	Restoration Action	Issue or Problem Addressed	Method of Implementation and Frequency	Estimated Cost Must give exact $$ figure and method used to determine	Direct Benefit to Listed Species During Drought	Potential Negative Impact	Additional Comments
San Marcos River	Protection of Texas Wild-rice (*Zizania texana*): Access and Exclusion Zones, Floating Vegetation Removal, and Sedimentation Removal	Currently, recreational access is not controlled and Wild-rice stands are trampled and uprooted during access.	Permanente access should be located at dog beach, Lion's Club Tube Rental, Bicentennial Park, Wildlife Annex, and potentially other areas. Areas between access points should be planted with vegetation that discourages streamside access (i.e. prickly pear). Additionally, instream exclusion zones should be established, perhaps through the State Scientific Area designation. Kiosks showing access points, exclusion zones, and associated educational components should be installed at key locations.	5 sites x $75,000/site = $375,000. Includes limited walkways and stairs, bank stabilization, and signage. Additionally would be an extra $50,000 for educational signage and exclusion zones for Wild-rice.	Reduces stress and mortality to Wild-rice.	Increased impervious cover and reduced recreational access.	State Scientific Area Designation is dependent upon approval from TPWD Commission. Stakeholder involvement is critical.
		Floating vegetation causes direct mortality of Wild-rice by contributing to low light levels, smothering plants stands, and inhibiting flowering.	Floating vegetation mats could be either pushed downstream out of listed species critical habitat or physically removed from the system. Mats should be pushed or removed two times a week during the recreation season and monthly during offseason.	Pushing plants downstream currently costs the City of San Marcos $20,000 per year for 1/4 mile of cleared river. Pushing mats from Spring Lake Dam downstream to IH 35, approximately 1 mile, makes our estimated project cost $80,000 per year. Removing mats would likely increase costs by at least four times this amount.	Reduces mortality to Wild-rice and increases sexual reproductive success.	Pushing vegetation downstream sends mats to downstream locations. Removal causes loss of aquatic life. Potential trampling of aquatic plants and associated turbidity.	Removal of floating debris over TWR stands must have an approved protocol and be accomplished with permission of USFWS and TPWD.
		Deposition of sediments on or around Wild-rice stands causes direct mortality by smothering or burying stands. Targeted areas should include Upper (upstream of University Drive) and Lower Sewell Park, at and downstream of the confluence with Purgatory Creek and upstream of IH 35.	Sediment may be removed by physical or mechanical methods. An underwater vacuum is one possible mechanical method. Any non-native vegetation that has established in these sediments should also be removed and Wild-rice established.	Based on cost of Crypto removal and native reestablishment in the San Marcos River in 2008, the projected cost is $500,000 per mile of river restored. Thus, the estimated cost for our target areas is estimated to cost $500,000.	Reestablish wild-rice habitat and stands.	Disturbance to habitat. Possible take of Endangered Species. Temporary water quality impairments.	Removal of sediment must be accomplished with a USACE 404 and TPWD sand and gravel permit.
	Control of Harmful Exotics: Domestic Waterfowl, Hydrilla (*Hydrilla verticillata)* , Nutria (*Myocastor coypus*), and Armored Catfish (family Loricariidae, *Hypostomus spp* . and *Pterygoplichthys spp* .).	Domestic Waterfowl are known to feed directly on Wild-rice and the seedheads, which effects population size, reproductive success, and genetic variability.	Selective netting and give aways to land owners; once a year after Easter	The cost is largely labor associated with trapping the waterfowl and an educational campaign. Estimates per year are thought to be around $10,000 - $20,000 per year.	Reduces the loss of Wild-rice stands and seedbank.	Public acceptance	City code should prohibit the feeding of wildlife. i.e The River Pub and Grill sells duck food.
		Hydrilla is highly invasive and covers a large percentage of river bottom, thus crowding out preferred darter habitat and occupying potential Wild-rice habitat.	Hydrilla may be removed by physical or mechanical means. An underwater vacuum is one possible mechanical method. Removed plants should be replaced with native aquatic vegetation that may include Wild-rice where conditions are suitable.	Based on cost of Crypto removal and native reestablishment in the San Marcos River in 2008, the projected cost is $500,000 per mile of river restored. Thus our project of Spring Lake and 1 mile of river restored is estimated to cost $1,000,000. This mile of restored river would include sections of Spring Lake, the slough arm of Spring lake, and the San Marcos River from Spring Lake to just below IH 35.	Hydrilla removal and native replacement would increase preferred darter habitat and increase potential Wild-rice habitat.	Disturbance to habitat. Possible take of Endangered Species. Temporary water quality impairments.	To ensure success of revegetation, water flow and quality conditions should be considered, as well as uses of that stretch of river. Removal of Hydrilla in its totality ensures success by limiting recolonization
		Nutria feed directly on Wild-rice and the seedheads, which effects population size, reproductive success, and genetic variability.	Texas Wildlife Services has an assistance program to asist with control of nuisance nutria. This is done once a year during the winter months.	Minimal Cost for bait and poison. Less than $1,000.	Reduces the loss of Wild-rice stands and seedbank.	Public acceptance and secondary poison.	The City of New Braunfels has had a successful program implemented since 2007.
		Armored Catfish Control - Numbers of these non-natives are growing and are detrimental to the habitat of all associated endangered species. Specifically the Armored Catfish eat vegetation and burrow into the sediment.	Armored Catfish are a tropical species that will congregate in winter near spring openings and other warm water sources. When the species congregate this creates the opportunity to use seines, gill nets, cast nets, or other methods to remove large quantities with minimal effort and minimal impact to the habitat. Artificial heating could be one method used to congregate fish in areas away from springs and endangered species to minimize the impacts from collection efforts. Initial efforts in year one should be intens and take place during the winters first freeze, with continued control every winter. Numerous removals during each winter would be most productive.	State and Federal agencies or Universities should be involved and would reduce the labor cost. Equipment costs are estimated near $10,000 for nets and other misc. gear. Artificial heating is very expensive. If heaters are used the price would greatly increase dependant on the size of heaters and water volume manipulated.	Fountain Darter mainly. Non-native species compete with native species for resources and alter habitat among other issues. Specifically, Armored Catfishes create large burrows causing the loss of vegetation, destabilizing banks, and other impacts. During times of low flow and drought this could further reduce already limited habitat for the Fountain Darter.	Collection efforts may impact fountain darters or habitat.	Possible locations for artificial heating could include backwaters near the golf course, Blieders creek slough, and other back water areas. This method has not been tested or proven effective.

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Comal River	**Control of Harmful Exotics: Tilapia (*Oreochromis aureus*) and Armored Catfish (family Loricariidae, *Hypostomus spp* . and *Pterygoplichthys spp* .).**	Control of Tilapia - Numbers of these non-natives are growing and are detrimental to the habitat of all associated endangered species.	Tilapia are a tropical species that will congregate in winter near spring openings and other warm water sources. When the species congregate this creates the opportunity to use seines, gill nets, cast nets, or other methods to remove large quantities with minimal effort and minimal impact to the habitat. Artificial heating could be one method used to congregate fish in areas away from springs and endangered species to minimize the impacts from collection efforts. Initial efforts in year one should be intense and take place during the winters first freeze, with continued control every winter. Numerous removals during each winter would be most productive.	State and Federal agencies or Universities should be involved and would reduce the labor cost. Equipment costs are estimated near $10,000 for nets and other misc. gear. Artificial heating is very expensive. If heaters are used the price would greatly increase dependant on the size of heaters and water volume manipulated.	Fountain darter mainly. Non-native species compete with native species for resources and alter habitat among other issues. Specifically, tilapia destroy vegetation by making bare ground nests. During times of low flow and drought this could further reduce already limited habitat for the Fountain Darter.	Collection efforts may impact fountain darters or habitat. If electroshocking is used it is detrimental to the Fountain Darter and other species.	Possible locations for artificial heating could include backwaters near the golf course, Blieders creek slough, and other back water areas. This method has not been tested or proven effective.
		Armored Catfish Control - Numbers of these non-natives are growing and are detrimental to the habitat of all associated endangered species. Specifically the Armored Catfish eat vegetation and burrow into the sediment.	Armored Catfish are a tropical species that will congregate in winter near spring openings and other warm water sources. When the species congregate this creates the opportunity to use seines, gill nets, cast nets, or other methods to remove large quantities with minimal effort and minimal impact to the habitat. Artificial heating could be one method used to congregate fish in areas away from springs and endangered species to minimize the impacts from collection efforts. Initial efforts in year one should be intense and take place during the winters first freeze, with continued control every winter. Numerous removals during each winter would be most productive.	State and Federal agencies or Universities should be involved and would reduce the labor cost. Equipment costs are estimated near $10,000 for nets and other misc. gear. Artificial heating is very expensive. If heaters are used the price would greatly increase dependant on the size of heaters and water volume manipulated.	Fountain Darter mainly. Non-native species compete with native species for resources and alter habitat among other issues. Specifically, Armored Catfishes create large burrows causing the loss of vegetation, destabilizing banks, and other impacts. During times of low flow and drought this could further reduce already limited habitat for the Fountain Darter.	Collection efforts may impact fountain darters or habitat.	Possible locations for artificial heating could include backwaters near the golf course, Blieders creek slough, and other back water areas. This method has not been tested or proven effective.
	Optimization of Fountain Darter (*Etheostoma fonticola*) Habitat in the Old/New Channel of the Comal River	Discharge from Landa Lake to the old and new channels of the Comal River are currently set at a constant flow and never changed. An established flow regime creating the maximum amount of usable habitat for the Fountain Darter would be beneficial, especially during low flows. Change in flow volume does not relate on a 1:1 basis with usable habitat. (reference Hardy models)	Implement a flow regime developed by a third party using the gated culverts at tee box # 2 and the LCRA weir would be necessary. Coordination with Springfed pool operation should be considered.	Cost would be associated with development of the flow regime. City of New Braunfels staff could be utilized at no cost to make adjustment to valve configuration and clean intake screens. It is estimated that a third party could establish the needed flow regime and criteria for $25,000.	Fountain darters benefit from ensured flow, required water quality parameters, and creation of the maximum usable habitat.	Some habitat may not be maintained to protect higher quality habitat.	Draft MOU available; possible flow regime in the 2003 draft Mgmt Plan by Hardy et al. 1999
	Establishment of riparian zones and removal of sediment in select areas to promote beetle (*Heterelmis comalensis* and *Stygoparnus comalensis)* habitat	Riparian habitat along the western shore from the headwaters of Spring Run 3 downstream to the Gazebo, contains little native riparian vegetation.	Method of riparian zone establishment includes the removal of all non-natives and replanting of native vegetation representing a functioning riparian zone. Trees and plants with extensive root systems should be given preference to create the maximum beetle habitat. Fine sediment coverings exposed roots and springs should be removed also. The riparian zone should be checked several times a year for continued success and removal of reestablished non-natives. It is also possible that area may need to be protected for the first year until the riparian zone becomes established.	Project size is estimated at 10 acres. Plants for establishment of riparian zone are estimated at $4,000/acre, labor for planting at $3,000/acre (includes planning), and sediment removal at $5,000/acre, plus an extra $20,000 b/c of hard to reach area = total project cost of $140,000.	Comal Springs riffle beetles are thought to feed on detritus (fungus and bacteria growing on woody debris, and leaf litter) within spring influenced riparian zones. They are also known to prefer areas free of fine sediments. Establishing a native riparian zone benefits the riffle beetle by increasing the amount of usable habitat and food sources. Having a larger population when drought occurs likely increases the ability of the species to withstand the drought. In addition, riparian restoration also benefits the system through bank stabilization and nutrient and sediment processes.	Reduced recreational access and temporary turbidity.	This location was chosen because the western shoreline of Spring run 3 is known to have numerous spring orifices that contain beetles and the riparian habitat is significantly degraded.
		Riparian habitat along the western shore of Landa Lake from the end of Spring Run 3 upstream to the Water Oriented Recreation District #1 property line, contains little native riparian vegetation.					This location was chosen because the western shoreline of Landa Lake is known to have numerous spring orifices that contain beetles and the riparian habitat is significantly degraded. This area was also chosen because it is one of the deeper parts of the lake (i.e. will hold water longest during drought) and also because the population of riffle beetles found along this shoreline is thought to be the most genetically diverse found in Landa Lake.

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Potential Actions that Require Additional Information to Implement	*control of the non-native Asian trematode (Centrocestus formosanus), from both Spring Systems.*	The gill parasite can cause stress to the fountain darter and eventually mortality; especially during low flows.	Method needs to be established; possible baffle and aeration systems installed on low water dams and water control structures.	The cost is unknown. Depends on method of implementation.	Reduced stress or mortality to the Fountain darter.	??	Two possible partial but untested control methods are physical removal of*M. tuberculatus* (by dredging) and water turbulence (dams, riffles, and air bubble) to kill drifting *C formosanus* cercaria. These methods have not been tested or proven effective.
	In-Situ Refugia at Comal	In-Situ Refugia may create temporary habitat for endangered species in their native habitat during times of low flow.	Needs more work study; Biowest is currently conducting a feasibility study.	??	Depends on approach and BioWest determination. Presumably the Fountain Darter and possibly the beetles.	??	This is dependant on results of the BioWest In-Situ Refugia feasibility study. Bio-West indicates in-situ refugia is only viable at flows between 130-50 cfs.