum*	G2/S1		X	
Gregg's wild-buckwheat	*Eriogonum greggii*				X
Irion County wild-buckwheat	*Eriogonum nealleyi*	G2/S2		X	
Basin wild-buckwheat	*Eriogonum tenellum var. ramosissimum*	G5T3/S3		X	
Low spurge	*Euphorbia peplidion*	G3/S3		X	X
Texas fescue	*Festuca versuta*	G3/S3		X	
Johnston's frankenia	*Frankenia johnstonii*	G3/S3			X
Watson's milk-pea	*Galactia watsoniana*	G1/S1		X	
Woolly butterfly-weed	*Gaura villosa ssp. parksii*	G5T3/S3			X
South Texas gilia	*Gilia ludens*	G3/S3		X	X
Texas greasebush	*Glossopetalon texense*	G1/S1		X	

Species	Specific Epithet	Global/State Ranking	Blackland Prairies	Edwards Plateau	South Texas Plains
Dimmit sunflower	*Helianthus praecox ssp. hirtus*	G4T2Q/S2			X
Red yucca	*Hesperaloe parviflora*	G3/S3		X	
Mexican mud-plantain	*Heteranthera mexicana*	G2G3/S1			X
Glass Mountains coral-root	*Hexalectris nitida*	G3/S3	X	X	
Warnock's coral-root	*Hexalectris warnockii*	G2G3/S2	X	X	
Drummond's rushpea	*Hoffmannseggia drummondii*	G3/S3			X
Slender rushpea	*Hoffmannseggia tenella*	G1/S1			X
Correll's bluet	*Houstonia correllii*	G1/S1			X
Greenman's bluet	*Houstonia croftiae*	G3/S3			X
Greenman's bluet	*Houstonia parviflora*	G3/S3		X	X
Pygmy prairie dawn	*Hymenoxys pygmea*	G1/S1	X		
Rock quillwort	*Isoetes lithophila*	G2/S2		X	
Piedmont quillwort	*Isoetes piedmontana*	G3/S1		X	
Texas stonecrop	*Lenophyllum texanum*	G3/S3			X
Glandular gay-feather	*Liatris glandulosa*	G3/S3	X		
Plateau loosestrife	*Lythrum ovalifolium*	G3G4/S3S4		X	
St. Joseph's staff	*Manfreda longiflora*	G2/S2			X
Siler's huaco	*Manfreda sileri*	G3/S3			X
Walker's manioc	*Manihot walkerae*	G3/S3			X
Shortcrown milkvine	*Matelea brevicoronata*	G3/S3			X
Plateau milkvine	*Matelea edwardsensis*	G3/S3		X	
Falfurrias milkvine	*Matelea radiata*	GH/SH			X
Arrowleaf milkvine	*Matelea sagittifolia*	G3/S3		X	X
Stanfield's beebalm	*Monarda punctata var. stanfieldii*	G5T3/S3		X	
Villous muhly	*Muhlenbergia villiflora var. villosa*	G5T3/S2		X	
Longstalk heimia	*Nesaea longipes*	G2G3/S2		X	
Heartleaf evening-primrose	*Oenothera cordata*	G3/S3		X	X
Heller's marbleseed	*Onosmodium helleri*	G3/S3		X	
Llano butterweed	*Packera texensis*	G2/S2		X	
Bushy whitlow-wort	*Paronychia congesta*	G1/S1			X
McCart's whitlow-wort	*Paronychia maccartii*	G1/S1			X
Bristle nailwort	*Paronychia setacea*	G3/S3	X		X
Turnip-root scurfpea	*Pediomelum cyphocalyx*	G3G4/S3S4		X	
Rydberg's scurfpea	*Pediomelum humile*	G1/S1			X
Guadalupe beardtongue	*Penstemon guadalupensis*	G3/S3		X	
Heller's beardtongue	*Penstemon triflorus ssp. integrifolius*	G3T3/S2		X	
Threeflower penstemon	*Penstemon triflorus ssp. triflorus*	G3T3/S3		X	
Canyon bean	*Phaseolus texensis*	G2/S2		X	
Canyon mock-orange	*Philadelphus ernestii*	G3/S3		X	
Oklahoma phlox	*Phlox oklahomensis*	G3/SH	X		
Hawksworth's mistletoe	*Phoradendron hawksworthii*	G3/S3		X	
Sand sheet leaf-flower	*Phyllanthus abnormis var. riograndensis*	G5T3/S3			X
Engelmann's bladderpod	*Physaria engelmannii*	G3/S3	X	X	
Zapata bladderpod	*Physaria thamnophila*	G1/S1			X
Correll's false dragon-head	*Physostegia correllii*	G2/S2		X	
South Texas yellow clammyweed	*Polanisia erosa ssp. breviglandulosa*	G5T3T4/S3S4B			X
Palmer's milkwort	*Polygala palmeri*	G3/S2		X	
Parks' jointweed	*Polygonella parksii*	G2/S2	X		
Stinking rushpea	*Pomaria austrotexana*	G3/S3			X

Species	Specific Epithet	Global/State Ranking	Blackland Prairies	Edwards Plateau	South Texas Plains
Broadpod rushpea	*Pomaria brachycarpa*	G2/S2		X	
Canyon rattlesnake-root	*Prenanthes carrii*	G2/S2		X	
Texas almond	*Prunus minutiflora*	G3G4/S3S4		X	X
Texas peachbush	*Prunus texana*	G3G4/S3S4	X	X	X
South Texas false cudweed	*Pseudognaphalium austrotexanum*	G3/S3			X
Big red sage	*Salvia penstemonoides*	G1/S1		X	
Tobusch fishhook cactus	*Sclerocactus brevihamatus ssp. tobuschii*	G4T3/S3		X	
Large selenia	*Selenia grandis*	G3/S3			X
Jones' selenia	*Selenia jonesii*	G3/S3		X	X
Texas seymeria	*Seymeria texana*	G3/S3		X	
Springrun whitehead	*Shinnersia rivularis*	G2G3/S1		X	
Florida pinkroot	*Spigelia texana*	G3/S3		X	
Bracted twistflower	*Streptanthus bracteatus*	G1G2/S1S2		X	
Broadpod twistflower	*Streptanthus platycarpus*	G3/S3		X	
Sycamore-leaf snowbell	*Styrax platanifolius ssp. platanifolius*	G3T3/S3		X	
Hairy sycamore-leaf snowbell	*Styrax platanifolius ssp. stellatus*	G3T3/S1		X	
Texas snowbells	*Styrax platanifolius ssp. Texanus*	G3T1/S1		X	
Billie's bitterweed	*Tetraneuris turneri*	G3/S3			X
Texas meadow-rue	*Thalictrum texanum*	G2/S2	X		
Burridge greenthread	*Thelesperma burridgeanum*	G3/S3			X
Shinner's rocket	*Thelypodiopsis shinnersii*	G2/S2			X
Ashy dogweed	*Thymophylla tephroleuca*	G2/S2			X
Bailey's ballmoss	*Tillandsia baileyi*	G2G3/S2			X
Buckley's spiderwort	*Tradescantia buckleyi*	G3/S3			X
Granite spiderwort	*Tradescantia pedicellata*	G2Q/S2		X	
Darkstem noseburn	*Tragia nigricans*	G3/S3		X	
Buckley tridens	*Tridens buckleyanus*	G3G4/S3S4		X	
Bigflower cornsalad	*Valerianella stenocarpa*	G3/S3		X	
Edwards Plateau cornsalad	*Valerianella texana*	G2/S2		X	
Small-leaved yellow velvet-leaf	*Wissadula parvifolia*	G1/S1			X
Texas shrimp-plant	*Yeatesia platystegia*	G3G4/S3S4			X
Jones's rainlily	*Zephyranthes jonesii*	G3/S3			X
Texas wild rice	*Zizania texana*	G1/S1	X	X	

[1]Global Conservation Ranking/State Conservation Ranking

GX/SX – Presumed Extinct; not located despite intensive searches and virtually no likelihood of discovery
GH/SH – Missing; known from only historical occurrences but still some hope of discovery
G1/S1 – Critically Imperiled; At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors
G2/S2 – Imperiled; At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors
G3/S3 – Vulnerable; At moderate risk of extinction due to restricted range , relatively few populations (often 80 or fewer), recent and widespread declines, or other factors
G4/S4 – Apparently Secure; Uncommon but not rare; some cause for long-term concern due to declines or other factors
G5/S5 – Secure; Common, widespread and abundant
GNR/SNR – Unranked; Nation or state conservation status not yet assessed
GU/SU – Unrankable; Currently unrankable due to lack of information or due to substantially conflicting information about status or trends
SNA – Secure; Common, widespread, and abundant in the nation or state
? – Inexact Numeric Rank
Q – Questionable Taxonomy; Taxonomic distinctiveness of this entity at the current level is questionable; resolution of this uncertainty may result in change from a species to a subspecies or hybrid, or the inclusion of this taxon, with the resulting taxon having a lower-priority conservation priority

Species	Specific Epithet	Global/State Ranking	Blackland Prairies	Edwards Plateau	South Texas Plains

T# – Infraspecific Taxon; The status of infraspecific taxa (subspecies or varieties) are indicated by a "T-rank" following the species' global rank.

G#G#/S#S# - Range Rank; A numeric range rank (e.g. G2G3/S2S3) is used to indicate the range of uncertainty in the status of a species.

NP – Not Provided

B – Breeding; Conservation status referes to the breeding population of the species

N – Nonbreeding; Conservation status refers to the non-breeding population of the species

ATTACHMENT 3: WESTSIDE CREEKS AVIAN SURVEY TEAM

Study Lead:
Danny Allen (CESWF)

Lead Birding Expert:
Martin Reid

Birding Experts:
Sheridan Coffee
Tom Collins
Dana Green
Fred Land (CESWF)
Derek Muschalek
Brent Ortego (TPWD)
Richard Redmond
Bobby Shelton (CESWF)

Birding Assistants:
Mark Bedgood
Beth Bendik (TPWD)
Mark Blair (CESWF)
Steven Caparco (CESWF)
Bill Colbert (CESWF)
Cim Howell
Sarah Kervin (CESWF)
Simon Ng (CESWF)
Cliff Shackelford (TPWD)
Leanna Torres (CESWF)
Palani Whiting (SARA)
Susan Wolters (CESWF)

ATTACHMENT 4: AVIAN POINT COUNTY SURVEY DATA SHEET

U S Army Corps of Engineers
Fort Worth District

Westside Creeks Avian IBI Point Count Survey Data Sheet

SAN ANTONIO RIVER AUTHORITY

Site: SAN PEDRO #6 Date: 3 MAY 2012

Observer 1: M. REID Start Time: 08:11

Observer 2: L. TORRES

Species Code	Channel			Floodway			Neighborhood			Flyovers		
	0-3 min	4-5 min	6-7 min	0-3 min	4-5 min	6-7 min	0-3 min	4-5 min	6-7 min	0-3 min	4-5 min	6-7 min
NOCA							1+1					
BHCO									1			
HOSP							3		3		1	
~~BW~~PUMA									1	2		
BLJA									1			
WWDO	2									1	1	4
GTGR	1											
KILL			1									
LEGO					2							
NOMO						1	1					
HOFI							6					
RTHA							1					
GFWO								1				
MODO										2		
ROPI										1		
SNEG											1	2
CLSW											2	
CAEG												1

Notes:
Warbler Sp, Neighborhood, 0-3 min interval

ATTACHMENT 5: WESTSIDE CREEKS AQUATIC HABITAT SURVEY

WEST SIDE CREEKS: FISH-HABITAT RELATIONSHIPS

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Engineer Research and Development Center
Environmental Laboratory
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INTRODUCTION

The San Antonio River basin is physically and faunistically distinctive from all other basins of the western Gulf Slope (Conner and Suttkus, 1986). It has the third smallest drainage area (10, 619 km^2) and discharge is low (<<0.1 m^3/km^2), but ionic concentrations (silica, calcium, magnesium, sodium, sulphate, chloride), total dissolved solids, hardness, specific conductance, and pH are the highest. Only 42 native freshwater fishes are documented, but 7 of these are eastern lowland or Mississippi Valley fishes at the southwestern most limits of their distribution. Native fish communities are dominated taxonomically by minnows and darters, including the state-endemic Texas shiner and Texas logperch. Environmentally sensitive ("intolerant") species, however, may constitute low percentages (< 6%) of the total biomass (Gonzales, 1988; Edwards, 2001).

Aquatic communities of the main channel of the San Antonio River are impacted by: urbanization and flood control projects; loss of riparian zone and floodplain habitats (pers. obs.); reduced complexity of instream physical habitat and availability of natural habitat (Gonzales, 1988); elevated nutrient levels (TNRCC, 2002); and burgeoning populations of exotic fishes (Hubbs et al. 1978; Hubbs, 1982; Edwards, 2001). Main channel fish assemblages in 2003 were comprised of 32 species, with diversity and biomass positively correlated with stream depth (Hoover et al., 2004).

Tributaries of the San Antonio River are subject to the same stressors as the main channel, but of possibly greater magnitude (e.g., deforestation), and others including impoundment, altered sediment transport, and elevated water temperatures. Collectively, these factors have reduced water volume, habitat quality, and connectivity among stream reaches, resulting in losses of fish habitat and passage. Conditions are pronounced in the San Pedro Creek drainage in the western San Antonio River Basin, referred to as Westside Creeks. Losses in riparian vegetation (with associated allochthonous inputs) and riffle-pool-run sequences (with associated habitat complexity) prompted a feasibility study to identify non-structural options for habitat restoration that would restore riparian-riverine functions while retaining or enhancing flood control and recreation (USACE, 2011a).

The U.S. Army Corps of Engineers (USACE) Fort Worth District, in partnership with the San Antonio River Authority (SARA) are developing and evaluating ecosystem restoration alternatives to provide recommendations for project implementation. As part of the planning process, the Engineer Research and Development Center, Environmental Laboratory (ERDC-EL) conducted an aquatic survey in Westside Creeks and nearby reference streams in April 2012 with the following goals:

- Provide an aquatic habitat description for each stream
- Describe fish assemblages for each stream
- Identify habitat limitations for Westside Creek reaches
- Recommend potential restoration measures to improve aquatic habitat for Westside Creeks

STUDY AREA

The proposed study includes San Pedro Creek from 1-35 to the confluence with the San Antonio River, Apache Creek from the Elmendorf Lake Dam to the confluence with San Pedro Creek, Alazan Creek from the Woodlawn Lake Dam to the confluence with Apache Creek, and Martinez Creek from Hildebrand Street to the confluence with Alazan Creek. All four creeks are contained within urban San Antonio and comprise the Westside Creeks system (USACE, 2011b).

- Martinez Creek is concrete-lined just above the project limit and is "broken" mid-length by culverts crossing under Interstate 10W. Sedimentation occurs throughout the system and is extensive in some locations. It is tributary to Alazan Creek.
- Alazan Creek is impounded at its upper limit (Woodlawn Lake) and walled on both sides at one location. It is sediment-starved above its confluence with Martinez Creek. Alazan Creek is tributary to San Pedro Creek.
- Apache Creek is impounded at its principal tributary Zarzamora Creek (Elmendorf Lake). The lake is a sediment trap, with 4-6 feet of accumulated sediment, and is stagnant. Water enters the stream from the lake only when overtopped at the weir and banks; sedimentation is extensive downstream to the confluence with the upper reach of Apache Creek. Aeration and water release structures have been proposed for the lake. Apache Creek is tributary to San Pedro Creek.
- San Pedro Creek flows through underground tunnels except at its uppermost and lower most reaches where it receives water from Alazan and Apache Creeks. It is tributary to the San Antonio River.

In addition to the four impacted streams within the project area, two reference streams, with reaches flowing extensively through non-urban areas, were sampled:

- Medio Creek is comparable in size and located directly west of Westside Creeks streams. It is tributary to the Medina River. Riparian forest may be thin or moderate, but is continuous at some reaches.
- Medina River is west and south of the Westside Creeks streams and is impounded in its upper reach (Medina Lake). Riparian forest may be substantial. It is substantially wider than any of the other streams.

Thirty-four collections were made at 15 stations throughout the study area: 2-3 stations/stream, 1-4 habitats/station. Twenty-eight localities or units (i.e., individual habitat at a station) were sampled by seine once during the period 11-12 Apr 2012. Six units were also sampled by electrofishing. Stations were distributed among the following waterbodies: Alazan Creek (2), Apache Creek (3), Martinez Creek (2), Medio Creek (3), Medina River (2) and San Pedro Creek (3). Maps highlighting location of each respective system and geographic location of each sample station are depicted in Figures 5-10. A detailed description of each sample station and general sampling conditions is provided in Attachment 4-1.

METHODS

FIELD METHODS

Physical habitat (stream hydraulics, substrate, and water quality) and fish communities (species-abundance, size structure) were sampled concurrently at discrete habitats (riffles, runs, glides, and pools) within the streams. Fishes were collected by seining or electrofishing within a defined homogenous macrohabitat unit (e.g., pool, run, glide, riffle, backwater) at each sampled station. Because of the small and highly variable size of individual habitats, standard sampling effort was inappropriate and scaled appropriately to the size of each individual locality. Small seines (8' x 10' length; no more than 10 hauls) were used in smaller streams and larger seines (8' x 20-ft length; 5 hauls) in the largest stream (Medina River). Both seines were constructed of 3/16" mesh. In addition, a Smith Root PC 15-B POW backpack electrofisher was used to sample a subset of macrohabitat units to facilitate comparisons of sampling effectiveness between gear types. Effort for electrofishing was recorded as total shocking time (seconds) for each sampled unit. Catch-per-unit-effort (CPUE) for seine samples was computed as number of individuals per seine haul. CPUE for electrofishing samples was computed as number of individuals per second of shocking time, and then standardized to a 60 second period to equate with the amount of time expended for a general seine haul conducted during this project period.

All fish were fixed in 10% formalin except for large specimens which were identified, measured, and released in the field. In the laboratory, preserved fishes were rinsed, sorted, identified, enumerated, and measured (total length to nearest mm). Specimens were preserved in isopropyl alcohol, cataloged, and deposited in the collections of the University of Louisiana at Monroe Museum of Natural History. Catalog numbers are available on request.

Water quality parameters were determined for each river section or macrohabitat unit sampled. Dissolved oxygen (mg/L), pH, conductivity (µS) and water temperature (C) were measured with a Quanta Hydrolab®. Turbidity (NTU) was measured with a Hach 2100P® turbidimeter. River width (m) and sampling distance (m) were measured using a Bushnell® laser rangefinder. Water depth (m, stadia rod) and surface velocity (cm/sec, Marsh-McBirney Flo-Mate) were taken at 5 equidistant points along a cross-sectional transect within the sampled reach. Dominant and sub-dominant substrata were recorded for each transect point following a modified Wentworth scale (Cummins 1962, Bain 1999). Stations were georeferenced using a hand-held Magellan® or Delorme PN40 GPS unit.

ANALYTICAL METHODS

The matrix for the comparison of environmental conditions consisted of 22 variables (Attachment 4-2) including measurements related to water quality (e.g., water temperature, dissolved oxygen, conductivity, pH, turbidity), physical habitat features (water depth, water velocity, stream width), land coverage attributes (percent overstory, shrub, herbaceous, rip-rap) and substrata (dominant, subdominant). Data were transformed (Log[x+1]), normalized and a Euclidean distance matrix was produced before conducting further analyses.

CPUE values in the final species matrix were square root transformed to reduce the influence of the most common species (Clarke and Gorley 2006). No species were excluded due to rarity. Resemblance matrices were created by computing Bray-Curtis similarity indices for each assemblage comparison. Analytical assessments of data structure (biological and environmental matrices) and sample similarity were computed with the procedures in the PRIMER (Plymouth Routines in Multivariate Ecological Research) version 6 statistical package (Clarke and Warwick 2001; Clarke and Gorley 2006).

Non-metric multi-dimensional scaling (MDS) was conducted to provide a graphical presentation of the similarity among samples in a low-dimensional space with those samples (i.e., points on the figure) occurring close together representing samples that are very similar in community composition. The reduction of the original dataset to a low-dimensional space is measured as "stress" and represents the effectiveness of the data reduction technique in depicting the similarity among samples in the original high-dimensional space. Values < 0.05 represent excellent representation of the low-dimensional solution with a value of 0.01 representing a perfect fit; < 0.1 represents a good solution; < 0.2 represents useful 2-dimensional solutions but signals the need for additional analyses to evaluate internal structure within the dataset; and stress values > 0.3 represent solutions that differ little from randomized points (Clarke and Warwick 2001).

An analysis of similarity (ANOSIM) was conducted to assess differences in species assemblages and/or environmental conditions between systems (e.g., Apache Creek and Medina River) or between any *a priori* defined groupings. This analytical approach is analogous to a 1-way ANOVA and assesses the degree of variability in similarity values within treatments in order to establish the strength of differences that may be found between treatments. The test statistic for ANOSIM, R, ranges from 0 to 1. Values close to 0 indicate little difference between groups and values approaching 1 represent complete separation of the groups (Clarke and Warwick 2001).

We calculated similarity percentages (SIMPER) on CPUE values to determine which species or environmental variable contribute to the similarity pattern depicted within groups (i.e., typifying species) as well as those features that contribute to the dissimilarity between groups (i.e., discriminating species). We conducted a hierarchical clustering technique (CLUSTER) on each respective resemblance matrices and incorporated the SIMPROF option to test for significance (alpha = 0.05) of internal structure.

A principal components analysis (PCA) was conducted to assess the relative importance of the measured environmental condition in developing discriminating factors (i.e., combination of environmental variables) for discerning differences between the respective groups of samples.

The BEST (Bio-Env + STepwise) routine was utilized to provide a measure of agreement between structure in the biotic assemblage and any multivariate environmental pattern depicted for the same sampled stations (Clarke and Gorley 2006).

RESULTS AND DISCUSSION

A total of 34 samples from representative macrohabitat units were taken at 15 stations resulting in 2,955 individuals representing 23 species of fishes during efforts conducted 11-12 April 2012 (Table 20). Sampling by seine was the predominant effort with 27 localities sampled with this gear type. The number of hauls varied depending on seine size with the 10' seine ranging 1-10 hauls (**mean** = 6.3; 24 units) and efforts with the 20' seine (3 localities) all consisting of 5 hauls. Seven (7) localities were sampled with both seine and backpack electrofisher (Table 20).

SPECIES RICHNESS

The number of species documented varied across stations, gear types and between habitats. Seining efforts, both sizes combined, documented 1-9 species per unit (**mean** = 3.7 species) with two units (pool and riffle) at Apache Creek yielding no catch. Electrofishing efforts produced 2-9 species (**mean** = 3.9) per sampled unit. The number of species varied between waterbodies with combined efforts on Alazan Creek yielding 2 species (**mean** = 2); San Pedro Creek, 1-4 species (**mean** = 2.2), Apache Creek, 2-5 species (**mean** = 2.3); Martinez Creek, 1-4 species (**mean** = 2.7); Medina River, 3-9 species (**mean** = 5.9) and Medio Creek, 4-9 species (**mean** = 6.4).

Combined sampling efforts by macrohabitat unit varied as well with pool units yielding 2-5 species **(mean** = 2.75) followed by riffle, 1-9 species (**mean** = 3.7); glide, 1-7 species (**mean** = 3.7); run, 1-9 species (**mean** = 4.5) and backwater, 6-7 species (**mean** = 6.7).

General trends in species diversity followed a similar pattern with variation attributed to gear type, waterbody and sampled habitat (Figure 11, 12). Comparative sampling efforts between seine and electrofishing gear generally resulted in greater or equal species diversity occurring with electrofishing efforts (Figure 11) although the mean number of species documented with each gear type was similar. Species diversity between habitat types was confounded by waterbody where total number of species was typically lower at Westside Creek stations. There was a similar pattern of diversity among macrohabitat units based on gear type with electrofishing generally resulting in slightly higher species diversity (Figure 12).

ENVIRONMENTAL CONDITIONS

The results of the MDS for the environmental conditions provided a good solution for a 3-dimensional portrayal of the data (stress = 0.11). The 2-D solution had a slight reduction in fit (stress = 0.16) (Figure 13) but illustrated a distinct separation between stations representing the reference systems (i.e., Medio Creek and Medina River) and the remaining samples in terms of measured habitat features. Sample units from San Pedro and Alazan creeks, along with numerous samples from Apache Creek, illustrated high similarity based on habitat conditions. Sample units from Martinez Creek were distinct from the remaining Westside Creek samples.

The similarity in environmental conditions is depicted well with the results of the CLUSTER analysis (Figure 14) indicating internal structure (i.e., statistically significant differences between clusters) by the SIMPROF analysis (Global Pi = 0.487, p = 0.001). Results of the ANOSIM indicated significant differences between waterbodies in terms of measured environmental conditions (Global R = 0.584, p = 0.001). The difference in habitat between Medio Creek and Medina River was statistically significant, and these two systems also differed from all remaining waterbodies (Table 12). Habitat features for Apache, San Pedro, Alazan and Martinez creek, in most cases, were not statistically different.

The PCA on the environmental variables provided a moderate solution with 78.1% of the variability in measured conditions being accounted for with 5 PC axes. Loadings on each axis were low to moderate with -0.483 reported as the highest overall loading (Table 22). All included variables had loadings > 0.300 except COND, SITE_LNGTH_M, SV_CV, SUB_SECONDARY_MEAN and SUB_SECONDARY_STD. PC axis 1 and 2 had higher loadings of variables generally associated with water quality and land coverage while PC axes 3-5 reflected physical habitat features of the sampled macrohabitat units. Inspection of the plots utilizing the first 2 axes provides a visual interpretation of the data and the relative loadings of each variable along each axis (Figure 15). The length of the trajectory for each variable indicates the strength of that particular variable for discriminating conditions along a particular axis.

Following the inclusion of all 22 environmental variables, the results of the BEST procedure indicated the best solution included 14 variables (Global Rho = 0.955, p = 0.01). The best explanatory variables, in descending order of contribution, included WTEM, COND, PH, TURBID, SV_MEAN, DEPTH_STD, WIDTH_DEPTH_RATIO, WET_PER, SHRUB, RIPRAP, OVR_W, SUB_PRIMARY_MEAN, SUB_SECONDARY_MEAN and SUB_SECONDARY_STD. Variables deemed non-significant in discriminating between sampled macrohabitat units were DO, SITE_LNGTH_M, SV_CV, DEPTH_MEAN, DEPTH_CV, OVRSTRY, HERB and SUB_PRIMARY_STD. Figure 16 depicts the correlations among all 22 environmental variables and illustrates well the lack of discriminating ability of some variables due to their correlative properties.

Using a more simplified approach we conducted a BEST procedure (BioEnv option) to determine which subset of the total suite of environmental variables best describes the pattern depicted in faunal assemblage for two groups (Westside Creeks vs. Reference Creeks) (Table 25). Five variables, in decreasing order of importance (DEPTH_STD, OVRSTRY, SHRUB, RIPRAP, SUB_SECONDARY_MEAN), were included in the best solution (r = 0.510, p= 0.010). Additional solutions with (r = 0.508, 0.502) included the same suite of variables except SHRUB and RIPRAP were replaced by OVR_W in their respective solutions.

All samples were coded based on respective station designation (Westside Creek, reference system [Medina River, Medio Creek]) and subjected to a SIMPER analysis to describe the contribution of each measured environmental variable in discerning differences (i.e., discriminating variables) between the two systems based on habitat conditions. Westside Creek stations were characterized with by no SHRUB, OVRSTRY or OVR_W and high levels of RIPRAP and HERB.

FISH FAUNA

The results of the MDS provided a good solution for a 3-dimensional portrayal of the data (stress = 0.11). The 2-D solution had a slight reduction in fit (stress = 0.17) but is presented instead due to ease of interpretation (Figure 17). Graphically, the MDS depicted a fairly clean separation between samples from the respective systems. In general, the depicted faunal pattern is similar to that portrayed with the environmental conditions of the sampled units (Figure 13).

Results of the SIMPROF indicated internal structure in terms of faunal similarity among the sampled stations (Global Pi = 1.574, p = 0.035) with the CLUSTER analysis (Figure 18) depicting major clusters among the sampled units. For example, the cluster containing sample units from Medio Creek and Medina River were faunistically similar and the inclusive cluster was significantly different from the remaining sample units. Similarly, all sample units from the Westside Creek stations were included within a single cluster that based on group averages was only 12% similar to the samples represented by the reference systems.

The one-way ANOSIM indicated significant fish assemblage differences between the sampled systems (Global R = 0.506, p = 0.001) with Medina River and Medio Creek being significantly different from all remaining systems except for one comparison between Medio and Martinez creeks (p = 0.006; Table 23). The remaining samples from the Westside Creek stations were not faunistically different.

Average faunal similarity (SIMPER analysis) between sample units within each respective waterbody ranged 24.8-43.2%. Westside Creek stations generally had a low number of species overall and samples were generally dominated by Central stoneroller, Common carp and Western mosquitofish. “Typifying species” (*sensu* Clarke and Gorley 2006) for Medio Creek samples included Western mosquitofish, Bluegill, Rio Grande cichlid, Longear sunfish and Red shiner which comprised 90.26% of the within group similarity. Similarly, Medina River samples included Blacktail shiner, Western mosquitofish, Central stoneroller, Rio Grande cichlid and Orangethroat darter which comprised 95.82% of the within group similarity for that system.

The average faunal dissimilarity between waterbodies included in the Westside Creek stations ranged 60.5-74.1% (SIMPER analysis) with most of these differences due to variations in CPUE abundance values for a few dominant species (Table 23, Martinez Creek & San Pedro Creek). In contrast, average dissimilarity between Westside Creek systems and reference systems were attributed in part to differences in species richness between the systems (i.e., 3 versus 7 species) and the differences in CPUE abundances for co-occurring species (i.e., Central stoneroller; Table 23). Overall, Westside Creeks are dominated by tolerant and small-sized invasive species of fish compared to reference streams. Large-bodied invasive fishes, such as suckermouth catfishes and tilapia that dominate the San Antonio River (Hoover et al 2002), were absent from the smaller tributaries suggesting that Westside Creeks are unsuitable for these species. Conversely, tributaries may be source populations for fish uncommon (e.g., Campostoma, logperch) in San Antonio River.

RESTORATION OPPORTUNITIES

Symptoms of the urban stream syndrome include a flashier hydrograph, elevated concentrations of nutrients and contaminants, altered channel morphology, and reduced biotic richness, with increased dominance of tolerant species (Walsh et al. 2005). Our analysis reflects these types of symptoms in Westside Creeks, but comparison to the Reference streams indicates that restoration will provide benefits. Best Analysis (Table 24) indicated certain environmental variables were correlated differently with Westside Creek compared to reference sites. To further illustrate this, an MDS was generated using average values from each waterbody and vectors were plotted showing environmental variables associated with potential restoration measures (Figure 19). Fish assemblages associated with Westside Creeks were correlated with reduced structural variables (vegetation, overstory), larger substrates including rip-rap, higher water temperatures, and shallower water (reduced depth and wetted perimeter). The type of fish assemblage (tolerant and more invasive species) reflect these degraded habitat conditions. Reference streams suggest that certain restoration measures will have a positive benefit to native fishes. Specifically, increasing overstory and stream riparian cover, along with greater depths and water velocity, should result in higher richness and diversity of the fish assemblage. This analysis provides justification to improve habitat conditions of Westside Creek with expected benefits to the overall aquatic community.

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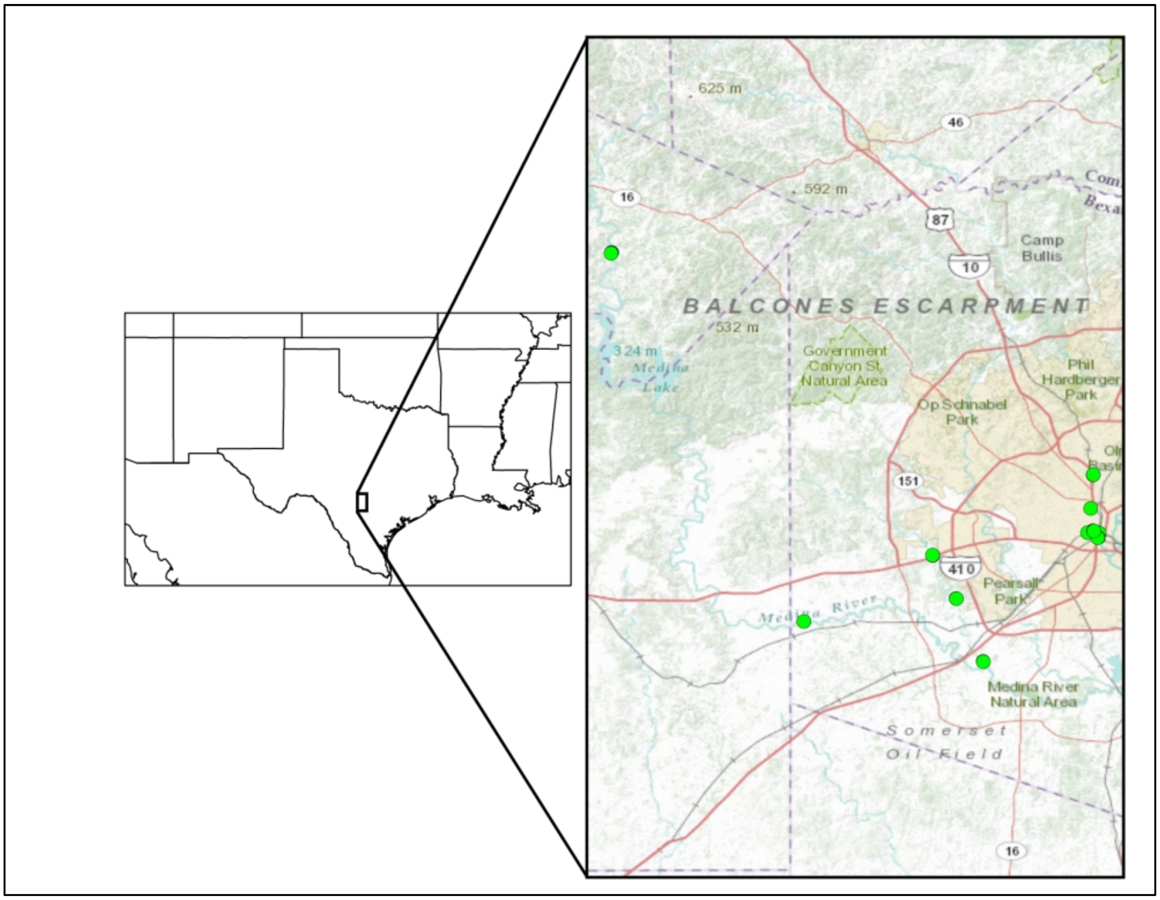

Figure 5. . Broad-scale geographic view depicting the project area within Texas and the relative location of the sampled stations for Westside Creek project.

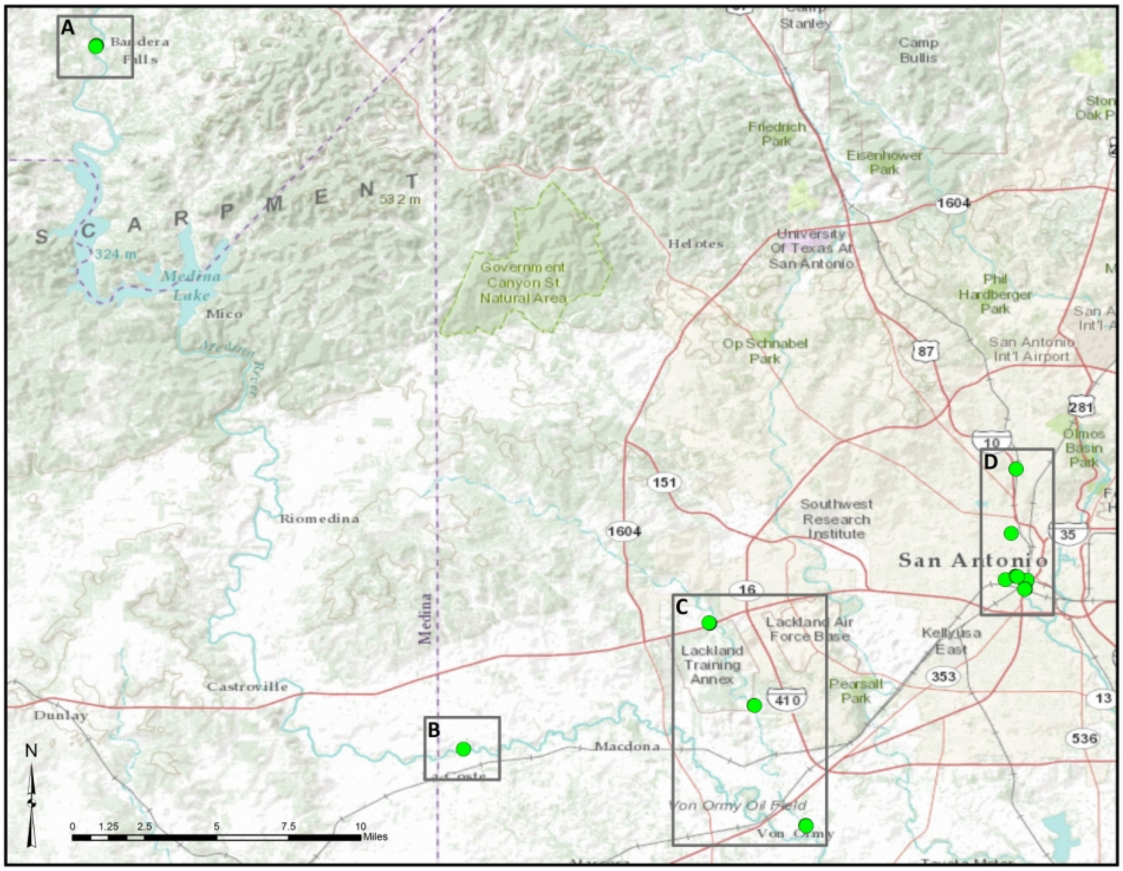

Figure 6. Map depicting the zones (Insets A-D) which include sampled reference waterbodies (Medina River, Inset A and B; Medio Creek, Inset C) and Westside creeks (Inset D).

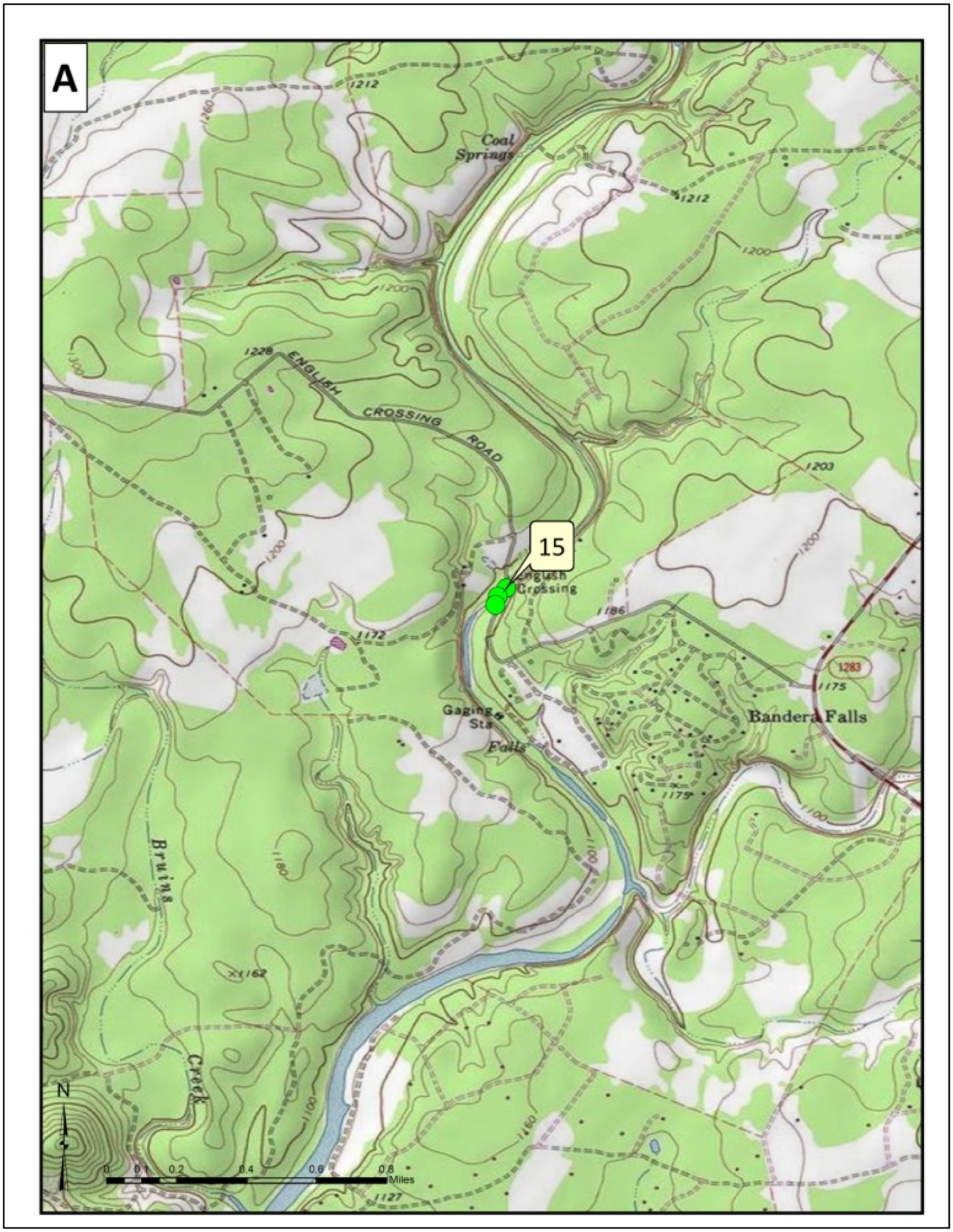

Figure 7. Detailed view of Inset A (see Figure 2) featuring stations sampled on the upper Medina River

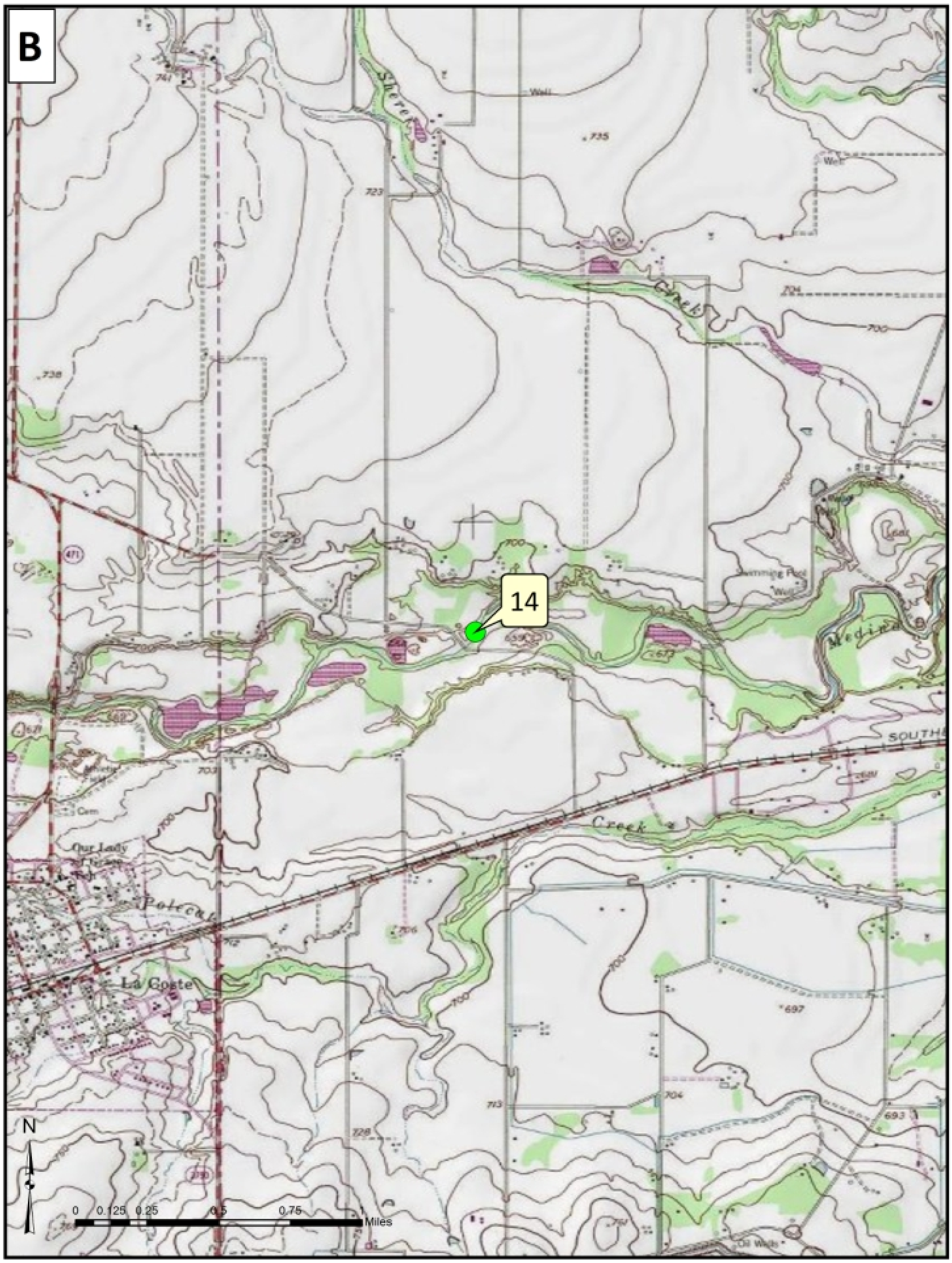

Figure 8. Detailed view of Inset B (see Figure 2) featuring stations sampled on the lower Medina River.

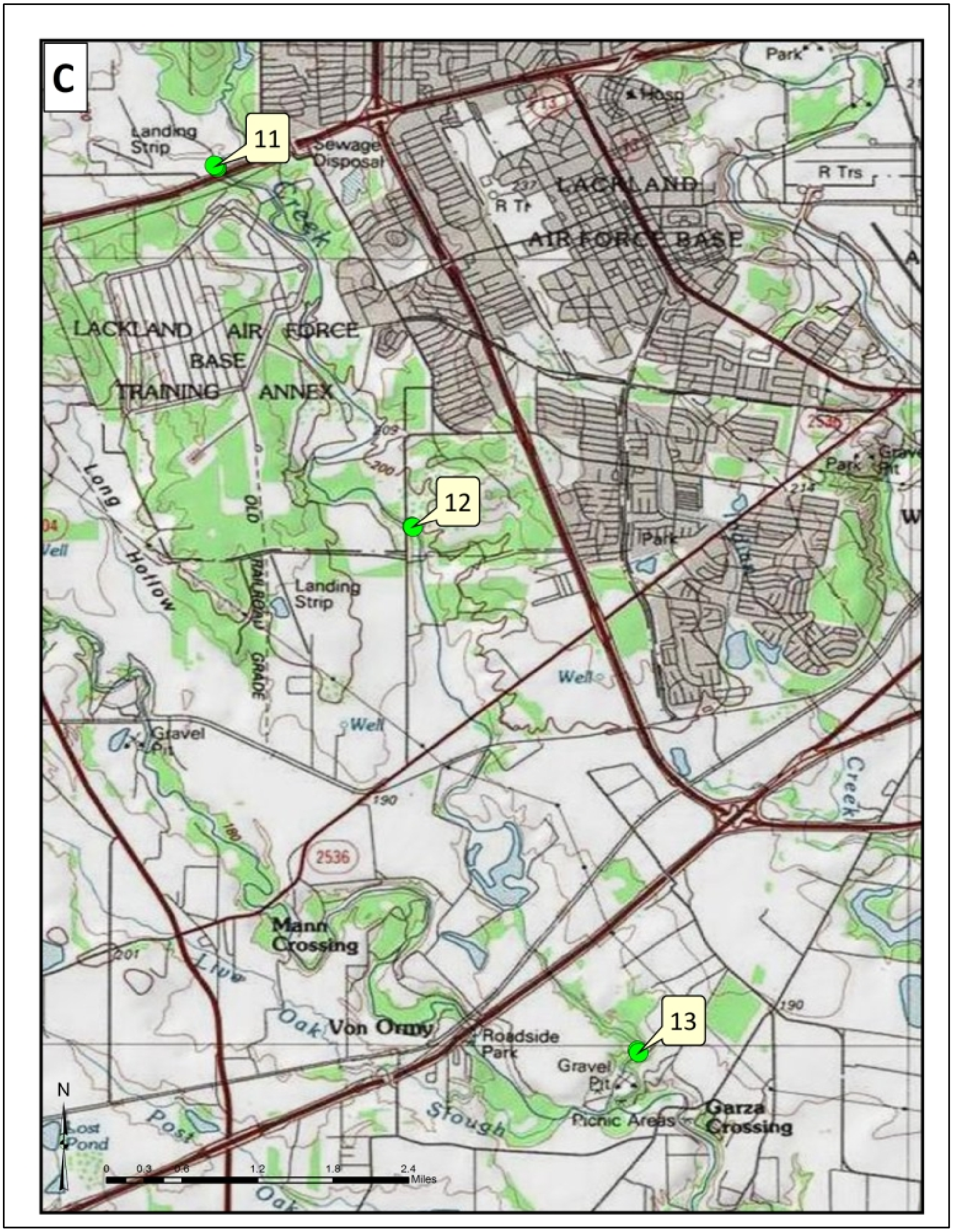

Figure 9. view of Inset C (see Figure 2) featuring stations sampled on Medio Creek

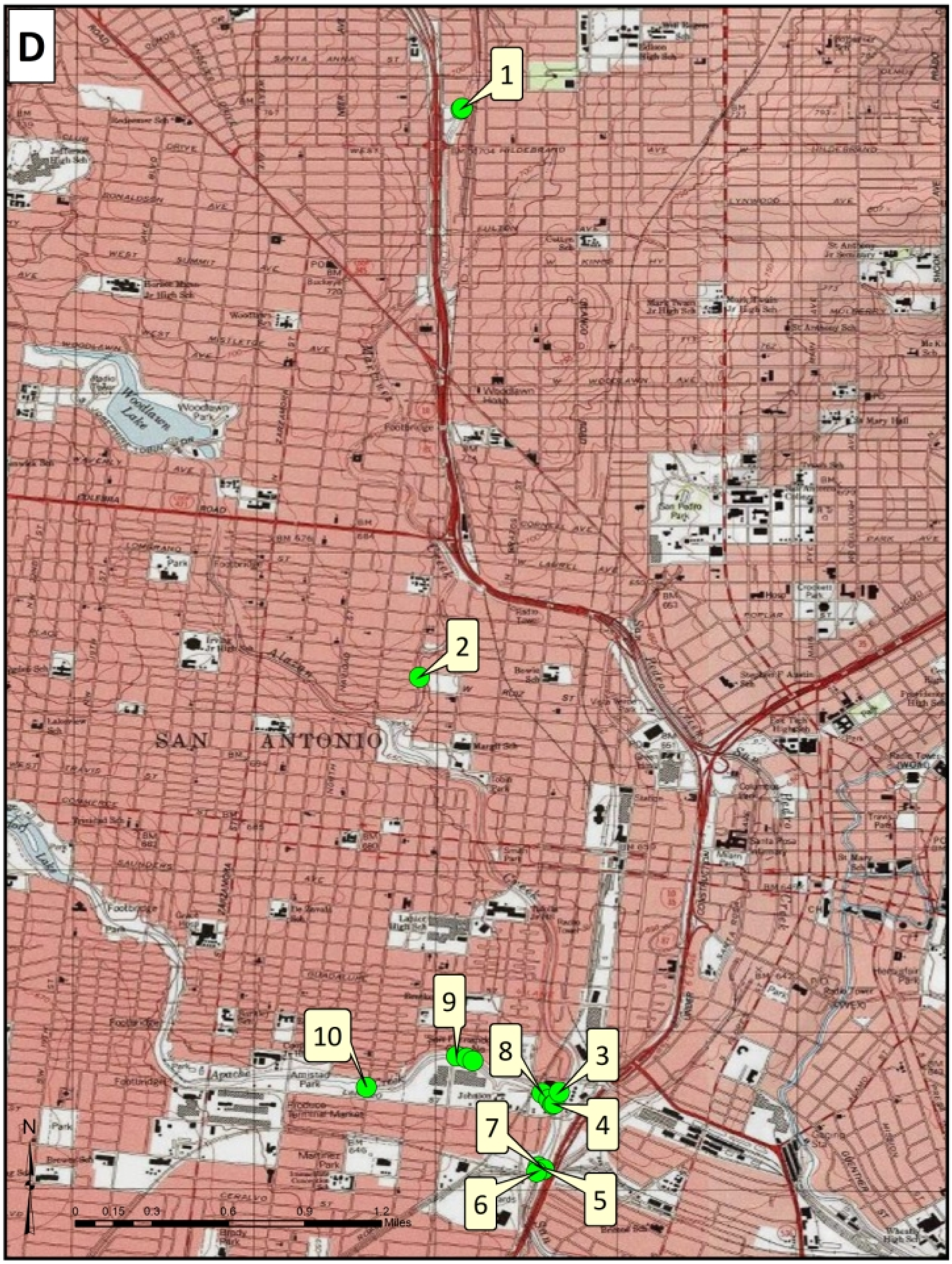

Figure 10. Detailed view of Inset D (see Figure 2) featuring stations sampled on Alazan, Apache, Martinez and San Pedro creeks (Westside Creek project area).

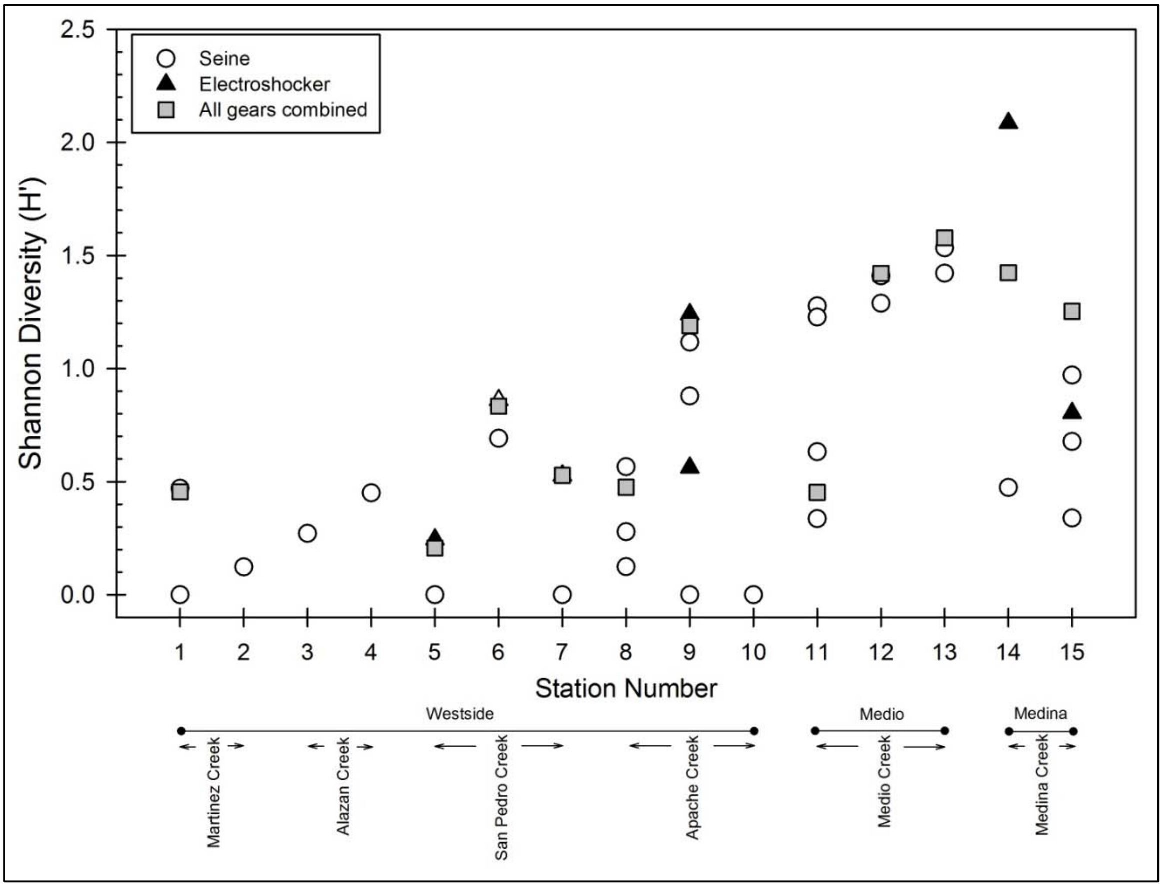

Figure 11. Shannon diversity values based on standardized CPUE for all samples conducted at the 15 stations within the project area with samples coded by gear type.

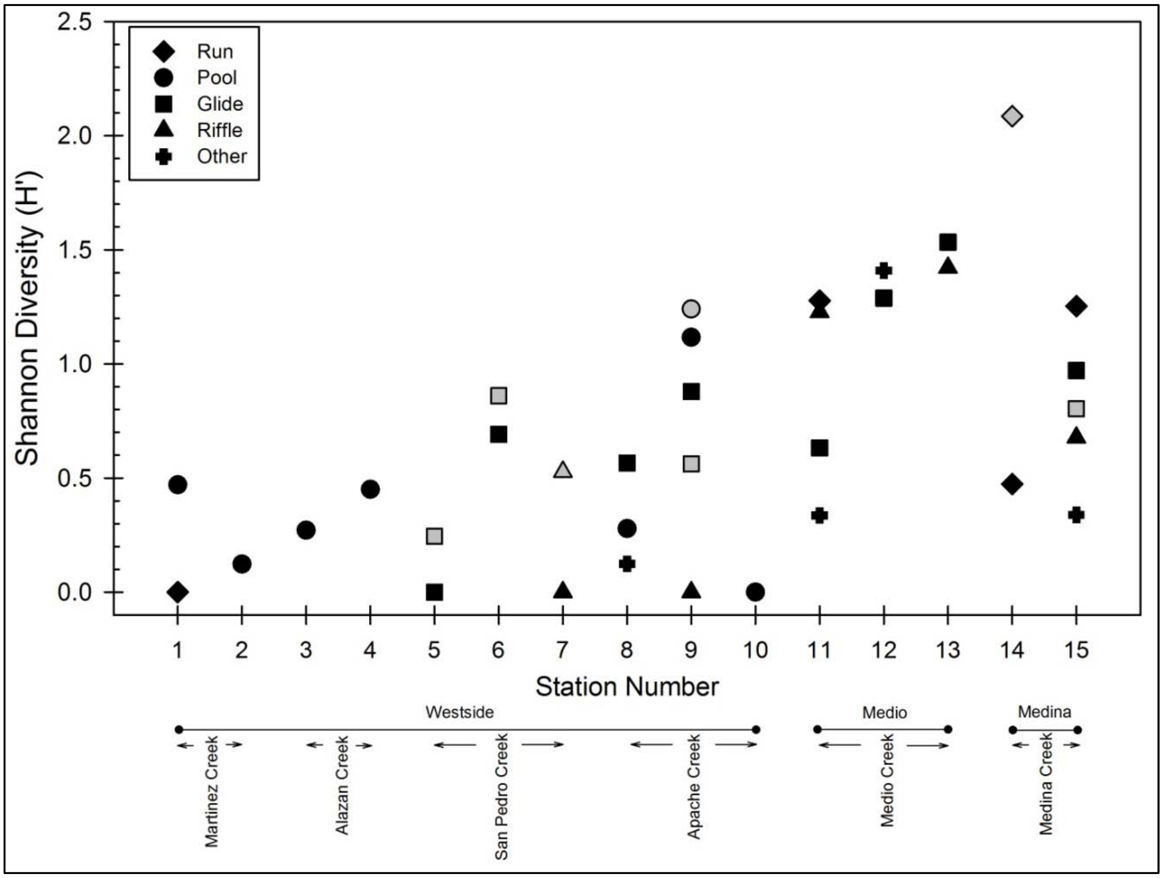

Figure 12. Shannon diversity values based on standardized CPUE for all samples conducted at the 15 stations within the project area with samples coded by sampled habitat. Solid symbols indicate seining efforts; grey symbols represent electrofishing efforts.

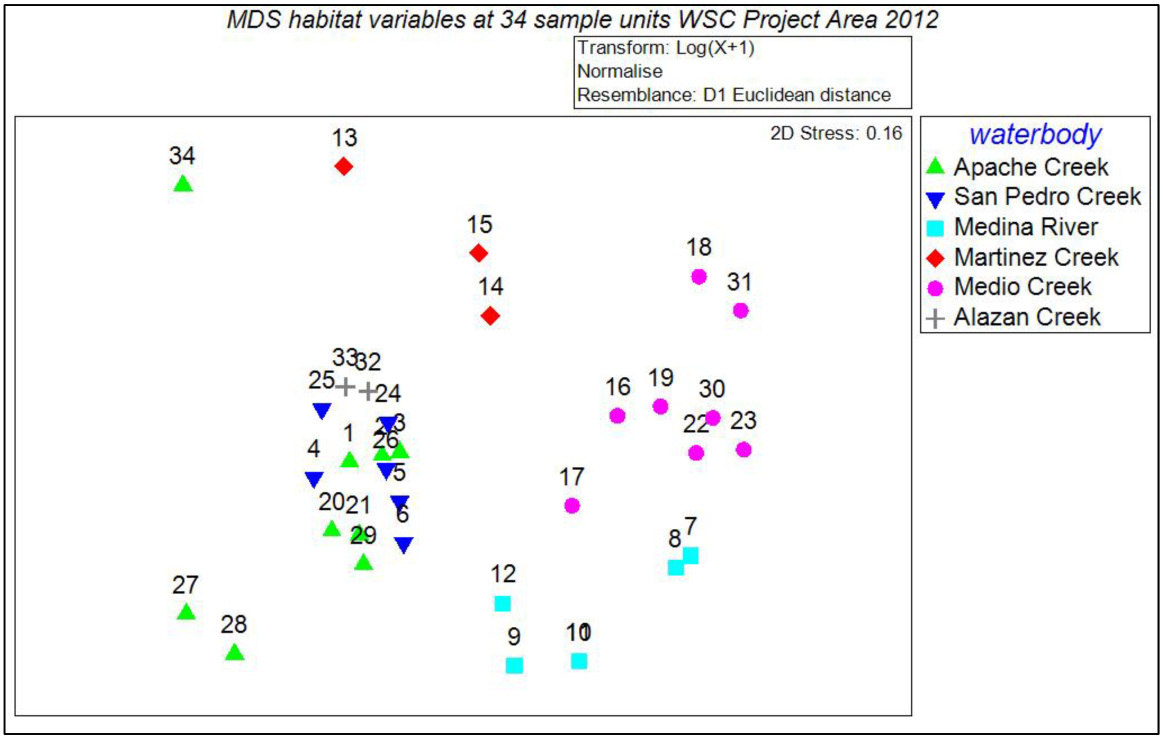

Figure 13. MDS plot of measured habitat variables taken at 34 sampled macrohabitat units distributed across 15 stations within the project area.

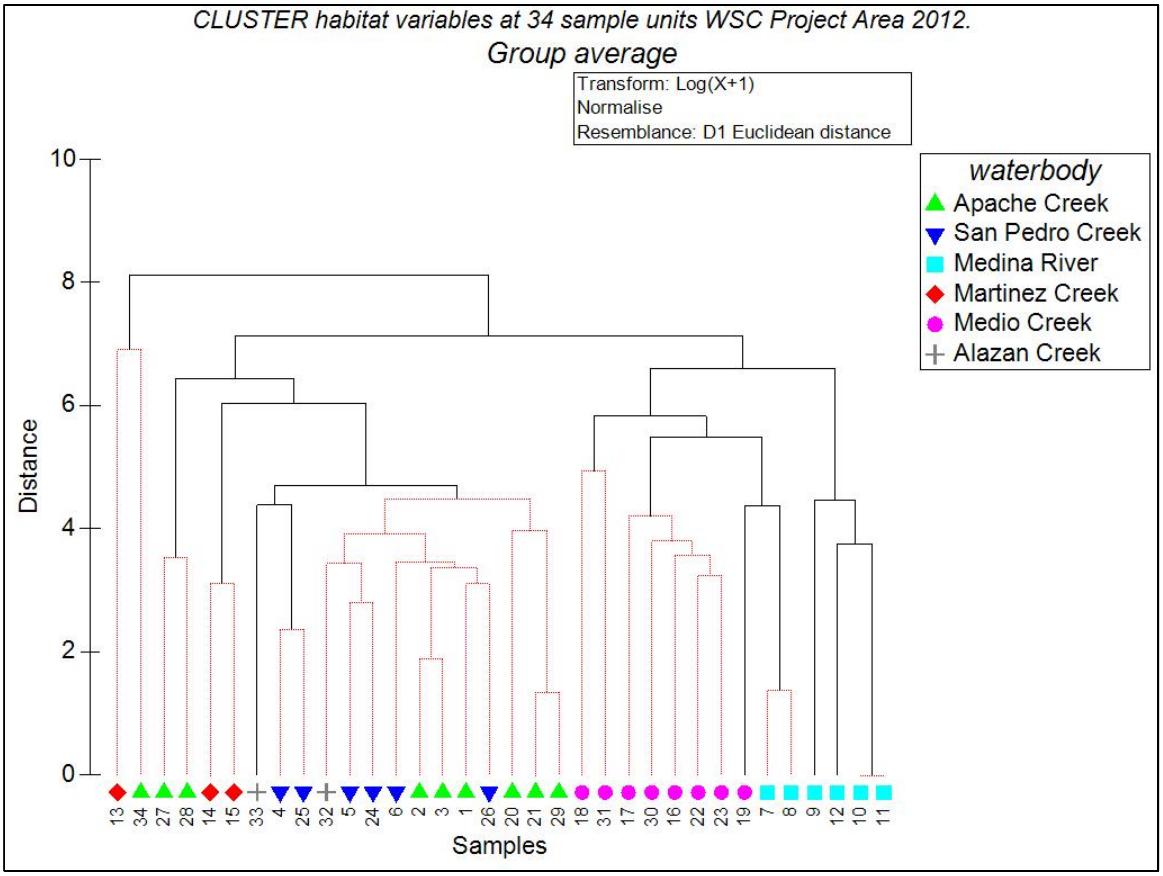

Figure 14. CLUSTER analysis depicting habitat similarity between sampled units across all included waterbodies. Statistically significant clusters are noted by black linkages; non-significant clusters are in red.

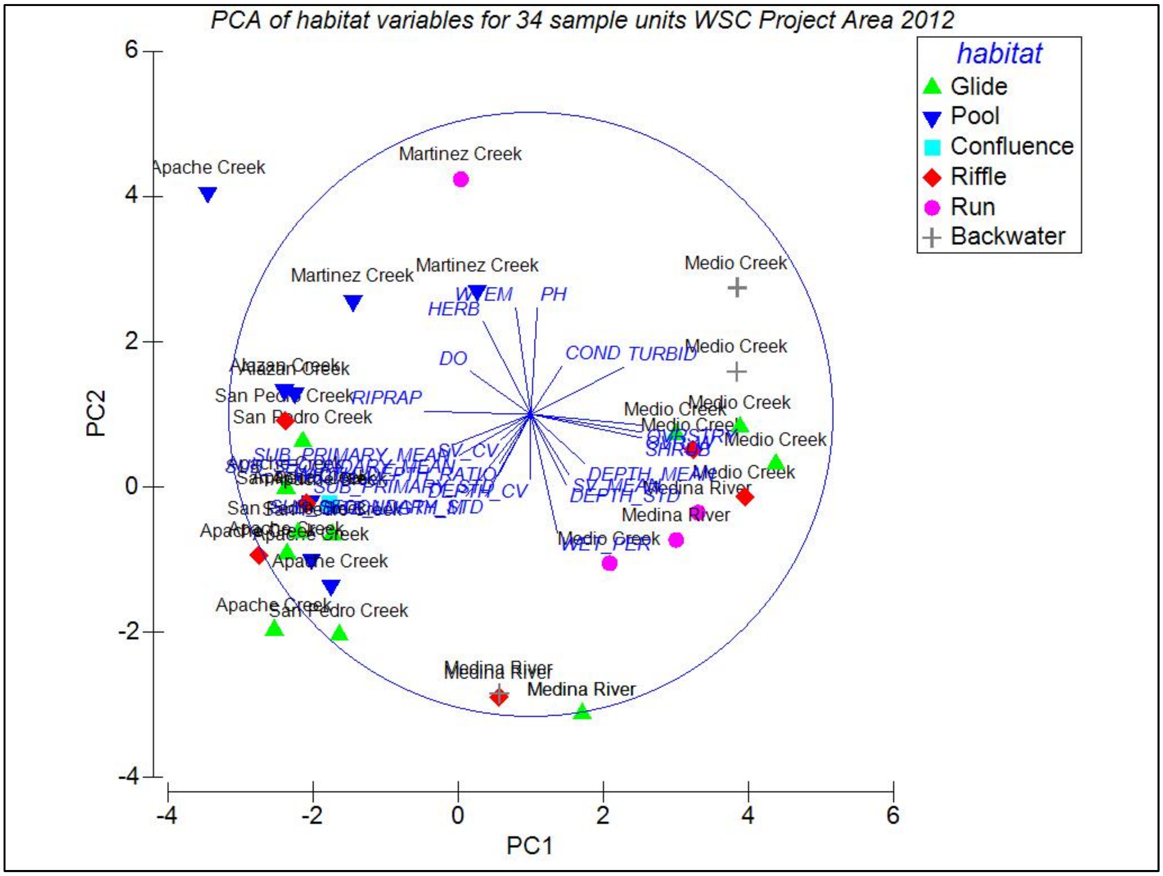

Figure 15. PCA of habitat variables recorded at 34 sampled macrohabitat units. Sample units are coded based on habitat type.

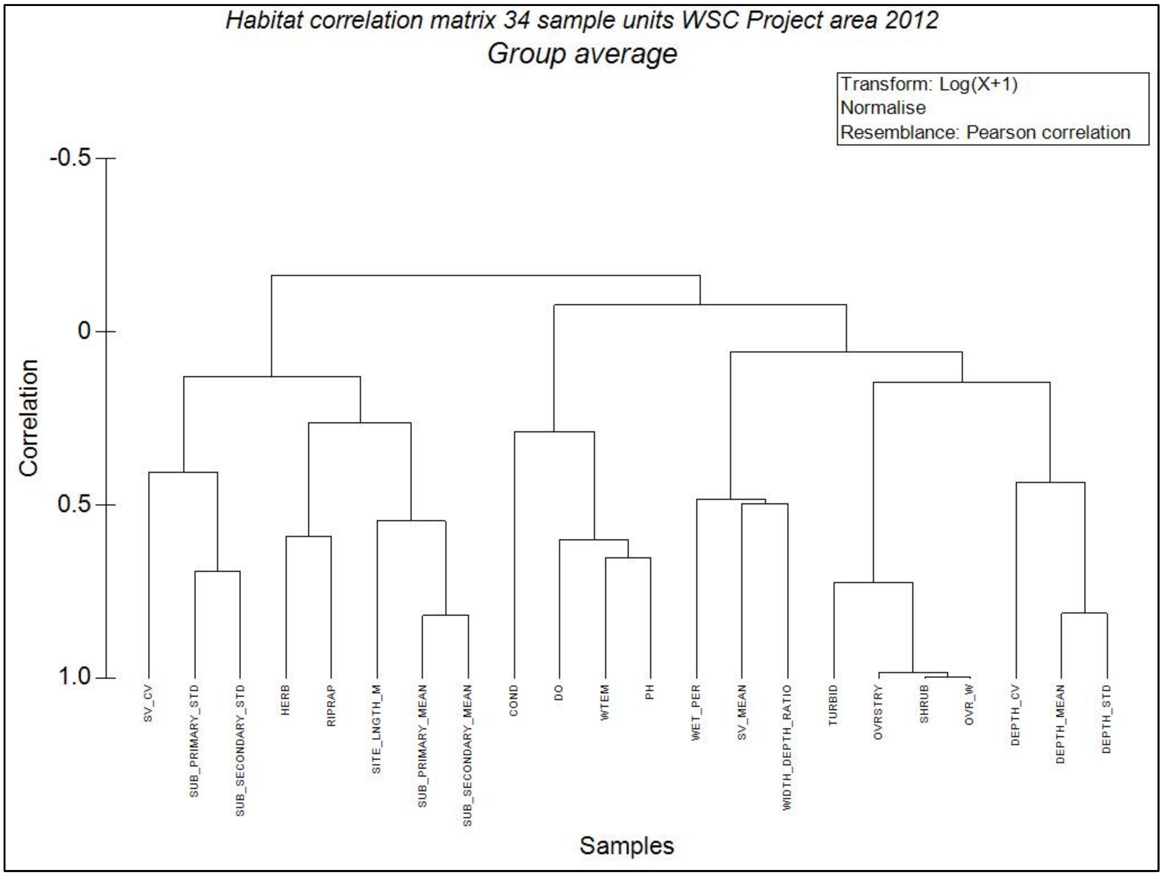

Figure 16. CLUSTER diagram depicting correlation among variables included in the environmental data matrix.

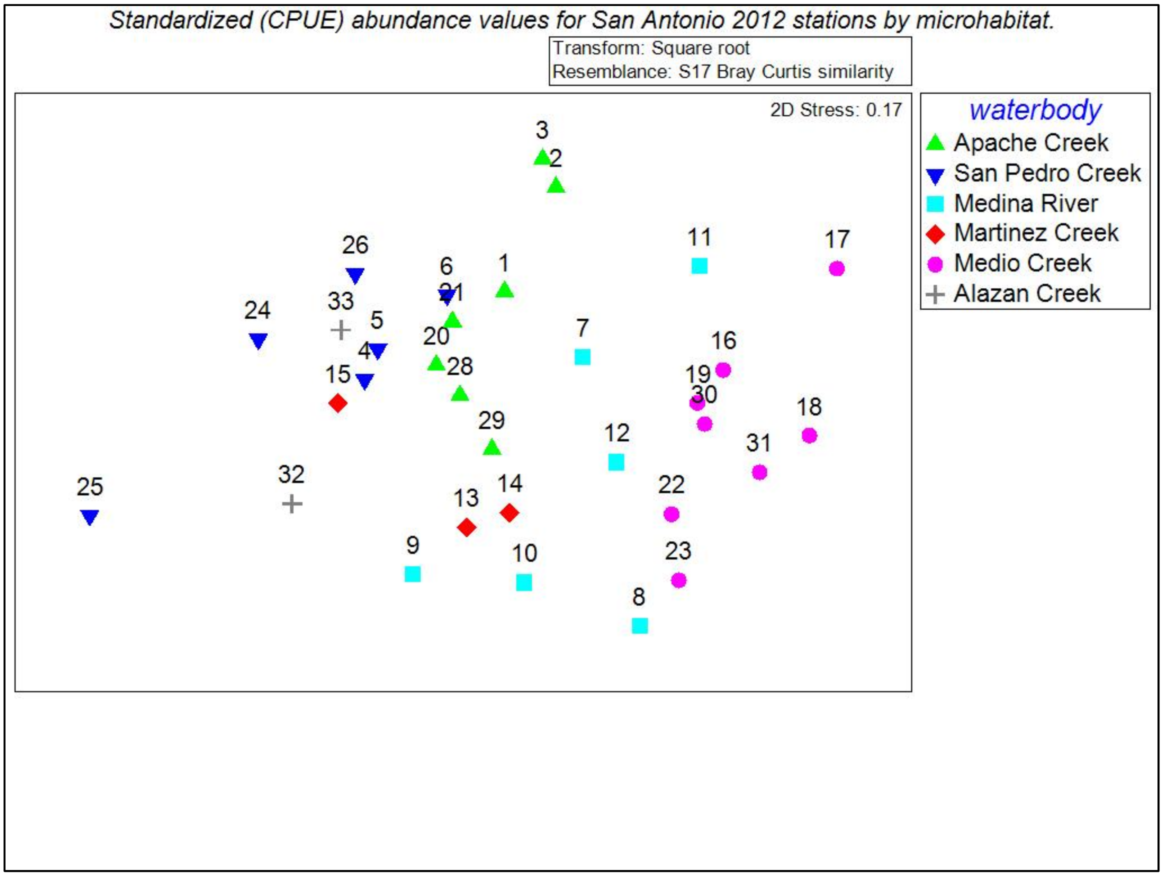

Figure 17. MDS of fish samples conducted at 34 macrohabitat units distributed across 15 stations within the project area.

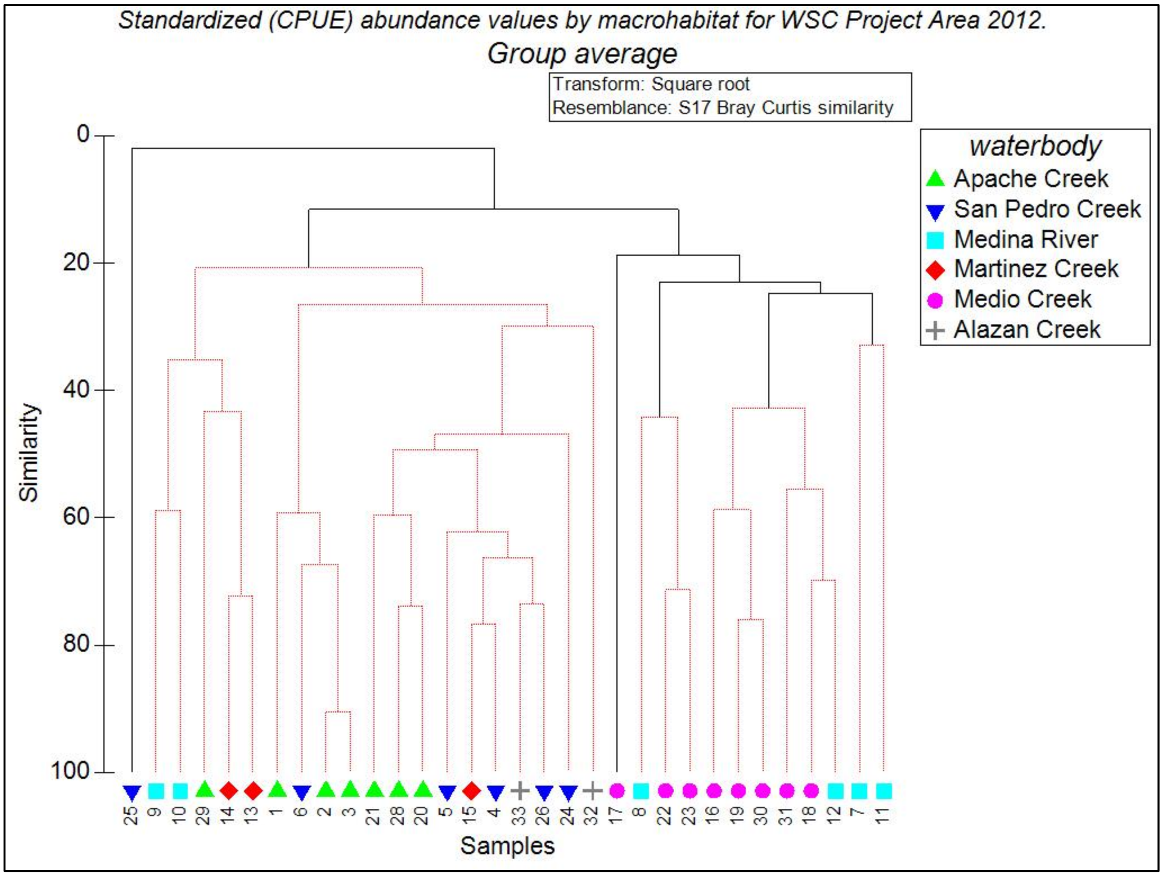

Figure 18. CLUSTER depicting faunal similarity between sampled macrohabitat units. Statistically significant clusters are noted by black linkages; non-significant clusters are in red.

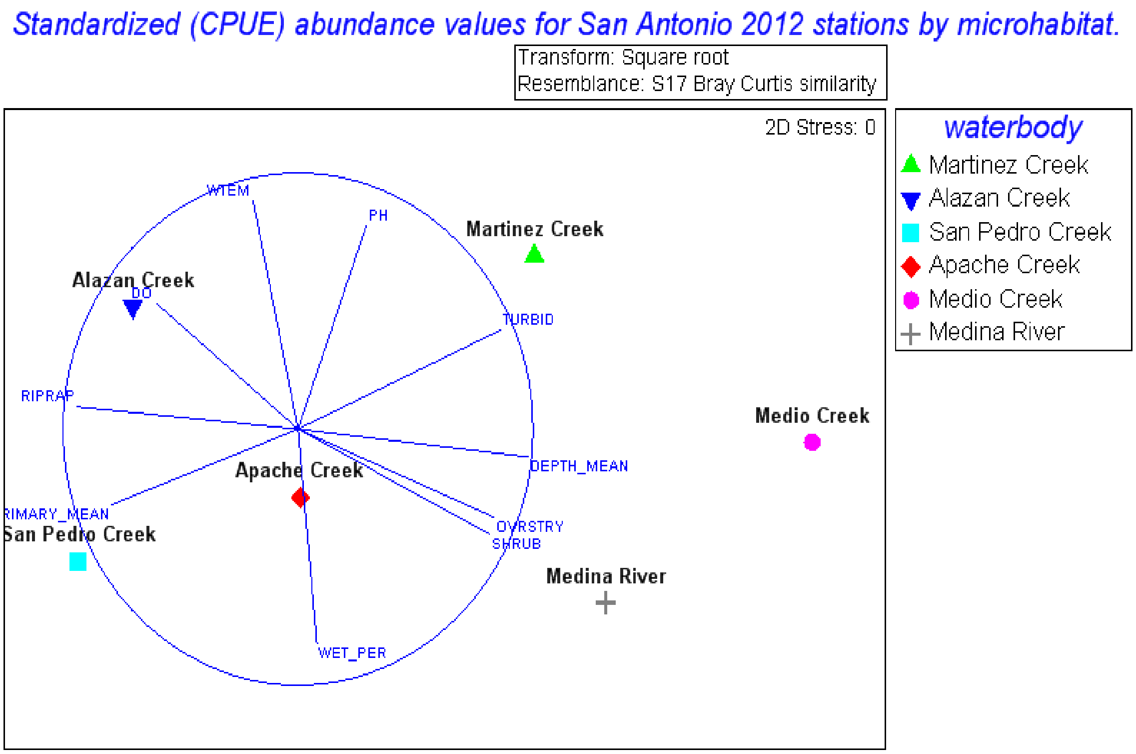

Figure 19. MDS plot of the average resemblance matrix by waterbody with vectors associated with habitat variables.

Table 20. . Species of fishes collected at each of the 15 sample locations within the project area including the specific macrohabitat unit sampled (e.g., glide, riffle, run, pool, backwater). All sampling was conducted with either a 10 or 20' seine; electrofishing samples are noted with an asterisk superscript (i.e., riffle*). Diversity (Shannon H' [Log e]), richness (Margalef d = [S-1]/Log[N]) and eveness (Pielou J' = H'/Log[S]) index values were computed with standardized CPUE values.

		Westside Stations			Westside Stations	Westside Stations	Westside Stations
		Martinez Creek			Martinez Creek	Alazan Creek	Alazan Creek
		Run	Pool	TOTAL	Pool	Pool	Pool
Scientific Name	Common name	1			2	3	4
Cyprinidae							
Campostoma anomalum	Central stoneroller	15	182	197	418	12	1
Cyprinella lutrensis	Red shiner				5		5
Cyprinella venusta	Blacktail shiner						
Cyprinus carpio	Common carp					1	
Notemigonus crysoleucas	Golden shiner						
Notropis stramineus	Sand shiner						
Notropis volucellus	Mimic shiner						
Pimephales vigilax	Bullhead minnow						
Characidae							
Astyanax mexicanus	Mexican tetra						
Ictaluridae							
Ictalurus punctatus	Channel catfish						
Poeciliidae							
Gambusia affinis	Western mosquitofish		32	32	2		
Poecilia latipinna	Sailfin molly		2	2			
Centrarchidae							
Lepomis auritus	Redbreast sunfish						
Lepomis cyanellus	Green sunfish						
Lepomis gulosus	Warmouth						
Lepomis macrochirus	Bluegill				2		
Lepomis megalotis	Longear sunfish						
Lepomis minitatus	Redspotted sunfish						
Micropterus salmoides	Largemouth bass						
Micropterus treculii	Guadalupe bass						
Percidae							
Etheostoma spectabile	Orangethroat darter						
Percina carbonaria	Texas logperch						
Cichlidae							
Herichthys cyanoguttatus	Rio Grande cichlid						
	TOTAL INDIVIDUALS	**15**	**216**	**231**	**427**	**13**	**6**
	Number of species	**1**	**3**	**3**	**4**	**2**	**2**
	Diversity (H')	0.000	0.471	0.456	0.123	0.271	0.451
	Richness (d)	0.000	0.468	0.462	0.675	1.615	0.558
	Eveness (J')	0.000	0.428	0.415	0.089	0.391	0.650

Table 20 (con't).

Westside Stations			Westside Stations			Westside Stations		
San Pedro Creek			San Pedro Creek			San Pedro Creek		
Glide*	Glide	TOTAL	Glide*	Glide	TOTAL	Riffle*	Riffle	TOTAL
5			6			7		
14	3	17	26	9	35	38	1	39
						1		1
			37	10	47	7		7
			2		2			
			1		1			
1		1						
15	**3**	**18**	**66**	**19**	**85**	**46**	**1**	**47**
2	**1**	**2**	**4**	**2**	**4**	**3**	**1**	**3**
0.245	0.000	0.207	0.861	0.692	0.834	0.528	0.000	0.527
2.842	0.000	1.707	1.492	1.338	1.328	1.348	0.000	1.348
0.353	0.000	0.298	0.621	0.998	0.602	0.480	0.000	0.480

Table 20 (con't).

Westside Stations				Westside Stations						Westside Stations
Apache Creek				Apache Creek						Apache Creek
Glide	Pool	Confluence	TOTAL	Riffle	Glide	Pool	Glide*	Pool*	TOTAL	Pool
8				9						10
2			2		12	36	6	5	59	
					2	23			25	
20	23	36	79							
						1			1	
2	2	1	5		5	11	2	2	20	
								3	3	
								1	1	
						1			1	
24	**25**	**37**	**86**	**0**	**19**	**72**	**8**	**11**	**110**	**0**
3	**2**	**2**	**3**	**0**	**3**	**5**	**2**	**4**	**7**	**0**
0.566	0.279	0.124	0.475	0.000	0.879	1.117	0.562	1.241	1.190	0.000
0.629	0.621	0.550	0.562	0.000	2.003	1.610	3.476	9.673	2.100	0.000
0.515	0.402	0.179	0.433	0.000	0.800	0.694	0.811	0.895	0.612	0.000

Medio Stations					Medio Stations			Medio Stations		
Medio Creek					Medio Creek			Medio Creek		
Glide	Run	Riffle	Backwater	TOTAL	Glide	Backwater	TOTAL	Riffle	Glide	TOTAL
11					12			13		
		1		1	1		1	35	35	70
								5	14	19
								1		1
								1	4	5
			2	2		2	2			
55		17	351	423	35	74	109	12	2	14
			7	7	8	28	36			
	1		1	2						
4	3	3	7	17	2	18	20	1	10	11
		1		1	3	8	11	8	17	25
4	2			6						
		1	1	2	2	10	12			
								1	1	2
3	1	13	6	23	7	3	10	1		1
66	**7**	**36**	**375**	**484**	**58**	**143**	**201**	**65**	**83**	**148**
4	**4**	**6**	**7**	**10**	**7**	**7**	**8**	**9**	**7**	**9**
0.632	1.277	1.228	0.336	0.453	1.289	1.409	1.420	1.422	1.533	1.578
1.422	1.542	3.607	1.243	1.826	3.220	1.892	2.053	4.046	2.426	2.713
0.456	0.921	0.685	0.173	0.197	0.662	0.724	0.683	0.647	0.788	0.718

Table 20 (con't).

Table 20. (concluded).

Medina Stations			Medina Stations					Project Area
Medina River			Medina River					System
Run*	Run	TOTAL	Riffle	Glide	Glide*	Backwater	TOTAL	Site description
14			15					Station No.
3		3	40	140		10	190	973
								108
3	46	49	94	308		1	403	471
								134
								1
				3			3	3
								1
								5
								4
3		3						3
2	2	4		28	2	354	384	995
1		1						46
2		2						2
								6
								1
						10	10	60
	3	3		5		2	7	47
1		1						7
								15
	1	1						3
			2	10	12		24	24
1		1						1
4		4			3	3	6	45
20	**52**	**72**	**136**	**494**	**17**	**380**	**1027**	**2955**
9	**4**	**11**	**3**	**6**	**3**	**6**	**8**	**23**
2.086	0.474	1.424	0.677	0.971	0.804	0.339	1.254	
8.535	1.820	4.883	0.606	1.089	1.962	1.155	1.315	
0.949	0.342	0.594	0.617	0.542	0.732	0.189	0.603	

Table 21. Results from ANOSIM procedure to assess differences in habitat similarity between sampled waterbodies.

ANOSIM

Habitat similarity between waterbodies

Global Test
Sample statistic (Global R): 0.584
Significance level of sample statistic: 0.1% (P =[0.001])
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to Global R: 0

Pairwise Tests

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
Apache Creek, San Pedro Creek	-0.001	0.446	5005	999	445
Apache Creek, Medina River	0.650	0.001	5005	999	0
Apache Creek, Martinez Creek	0.426	0.055	220	220	12
Apache Creek, Medio Creek	0.775	0.001	24310	999	0
Apache Creek, Alazan Creek	-0.147	0.618	55	55	34
San Pedro Creek, Medina River	0.831	0.002	462	462	1
San Pedro Creek, Martinez Creek	0.821	0.012	84	84	1
San Pedro Creek, Medio Creek	0.957	0.002	3003	999	1
San Pedro Creek, Alazan Creek	0.302	0.179	28	28	5
Medina River, Martinez Creek	0.981	0.012	84	84	1
Medina River, Medio Creek	0.690	0.001	3003	999	0
Medina River, Alazan Creek	0.948	0.036	28	28	1
Martinez Creek, Medio Creek	0.739	0.006	165	165	1
Martinez Creek, Alazan Creek	0.167	0.300	10	10	3
Medio Creek, Alazan Creek	0.970	0.022	45	45	1

Table 22. Results from PCA assessment on measured habitat features from 34 sampled macrohabitat units. Loadings highlighted in yellow were considered strong loadings.

PCA
Principal Component Analysis

Data worksheet
Name: Data5
Data type: Environmental
Sample selection: All
Variable selection: All

Eigenvalues

PC	Eigenvalues	%Variation	Cum.%Variation
1	6.64	30.2	30.2
2	3.52	16.0	46.2
3	3.06	13.9	60.1
4	2.53	11.5	71.6
5	1.43	6.5	78.1

Eigenvectors
(Coefficients in the linear combinations of variables making up PC's)

Variable	PC1	PC2	PC3	PC4	PC5
WTEM	-0.050	0.354	-0.262	-0.057	-0.168
DO	-0.201	0.143	-0.373	-0.092	-0.183
COND	0.104	0.160	-0.214	-0.181	-0.206
PH	0.021	0.354	-0.245	-0.185	0.018
TURBID	0.309	0.156	0.166	0.037	0.111
SITE_LNGTH_M	-0.216	-0.273	-0.104	-0.057	0.264
SV_MEAN	0.126	-0.200	-0.232	0.365	0.130
SV_CV	-0.100	-0.085	0.292	0.126	0.161
DEPTH_MEAN	0.179	-0.162	-0.080	-0.429	0.329
DEPTH_STD	0.116	-0.234	-0.120	-0.483	0.020
DEPTH_CV	-0.001	-0.216	0.042	-0.346	-0.390
WIDTH_DEPTH_RATIO	-0.105	-0.163	-0.205	0.428	-0.357
WET_PER	0.088	-0.392	-0.281	0.013	-0.161
OVRSTRY	0.370	-0.036	-0.011	0.077	0.042
SHRUB	0.368	-0.078	-0.054	0.088	0.068
HERB	-0.158	0.307	0.267	-0.035	0.149
RIPRAP	-0.354	0.010	0.042	-0.026	0.086
OVR_W	0.366	-0.059	-0.035	0.092	0.097
SUB_PRIMARY_MEAN	-0.255	-0.100	-0.207	0.017	0.394
SUB_PRIMARY_STD	-0.109	-0.204	0.307	-0.149	-0.146
SUB_SECONDARY_MEAN	-0.238	-0.136	-0.288	0.024	0.261
SUB_SECONDARY_STD	-0.150	-0.271	0.261	-0.032	-0.257

Table 23. Results from ANOSIM procedure to assess differences in faunal similarity between sampled waterbodies.

ANOSIM
Analysis of Similarities

Resemblance worksheet
Name: Resem7
Data type: Similarity
Selection: All

Global Test
Sample statistic (Global R): 0.506
Significance level of sample statistic: 0.1% (P = 0.001)
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to Global R: 0

Pairwise Tests

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
Martinez Creek, Alazan Creek	0.750	0.100	10	10	1
Martinez Creek, San Pedro Creek	0.228	0.167	84	84	14
Martinez Creek, Apache Creek	0.302	0.092	120	120	11
Martinez Creek, Medio Creek	0.742	0.006	165	165	1
Martinez Creek, Medina River	0.235	0.107	84	84	9
Alazan Creek, San Pedro Creek	-0.135	0.607	28	28	17
Alazan Creek, Apache Creek	0.182	0.194	36	36	7
Alazan Creek, Medio Creek	0.940	0.022	45	45	1
Alazan Creek, Medina River	0.740	0.036	28	28	1
San Pedro Creek, Apache Creek	0.127	0.110	1716	999	109
San Pedro Creek, Medio Creek	0.922	0.002	3003	999	1
San Pedro Creek, Medina River	0.574	0.002	462	462	1
Apache Creek, Medio Creek	0.706	0.001	6435	999	0
Apache Creek, Medina River	0.476	0.003	1716	999	2
Medio Creek, Medina River	0.376	0.004	3003	999	3

Table 24. Results from SIMPER procedure to describe percent faunal similarity between sampled waterbodies.

SIMPER

Similarity Percentages - species contributions

CPUE species abundance matrix

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 90.00%

Groups Martinez Creek & San Pedro Creek
Average dissimilarity = 72.46

Species	Group Martinez Creek Av.Abund	Group San Pedro Creek Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Central stoneroller	6.29	1.07	48.08	1.96	66.36	66.36
Western mosquitofish	1.30	0.08	9.64	0.92	13.30	79.66
Common carp	0.00	0.65	7.01	0.73	9.67	89.33
Red shiner	0.33	0.05	2.87	0.80	3.96	93.28

Groups Alazan Creek & Medina River
Average dissimilarity = 91.00

Species	Group Alazan Creek Av.Abund	Group Medina River Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Blacktail shiner	0.00	2.57	23.81	1.15	26.16	26.16
Western mosquitofish	0.00	2.05	16.81	0.85	18.48	44.64
Central stoneroller	0.84	1.69	15.30	1.55	16.82	61.45
Orangethroat darter	0.00	0.57	7.98	0.63	8.77	70.22
Red shiner	0.42	0.00	6.14	0.77	6.75	76.97
Rio Grande cichlid	0.00	0.36	5.67	0.82	6.24	83.21
Longear sunfish	0.00	0.36	3.41	0.81	3.75	86.96
Common carp	0.19	0.00	2.53	0.79	2.78	89.74
Channel catfish	0.00	0.10	1.69	0.43	1.86	91.60

Table 25. Results from SIMPER procedure to describe percent similarity of environmental variables between Westside Creek (Group 1) and reference stations (Group 2).

SIMPER

Similarity Percentages - species contributions
One-Way Analysis

Data worksheet
Name: Data5
Data type: Environmental
Sample selection: 1-26,28-33
Variable selection: All

Parameters
Resemblance: D1 Euclidean distance
Cut off for low contributions: 90.00%

Factor Groups
Sample restoration_code

Group 1 – Westside Creek stations
Group 2 – Medina and Medio

Groups 1 & 2
Average squared distance = 51.82

Variable	Group 1 Av. Value	Group 2 Av. Value	Av.Sq.Dist	Sq.Dist/SD	Contrib%	Cum.%
SHRUB	-0.795	1.140	3.89	2.45	7.51	7.51
OVRSTRY	-0.782	1.120	3.84	2.35	7.42	14.93
OVR_W	-0.773	1.100	3.81	1.84	7.35	22.28
RIPRAP	0.710	-1.040	3.46	2.82	6.68	28.96
HERB	0.548	-0.782	3.09	0.77	5.95	34.92
TURBID	-0.425	0.667	2.62	0.93	5.06	39.97
SV_MEAN	-0.459	0.539	2.59	0.95	5.00	44.97
SITE_LNGTH_M	0.403	-0.470	2.46	0.62	4.74	49.71
SUB_PRIMARY_MEAN	0.343	-0.596	2.41	0.63	4.65	54.37
SUB_SECONDARY_MEAN	0.249	-0.512	2.21	0.84	4.26	58.62
DEPTH_MEAN	-0.256	0.538	2.09	0.80	4.03	62.66
WET_PER	-0.233	0.519	2.07	0.66	4.00	66.66
SUB_PRIMARY_STD	0.194	-0.240	2.05	0.95	3.95	70.61
DEPTH_STD	-0.161	0.410	2.03	0.77	3.92	74.53
WIDTH_DEPTH_RATIO	6.21E-4	-7.69E-2	2.03	0.80	3.92	78.45
SUB_SECONDARY_STD	0.221	-0.284	2.02	0.96	3.90	82.35
DO	0.258	-0.451	1.88	0.72	3.62	85.97
SV_CV	6.68E-2	-0.235	1.85	0.75	3.58	89.55
DEPTH_CV	0.197	1.21E-4	1.6	0.87	3.08	92.63

ATTACHMENT 5-1:DETIALED DESCRIPTIONS OF EACH SAMPLE STATION AND THE GENERAL SAMPLING CONDITIONS NOTED DURING SAMPLING EFFORTS.

Appendix I. Detailed descriptions of each sample station and the general sampling conditions noted during sampling efforts.

SUMMARY LOCALITY DATA FOR WESTSIDE CREEK PROJECT

COLLECTION NUMBER: 1 **ERDC STATION NUMBER:** 8

TDEQ SITE NUMBER:

STATE: Texas **County:** Bexar

WATER BODY: Apache Creek

LOCALE: Apache Creek at confluence of Alazan Creek at Laredo St.

LATITUDE (DD.dddd): 29.41272 **LONGITUDE (DD.dddd):** -98.5097

DATE (M/D/YY): 4 / 11 / 12 **TIME:** 10:47

GEAR: 10' Seine **EFFORT (HAULS/SECONDS):** 1

WATER TEMPERATURE (C): 23.04 **CONDUCTIVITY (µS):** 1010

pH: 8.37 **DISSOLVED OXYGEN (mg/L):** 9.66

TURBIDITY (NTU): 3.3 **SITE LENGTH (m):** 30

STREAM WIDTH (m): 5.334

COLLECTION NUMBER: 2 **ERDC STATION NUMBER:** 8

TDEQ SITE NUMBER:

STATE: Texas **County:** Bexar

WATER BODY: Apache Creek

LOCALE: Apache Creek at confluence of Alazan Creek at Laredo St.

LATITUDE (DD.dddd): 29.41237 **LONGITUDE (DD.dddd):** -98.50931

DATE (M/D/YY): 4 / 11 / 12 **TIME:** 10:47

GEAR: 10' Seine **EFFORT (HAULS/SECONDS):** 5

WATER TEMPERATURE (C): 23.04 **CONDUCTIVITY (µS):** 1010

pH: 8.37 **DISSOLVED OXYGEN (mg/L):** 9.66

TURBIDITY (NTU): 3.3 **SITE LENGTH (m):** 32

STREAM WIDTH (m): 6.858

COLLECTION NUMBER: 3 **ERDC STATION NUMBER:** 8

TDEQ SITE NUMBER:

STATE: Texas **County:** Bexar

WATER BODY: Apache Creek

LOCALE: Apache Creek at confluence of Alazan Creek at Laredo St.

LATITUDE (DD.dddd): 29.41205 **LONGITUDE (DD.dddd):** -98.5091

DATE (M/D/YY): 4 / 11 / 12 **TIME:** 10:47

GEAR: 10' Seine **EFFORT (HAULS/SECONDS):** 6

WATER TEMPERATURE (C): 23.04 **CONDUCTIVITY (µS):** 1010

pH: 8.37 **DISSOLVED OXYGEN (mg/L):** 9.66

TURBIDITY (NTU): 3.3 **SITE LENGTH (m):** 27

STREAM WIDTH (m): 7.4676

COLLECTION NUMBER: 4 **ERDC STATION NUMBER:** 7

TDEQ SITE NUMBER:

STATE: Texas **County:** Bexar

WATER BODY: San Pedro Creek

LOCALE: San Pedro Creek above confluence with Alazan Creek

LATITUDE (DD.dddd): 29.40838 **LONGITUDE (DD.dddd):** -98.50959

DATE (M/D/YY): 4 / 11 / 12 **TIME:** 8:20

GEAR: Electroshocker **EFFORT (HAULS/SECONDS):** 626

WATER TEMPERATURE (C): 21.92 **CONDUCTIVITY (µS):** 702

pH: 7.97 **DISSOLVED OXYGEN (mg/L):** 6.91

TURBIDITY (NTU): 2.88 **SITE LENGTH (m):** 38

STREAM WIDTH (m): 6.5532

COLLECTION NUMBER: 5 **ERDC STATION NUMBER:** 5
TDEQ SITE NUMBER: 20119
STATE: Texas **County:** Bexar
WATER BODY: San Pedro Creek
LOCALE: San Pedro Creek above I-35
LATITUDE (DD.dddd): 29.40853 **LONGITUDE (DD.dddd):** -98.50991
DATE (M/D/YY): 4 / 11 / 12 **TIME:** 8:45
GEAR: Electroshocker **EFFORT (HAULS/SECONDS):** 633
WATER TEMPERATURE (C): 21.98 **CONDUCTIVITY (µS):** 698
pH: 7.92 **DISSOLVED OXYGEN (mg/L):** 6.27
TURBIDITY (NTU): 2.86 **SITE LENGTH (m):** 37
STREAM WIDTH (m): 5.12064

COLLECTION NUMBER: 6 **ERDC STATION NUMBER:** 6
TDEQ SITE NUMBER: 14924
STATE: Texas **County:** Bexar
WATER BODY: San Pedro Creek
LOCALE: San Pedro Creek below confluence with Alazan Creek
LATITUDE (DD.dddd): 29.40823 **LONGITUDE (DD.dddd):** -98.51
DATE (M/D/YY): 4 / 11 / 12 **TIME:** 8:00
GEAR: Electroshocker **EFFORT (HAULS/SECONDS):** 530
WATER TEMPERATURE (C): 21.73 **CONDUCTIVITY (µS):** 698
pH: 7.91 **DISSOLVED OXYGEN (mg/L):** 5.37
TURBIDITY (NTU): 3.65 **SITE LENGTH (m):** 40
STREAM WIDTH (m): 12

COLLECTION NUMBER: 7 **ERDC STATION NUMBER:** 14
TDEQ SITE NUMBER: 14200
STATE: Texas **County:** Bandera
WATER BODY: Medina River
LOCALE: Medina River at County Road 484
LATITUDE (DD.dddd): 29.32796 **LONGITUDE (DD.dddd):** -98.79183
DATE (M/D/YY): 4 / 12 / 12 **TIME:** 14:20
GEAR: Electroshocker **EFFORT (HAULS/SECONDS):** 470
WATER TEMPERATURE (C): 23.43 **CONDUCTIVITY (µS):** 525
pH: 8.07 **DISSOLVED OXYGEN (mg/L):** 6.81
TURBIDITY (NTU): 17.3 **SITE LENGTH (m):** 17
STREAM WIDTH (m): 11

COLLECTION NUMBER: 8 **ERDC STATION NUMBER:** 14
TDEQ SITE NUMBER: 14200
STATE: Texas **County:** Bandera
WATER BODY: Medina River
LOCALE: Medina River at County Road 484
LATITUDE (DD.dddd): 29.32796 **LONGITUDE (DD.dddd):** -98.79183
DATE (M/D/YY): 4 / 12 / 12 **TIME:** 15:25
GEAR: 10' Seine **EFFORT (HAULS/SECONDS):** 10
WATER TEMPERATURE (C): 23.43 **CONDUCTIVITY (µS):** 525
pH: 8.07 **DISSOLVED OXYGEN (mg/L):** 6.81
TURBIDITY (NTU): 17.3 **SITE LENGTH (m):** 35
STREAM WIDTH (m): 11

COLLECTION NUMBER: 9 **ERDC STATION NUMBER:** 15
TDEQ SITE NUMBER: 12380
STATE: Texas **County:** Bandera
WATER BODY: Medina River
LOCALE: Medina River at Old English
LATITUDE (DD.dddd): 29.68139 **LONGITUDE (DD.dddd):** -98.97608
DATE (M/D/YY): 4 / 12 / 12 **TIME:** 12:35
GEAR: 20' Seine **EFFORT (HAULS/SECONDS):** 5
WATER TEMPERATURE (C): 23.65 **CONDUCTIVITY (µS):** 601
pH: 8.08 **DISSOLVED OXYGEN (mg/L):** 8.68
TURBIDITY (NTU): 3.17 **SITE LENGTH (m):** 39
STREAM WIDTH (m): 21

COLLECTION NUMBER: 10 **ERDC STATION NUMBER:** 15
TDEQ SITE NUMBER: 12380
STATE: Texas **County:** Bandera
WATER BODY: Medina River
LOCALE: Medina River at Old English
LATITUDE (DD.dddd): 29.68104 **LONGITUDE (DD.dddd):** -98.97643
DATE (M/D/YY): 4 / 12 / 12 **TIME:** 12:50
GEAR: 20' Seine **EFFORT (HAULS/SECONDS):** 5
WATER TEMPERATURE (C): 23.65 **CONDUCTIVITY (µS):** 601
pH: 8.08 **DISSOLVED OXYGEN (mg/L):** 8.68
TURBIDITY (NTU): 3.17 **SITE LENGTH (m):** 38
STREAM WIDTH (m): 19

COLLECTION NUMBER: 11
ERDC STATION NUMBER: 15
TDEQ SITE NUMBER: 12380
STATE: Texas
County: Bandera
WATER BODY: Medina River
LOCALE: Medina River at Old English
LATITUDE (DD.dddd): 29.68104
LONGITUDE (DD.dddd): -98.97643
DATE (M/D/YY): 4 / 12 / 12
TIME: 13:05
GEAR: Electroshocker
EFFORT (HAULS/SECONDS): 368
WATER TEMPERATURE (C): 23.65
CONDUCTIVITY (µS): 601
pH: 8.08
DISSOLVED OXYGEN (mg/L): 8.68
TURBIDITY (NTU): 3.17
SITE LENGTH (m): 38
STREAM WIDTH (m): 19

COLLECTION NUMBER: 12
ERDC STATION NUMBER: 15
TDEQ SITE NUMBER: 12380
STATE: Texas
County: Bandera
WATER BODY: Medina River
LOCALE: Medina River at Old English
LATITUDE (DD.dddd): 29.6807
LONGITUDE (DD.dddd): -98.97653
DATE (M/D/YY): 4 / 12 / 12
TIME: 13:20
GEAR: 20' Seine
EFFORT (HAULS/SECONDS): 5
WATER TEMPERATURE (C): 23.65
CONDUCTIVITY (µS): 601
pH: 8.08
DISSOLVED OXYGEN (mg/L): 8.68
TURBIDITY (NTU): 3.17
SITE LENGTH (m): 38
STREAM WIDTH (m): 10

COLLECTION NUMBER: 13 **ERDC STATION NUMBER:** 2
TDEQ SITE NUMBER:
STATE: Texas **County:** Bexar
WATER BODY: Martinez Creek
LOCALE: Martinez Creek at Ruiz St.
LATITUDE (DD.dddd): 29.43632 **LONGITUDE (DD.dddd):** -98.51665
DATE (M/D/YY): 4 / 11 / 12 **TIME:**
GEAR: 10' Seine **EFFORT (HAULS/SECONDS):** 5
WATER TEMPERATURE (C): 27.63 **CONDUCTIVITY (µS):** 719
pH: 10.31 **DISSOLVED OXYGEN (mg/L):** 14.94
TURBIDITY (NTU): 4.89 **SITE LENGTH (m):** 31
STREAM WIDTH (m): 5.4864

COLLECTION NUMBER: 14 **ERDC STATION NUMBER:** 1
TDEQ SITE NUMBER: 15723
STATE: Texas **County:** Bexar
WATER BODY: Martinez Creek
LOCALE: Martinez Creek at West Hildebrand Ave.
LATITUDE (DD.dddd): 29.46861 **LONGITUDE (DD.dddd):** -98.51423
DATE (M/D/YY): 4 / 11 / 12 **TIME:** 16:22
GEAR: 10' Seine **EFFORT (HAULS/SECONDS):** 3
WATER TEMPERATURE (C): 28.03 **CONDUCTIVITY (µS):** 1970
pH: 8.67 **DISSOLVED OXYGEN (mg/L):** 7.27
TURBIDITY (NTU): 13.3 **SITE LENGTH (m):** 13
STREAM WIDTH (m): 2.667

COLLECTION NUMBER: 15 **ERDC STATION NUMBER:** 1

TDEQ SITE NUMBER: 15723

STATE: Texas **County:** Bexar

WATER BODY: Martinez Creek

LOCALE: Martinez Creek at West Hildebrand Ave.

LATITUDE (DD.dddd): 29.46854 **LONGITUDE (DD.dddd):** -98.51429

DATE (M/D/YY): 4 / 11 / 12 **TIME:** 16:11

GEAR: 10' Seine **EFFORT (HAULS/SECONDS):** 4

WATER TEMPERATURE (C): 28.27 **CONDUCTIVITY (µS):** 1970

pH: 8.8 **DISSOLVED OXYGEN (mg/L):** 7.62

TURBIDITY (NTU): 15.2 **SITE LENGTH (m):** 15

STREAM WIDTH (m): 1.2192

COLLECTION NUMBER: 16 **ERDC STATION NUMBER:** 11

TDEQ SITE NUMBER: 12735

STATE: Texas **County:** Bexar

WATER BODY: Medio Creek

LOCALE: Medio Creek at Hwy. 90

LATITUDE (DD.dddd): 29.39128 **LONGITUDE (DD.dddd):** -98.66821

DATE (M/D/YY): 4 / 12 / 12 **TIME:** 12:05

GEAR: 10' Seine **EFFORT (HAULS/SECONDS):** 8

WATER TEMPERATURE (C): 25.16 **CONDUCTIVITY (µS):** 1062

pH: 8.12 **DISSOLVED OXYGEN (mg/L):** 6.31

TURBIDITY (NTU): 9.61 **SITE LENGTH (m):** 17

STREAM WIDTH (m): 5.334

COLLECTION NUMBER: 17
ERDC STATION NUMBER: 11
TDEQ SITE NUMBER: 12735
STATE: Texas
County: Bexar
WATER BODY: Medio Creek
LOCALE: Medio Creek at Hwy. 90
LATITUDE (DD.dddd): 29.39118
LONGITUDE (DD.dddd): -98.42
DATE (M/D/YY): 4 / 12 / 12
TIME: 12:05
GEAR: 10' Seine
EFFORT (HAULS/SECONDS): 8
WATER TEMPERATURE (C): 25.16
CONDUCTIVITY (µS): 1062
pH: 8.12
DISSOLVED OXYGEN (mg/L): 6.31
TURBIDITY (NTU): 9.61
SITE LENGTH (m): 21
STREAM WIDTH (m): 6.5532

COLLECTION NUMBER: 18
ERDC STATION NUMBER: 11
TDEQ SITE NUMBER: 12735
STATE: Texas
County: Bexar
WATER BODY: Medio Creek
LOCALE: Medio Creek at Hwy. 90
LATITUDE (DD.dddd): 29.39146
LONGITUDE (DD.dddd): -98.66848
DATE (M/D/YY): 4 / 12 / 12
TIME: 12:05
GEAR: 10' Seine
EFFORT (HAULS/SECONDS): 3
WATER TEMPERATURE (C): 25.16
CONDUCTIVITY (µS): 1062
pH: 8.12
DISSOLVED OXYGEN (mg/L): 6.31
TURBIDITY (NTU): 9.61
SITE LENGTH (m): 5.4864
STREAM WIDTH (m): 3.5052

COLLECTION NUMBER: 19
ERDC STATION NUMBER: 11
TDEQ SITE NUMBER: 12735
STATE: Texas
County: Bexar
WATER BODY: Medio Creek
LOCALE: Medio Creek at Hwy. 90
LATITUDE (DD.dddd): 29.39138
LONGITUDE (DD.dddd): -98.43
DATE (M/D/YY): 4 / 12 / 12
TIME: 12:05
GEAR: 10' Seine
EFFORT (HAULS/SECONDS): 9
WATER TEMPERATURE (C): 25.16
CONDUCTIVITY (µS): 1062
pH: 8.12
DISSOLVED OXYGEN (mg/L): 6.31
TURBIDITY (NTU): 9.61
SITE LENGTH (m): 15
STREAM WIDTH (m): 11.5824

COLLECTION NUMBER: 20
ERDC STATION NUMBER: 9
TDEQ SITE NUMBER: 18735
STATE: Texas
County: Bexar
WATER BODY: Apache Creek
LOCALE: Apache Creek at S. Brazos St.
LATITUDE (DD.dddd): 29.41471
LONGITUDE (DD.dddd): -98.51398
DATE (M/D/YY): 4 / 12 / 12
TIME: 9:49
GEAR: Electroshocker
EFFORT (HAULS/SECONDS): 360
WATER TEMPERATURE (C): 23.06
CONDUCTIVITY (µS): 1141
pH: 7.79
DISSOLVED OXYGEN (mg/L): 6
TURBIDITY (NTU): 2.28
SITE LENGTH (m): 35
STREAM WIDTH (m): 4.7244

COLLECTION NUMBER: 21 **ERDC STATION NUMBER:** 9

TDEQ SITE NUMBER: 18735

STATE: Texas **County:** Bexar

WATER BODY: Apache Creek

LOCALE: Apache Creek at S. Brazos St.

LATITUDE (DD.dddd): 29.41455 **LONGITUDE (DD.dddd):** -98.51362

DATE (M/D/YY): 4 / 12 / 12 **TIME:** 9:49

GEAR: Electroshocker **EFFORT (HAULS/SECONDS):** 484

WATER TEMPERATURE (C): 23.06 **CONDUCTIVITY (µS):** 1141

pH: 7.79 **DISSOLVED OXYGEN (mg/L):** 6

TURBIDITY (NTU): 2.28 **SITE LENGTH (m):** 87

STREAM WIDTH (m): 7.0104

COLLECTION NUMBER: 22 **ERDC STATION NUMBER:** 13

TDEQ SITE NUMBER: 12916

STATE: Texas **County:** Bexar

WATER BODY: Medio Creek

LOCALE: Medio Creek at Hidden Valley Campground

LATITUDE (DD.dddd): 29.28971 **LONGITUDE (DD.dddd):** -98.6198

DATE (M/D/YY): 4 / 12 / 12 **TIME:** 9:00

GEAR: 10' Seine **EFFORT (HAULS/SECONDS):** 9

WATER TEMPERATURE (C): 22.91 **CONDUCTIVITY (µS):** 844

pH: 8.81 **DISSOLVED OXYGEN (mg/L):** 4.61

TURBIDITY (NTU): 31.6 **SITE LENGTH (m):** 19

STREAM WIDTH (m): 5.4864

COLLECTION NUMBER: 23 **ERDC STATION NUMBER:** 13

TDEQ SITE NUMBER: 12916

STATE: Texas **County:** Bexar

WATER BODY: Medio Creek

LOCALE: Medio Creek at Hidden Valley Campground

LATITUDE (DD.dddd): 29.28946 **LONGITUDE (DD.dddd):** -98.61967

DATE (M/D/YY): 4 / 12 / 12 **TIME:** 9:00

GEAR: 10' Seine **EFFORT (HAULS/SECONDS):** 7

WATER TEMPERATURE (C): 22.91 **CONDUCTIVITY (µS):** 844

pH: 8.81 **DISSOLVED OXYGEN (mg/L):** 4.61

TURBIDITY (NTU): 31.6 **SITE LENGTH (m):** 20

STREAM WIDTH (m): 6.096

COLLECTION NUMBER: 24 **ERDC STATION NUMBER:** 5

TDEQ SITE NUMBER: 20119

STATE: Texas **County:** Bexar

WATER BODY: San Pedro Creek

LOCALE: San Pedro Creek above I-35

LATITUDE (DD.dddd): 29.40853 **LONGITUDE (DD.dddd):** -98.50991

DATE (M/D/YY): 4 / 11 / 12 **TIME:**

GEAR: 10' Seine **EFFORT (HAULS/SECONDS):** 8

WATER TEMPERATURE (C): 26.97 **CONDUCTIVITY (µS):** 627

pH: 8.4 **DISSOLVED OXYGEN (mg/L):** 10.09

TURBIDITY (NTU): 3 **SITE LENGTH (m):** 37

STREAM WIDTH (m): 5.12064

COLLECTION NUMBER: 25 **ERDC STATION NUMBER:** 7

TDEQ SITE NUMBER:

STATE: Texas **County:** Bexar

WATER BODY: San Pedro Creek

LOCALE: San Pedro Creek above confluence with Alazan Creek

LATITUDE (DD.dddd): 29.40838 **LONGITUDE (DD.dddd):** -98.50959

DATE (M/D/YY): 4 / 11 / 12 **TIME:** 15:00

GEAR: 10' Seine **EFFORT (HAULS/SECONDS):** 9

WATER TEMPERATURE (C): 26.47 **CONDUCTIVITY (µS):** 629

pH: 8.42 **DISSOLVED OXYGEN (mg/L):** 9.54

TURBIDITY (NTU): 3.08 **SITE LENGTH (m):** 38

STREAM WIDTH (m): 6.5532

COLLECTION NUMBER: 26 **ERDC STATION NUMBER:** 6

TDEQ SITE NUMBER: 14924

STATE: Texas **County:** Bexar

WATER BODY: San Pedro Creek

LOCALE: San Pedro Creek below confluence with Alazan Creek

LATITUDE (DD.dddd): 29.40823 **LONGITUDE (DD.dddd):** -98.51

DATE (M/D/YY): 4 / 11 / 12 **TIME:** 14:42

GEAR: 10' Seine **EFFORT (HAULS/SECONDS):** 9

WATER TEMPERATURE (C): 26.95 **CONDUCTIVITY (µS):** 642

pH: 8.39 **DISSOLVED OXYGEN (mg/L):** 10.57

TURBIDITY (NTU): 3.64 **SITE LENGTH (m):** 40

STREAM WIDTH (m): 12

COLLECTION NUMBER: 27
ERDC STATION NUMBER: 9
TDEQ SITE NUMBER: 18735
STATE: Texas
County: Bexar
WATER BODY: Apache Creek
LOCALE: Apache Creek at S. Brazos St.
LATITUDE (DD.dddd): 29.41482
LONGITUDE (DD.dddd): -98.51455
DATE (M/D/YY): 4 / 11 / 12
TIME: 9:27
GEAR: 10' Seine
EFFORT (HAULS/SECONDS): 1
WATER TEMPERATURE (C): 20.94
CONDUCTIVITY (µS): 1.132
pH: 7.56
DISSOLVED OXYGEN (mg/L): 6.18
TURBIDITY (NTU): 4.86
SITE LENGTH (m): 25
STREAM WIDTH (m): 2.234184

COLLECTION NUMBER: 28
ERDC STATION NUMBER: 9
TDEQ SITE NUMBER: 18735
STATE: Texas
County: Bexar
WATER BODY: Apache Creek
LOCALE: Apache Creek at S. Brazos St.
LATITUDE (DD.dddd): 29.41471
LONGITUDE (DD.dddd): -98.51398
DATE (M/D/YY): 4 / 11 / 12
TIME: 9:27
GEAR: 10' Seine
EFFORT (HAULS/SECONDS): 7
WATER TEMPERATURE (C): 20.94
CONDUCTIVITY (µS): 1.132
pH: 7.56
DISSOLVED OXYGEN (mg/L): 6.18
TURBIDITY (NTU): 4.86
SITE LENGTH (m): 35
STREAM WIDTH (m): 4.7244

COLLECTION NUMBER: 29
ERDC STATION NUMBER: 9
TDEQ SITE NUMBER: 18735
STATE: Texas
County: Bexar
WATER BODY: Apache Creek
LOCALE: Apache Creek at S. Brazos St.
LATITUDE (DD.dddd): 29.41455
LONGITUDE (DD.dddd): -98.51362
DATE (M/D/YY): 4 / 11 / 12
TIME: 9:27
GEAR: 10' Seine
EFFORT (HAULS/SECONDS): 6
WATER TEMPERATURE (C): 20.94
CONDUCTIVITY (µS): 1132
pH: 7.56
DISSOLVED OXYGEN (mg/L): 6.18
TURBIDITY (NTU): 4.86
SITE LENGTH (m): 87
STREAM WIDTH (m): 7.0104

COLLECTION NUMBER: 30
ERDC STATION NUMBER: 12
TDEQ SITE NUMBER: 12730
STATE: Texas
County: Bexar
WATER BODY: Medio Creek
LOCALE: Medio Creek at Covel Rd.
LATITUDE (DD.dddd): 29.34995
LONGITUDE (DD.dddd): -98.64573
DATE (M/D/YY): 4 / 12 / 12
TIME: 10:45
GEAR: 10' Seine
EFFORT (HAULS/SECONDS): 9
WATER TEMPERATURE (C): 22.62
CONDUCTIVITY (µS): 1093
pH: 8.72
DISSOLVED OXYGEN (mg/L): 6.31
TURBIDITY (NTU): 11.4
SITE LENGTH (m): 27
STREAM WIDTH (m): 4.4196

COLLECTION NUMBER: 31 **ERDC STATION NUMBER:** 12
TDEQ SITE NUMBER: 12730
STATE: Texas **County:** Bexar
WATER BODY: Medio Creek
LOCALE: Medio Creek at Covel Rd.
LATITUDE (DD.dddd): 29.34988 **LONGITUDE (DD.dddd):** -98.64562
DATE (M/D/YY): 4 / 12 / 12 **TIME:** 11:05
GEAR: 10' Seine **EFFORT (HAULS/SECONDS):** 6
WATER TEMPERATURE (C): 22.07 **CONDUCTIVITY (µS):** 1067
pH: 8.52 **DISSOLVED OXYGEN (mg/L):** 5.79
TURBIDITY (NTU): 29.2 **SITE LENGTH (m):** 25
STREAM WIDTH (m): 6.4008

COLLECTION NUMBER: 32 **ERDC STATION NUMBER:** 4
TDEQ SITE NUMBER:
STATE: Texas **County:** Bexar
WATER BODY: Alazan Creek
LOCALE: Alazan Creek at confluence with Apache, upstream from Laredo St.
LATITUDE (DD.dddd): 29.41209 **LONGITUDE (DD.dddd):** -98.50901
DATE (M/D/YY): 4 / 11 / 12 **TIME:** 12:06
GEAR: 10' Seine **EFFORT (HAULS/SECONDS):** 7
WATER TEMPERATURE (C): 27.18 **CONDUCTIVITY (µS):** 661
pH: 8.19 **DISSOLVED OXYGEN (mg/L):** 9.91
TURBIDITY (NTU): 4.49 **SITE LENGTH (m):** 49
STREAM WIDTH (m): 6.4008

COLLECTION NUMBER: 33
ERDC STATION NUMBER: 3
TDEQ SITE NUMBER:
STATE: Texas
County: Bexar
WATER BODY: Alazan Creek
LOCALE: Alazan Creek at Tampico St.
LATITUDE (DD.dddd): 29.41278
LONGITUDE (DD.dddd): -98.50871
DATE (M/D/YY): 4 / 11 / 12
TIME: 12:26
GEAR: 10' Seine
EFFORT (HAULS/SECONDS): 7
WATER TEMPERATURE (C): 27.78
CONDUCTIVITY (µS): 663
pH: 8.42
DISSOLVED OXYGEN (mg/L): 10.44
TURBIDITY (NTU): 4.6
SITE LENGTH (m): 42
STREAM WIDTH (m): 4.572

COLLECTION NUMBER: 34
ERDC STATION NUMBER: 10
TDEQ SITE NUMBER:
STATE: Texas
County: Bexar
WATER BODY: Apache Creek
LOCALE: Apache Creek at Trinity St.
LATITUDE (DD.dddd): 29.41306
LONGITUDE (DD.dddd): -98.51966
DATE (M/D/YY): 4 / 11 / 12
TIME: 13:01
GEAR: 10' Seine
EFFORT (HAULS/SECONDS): 4
WATER TEMPERATURE (C): 30.68
CONDUCTIVITY (µS): 841
pH: 9.99
DISSOLVED OXYGEN (mg/L): 14.78
TURBIDITY (NTU): 1.49
STREAM WIDTH (m): 3.3528

ATTACHMENT 5-2. FINAL SUITE OF MEASURED AND DERIVED ENVIRONMENTAL VARIABLES INCLUDED IN SUBSEQUENT ANALYSES AND A GENERAL DESCRIPTION OF EACH VARIABLE.

Variable	Description
WTEM	Water temperature (Celcius)
DO	Dissolved oxygen (mg/L)
COND	Conductivity (µS)
PH	pH
TURBID	Turbidity (NTU)
SITE_LNGTH_M	Length of sampled stream habitat unit (m)
SV_MEAN	Mean surface velocity (cm/sec)
SV_CV	Coefficient of variation surface velocity
DEPTH_MEAN	Mean water depth (m)
DEPTH_STD	Standard deviation of water depth
DEPTH_CV	Coefficient of variation water depth
WIDTH_DEPTH_RATIO	Ratio of sampled stream unit width to depth
WET_PER	Wetted perimeter of sampled stream unit
OVRSTRY	Percentage of overstory
SHRUB	Percentage of shrub
HERB	Percentage of herbaceous vegetation
RIPRAP	Percentage of rip rap
OVR_W	OVR_W
SUB_PRIMARY_MEAN	Mean value for dominant substratum
SUB_PRIMARY_STD	Standard deviation for dominant substratum
SUB_SECONDARY_MEAN	Mean value for sub-dominant substratum
SUB_SECONDARY_STD	Standard deviation for sub-dominant substratum

ATTACHMENT 6: MONITORING AND ADAPTIVE MANAGEMENT PLAN

INTRODUCTION

This section outlines the feasibility level monitoring and adaptive management plan for the Westside Creeks (WSC) Ecosystem Restoration Study. This plan identifies and describes the monitoring and adaptive management activities proposed for the project and estimates their cost and duration. This plan will be further developed in the preconstruction, engineering, and design (PED) phase as specific design details are made available.

The WSC adaptive management plan will describe and justify whether adaptive management is needed in relation to the alternatives identified in the Feasibility Study. The plan will outline how the results of the project-specific monitoring program would be used to adaptively manage the project, including specification of conditions that will define project success.

The primary intent of this Monitoring and Adaptive Management Plan is to develop monitoring and adaptive management actions appropriate for the project's restoration goals and objectives. The presently identified management actions permit estimation of the adaptive management program costs and duration for the WSC Ecosystem Restoration. This plan is based on currently available data and information developed during plan formulation as part of the feasibility study. Uncertainties remain regarding the exact project features, monitoring elements, and adaptive management opportunities. Components of the monitoring and adaptive management plan, including costs, were estimated using currently available information. Uncertainties will be addressed in PED, and a detailed monitoring and adaptive management plan, including cost breakdown, will be drafted by the project delivery team (PDT) as a component of the design document.

AUTHORITY AND PURPOSE

Ecosystem restoration feasibilities are required to include a plan for monitoring the success of the restoration (Section 2039, WRDA 2007). "Monitoring includes the systematic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, or whether adaptive management may be needed to attain project benefits." Section 2039 also directs that a Contingency Plan (Adaptive Management Plan) be developed for all ecosystem restoration projects.

PROJECT GOALS AND OBJECTIVES

During the initial stages of project development, the PDT developed restoration goals and objectives to be achieved by the restoration measures. The goal of the WSC Ecosystem Restoration Project is to restore structure and function of the riverine habitat within the WSC corridor. The resulting objective focuses on the importance of riverine habitat in South Central Texas to migratory birds for stop-over and breeding. Specifically, the ecosystem restoration objective for WSC is to "restore, to the extent practicable, a sustainable, dynamic riverine ecosystem providing habitat for aquatic and riparian dependent migratory and native resident bird species in the WSC study area over the next 75 years."

Management and Restoration Actions

The PDT performed a thorough plan formulation process to identify potential management measures and restoration actions that address the project objective. Numerous alternatives were considered, evaluated, and screened in producing a final array of alternatives. The PDT subsequently identified a tentatively selected plan (TSP). The TSP included the following ecosystem restoration components (the guidance only applies to ecosystem restoration features so the recreation elements are not included):

- San Pedro Creek
  - 67 acres of native aquatic, wetland, and riparian vegetation (mixture of meadow and woody vegetation)
  - 2.4 miles of natural channel design (NCD) pilot channel with slackwater areas
  - 51 pool-riffle complexes
- Apache Creek
  - 34 acres of native aquatic, wetland, and riparian vegetation (mixture of meadow and woody vegetation)
  - 0.8 miles of NCD pilot channel with slackwater areas
  - 17 pool-riffle complexes
- Alazan Creek
  - 71 acres of native aquatic, wetland, and riparian vegetation (mixture of meadow and woody vegetation)
  - 3.3 miles of NCD pilot channel with slackwater areas
  - 79 pool-riffle complexes
- Martinez Creek
  - 50 acres of native aquatic, wetland, and riparian vegetation (mixture of meadow and woody vegetation)

Implementation

Pre-construction, during construction, and post construction monitoring shall be conducted by utilizing a Monitoring and Adaptive Management Team (MAMT) consist of representatives of the U.S. Army Corps of Engineers (USACE), San Antonio River Authority (SARA), and contracted personnel.

Monitoring will focus on evaluating project success and guiding adaptive management actions by determining if the project has met Performance Standards. Validation monitoring will involve various degrees of quantitative monitoring aimed at verifying that restoration objectives have been achieved for both biological and physical resources. Effectiveness monitoring will be implemented to confirm that project construction elements perform as designed. Monitoring will be carried out until the project has been determined to be successful (performance standards have been met), as required by Section 2039 of WRDA 2007. Monitoring objectives have been tied to original baseline measurements that were performed during the Avian Index of Biotic Integrity (IBI) modeling effort and are summarized in Table 26 and discussed below.

Table 26: Monitoring Criteria, Performance Standards, and Adaptive Management Strategies for the WSC Ecosystem Restoration Project

Measurement	Performance Standard	Adaptive Management
Vegetation		
Woody Stem Density	70-, 30-, and 0-stems per acre depending on the assigned habitat category	Replacement of dead woody vegetation; modifying woody species composition or location within the assigned habitat category area; allowing natural succession of native woody species within the assigned habitat category area.
Herbaceous Percent Canopy	>80-percent canopy cover at PCS	Remedial planting/seeding; modification of plant species composition; amending the soil; increased irrigation.
Non-native Vegetation	<25-percent canopy cover of non-native species at PCS; and no areas >0.25 acres in size with >25-percent non-native species	Remedial planting/seeding; modification of plant species composition; amending the soil; increased irrigation; herbicide application; biological control; mechanical removal.
Non-native and NoxiousWeeds	<25-percent canopy cover of non-native or noxious species at PCS; and no areas >0.25 acres in size with >25-percent non-native or noxious weed species	Chemical and mechanical removal.
Hydrology		
Cross-vane Structures	>80-percent of structures functioning with minimal maintenance	Repair of structures; redesign of structures.
Pool-Riffle Complexes	>80-percent of complexes functioning with minimal maintenance	Repair of complexes; redesign of complexes.

VEGETATION

Baseline vegetation metrics were compiled during initial site assessments at six established point count stations (PCS) per creek. Vegetation metrics included woody stem density; percent canopy cover of the overstory, shrub, and herbaceous layers; percent cover for each species; and percent of native/non-native species within a 50-meter radius centered on the center of the creek channel at each PCS.

Woody stem density goals are dependent on the woody vegetation measure assigned to the particular area of the project area. Three densities of woody vegetation are incorporated in the WSC Ecosystem Restoration Study: 70 stems per acre, 30 stems per acre, and 0 stems per acre. The woody stems per acre measurement should be able to meet these performance standards. Any planted woody vegetation that has died within the warranty period shall be replaced. Post warranty period, adaptive management could include replacement of woody vegetation, modifying the woody species composition or location within the assigned habitat category area and allowance of natural succession of native woody species within the assigned stem density area.

Restoration of the riparian herbaceous vegetation would be considered successful when the site is generally vegetated along its entire length and when the percent herbaceous canopy at each PCS is at least 80-percent. Adaptive management could include remedial planting/seeding, modifying the species composition, amending the soil, and/or increased irrigation to ensure establishment of herbaceous canopy.

The percent canopy cover of non-native vegetation should be less than 25-percent at each PCS. On an annual basis, or more frequently if needed, areas greater than or equal to 0.25 acres in size that have more the 25-percent areal cover of non-native vegetation shall be treated per the Operations and Maintenance Manual for the WSC project. This typically includes the use of chemical and mechanical methods for management of non-native weeds. Noxious weeds shall also be monitored with a performance standard of less than or equal to 25-percent.

HYDROLOGY

The NCD of the pilot channel is designed to mimic natural stream processes such as sediment transport, energy dissipation, and channel formation. The proposed cross-vane structures are designed to address these processes in a controlled and constrained system. In addition, the cross-vane structures assist in the formation of pools and riffles that provide habitat for aquatic organisms. The NCD pilot channel transports sediment along the stream and across riffle structures eventually depositing the sediments in the lower velocity pool areas. The NCD pilot channel is designed based on the channel forming flood event (approximately a 1.5 year storm event). During flood events, deposited sediments are flushed from the pools and riffles are reformed with larger and heavier sediment material. Restoration of the aquatic structural habitat would be considered successful when 80-percent of the cross-vane structures, pools, and riffles function as designed and can be maintained with minimal effort over a five-year period.

Although the NCD is designed to function and rebuild during flood events, excessive flood velocities could damage the cross-vane structures, pools, and riffles. Adaptive management could rebuild, and/or redesign if necessary, cross vane structures, pools and riffles damaged during large flooding events.

REPORTING

Evaluation of the success of the WSC Ecosystem Restoration Project will be assessed annually at a maximum until all performance standards are met. Site assessments will be conducted annually by the MAMT and an annual report will be submitted to the U.S. Fish and Wildlife Service (USFWS), TPWD, the Westside Creeks Oversight Committee, and other interested parties by January 30 following each monitoring year.

Permanent locations for photographic documentation will be established to provide a visual record of habitat development over time. The locations of photo points will be identified in the pre-construction monitoring report. Photographs taken at each photo point will be included in monitoring reports.

MONITORING AND ADAPTIVE MANAGEMENT PLAN COSTS

Costs to be incurred during PED and construction phases include drafting of the detailed monitoring and adaptive management plan. Cost calculations for post-construction monitoring are displayed for a three year monitoring period

It is intended that monitoring conducted under the WSC Ecosystem Restoration project will utilize centralized data management, data analysis, and reporting functions associated with the WSC Sharepoint® site. All data collection activities will follow consistent and standardized processes established in the detailed monitoring and adaptive management plan. Cost estimates include monitoring equipment, photo point establishment, data collection, quality assurance/quality control, data analysis, assessment, and reporting for the proposed monitoring elements (

Table 27). Unless otherwise noted, costs will begin at the onset of the PED phase and will be budgeted as construction costs.

Table 27: Preliminary Cost Estimates for Implementation of the Monitoring and Adaptive Management Plan for the WSC Ecosystem Restoration Project

Category	Activities	PED Set-up & Data Acquisition	Construction	3-year Post Construction	Total
Monitoring: Planning and Management	Monitoring workgroup, drafting detailed monitoring plan, working with PDT on performance measures	$10,000			$10,000
Monitoring: Data Collection	Vegetation		$15,000	$45,000	$60,000
	Hydrology		$15,000	$45,000	$60,000
Data Analysis	Assessment of Monitoring Data and Performance Standards		$10,000	$30,000	$40,000
Adaptive Management Program	Detailed Adaptive Management Plan and Program Establishment	10,000			$10,000
	Management of Adaptive Management Program			$600,000	$600,000
Database Management	Database development, management and maintenance		$5,000	$15,000	$20,000
Total		**20,000**	**$45,000**	**$735,000**	**$800,000**