Section 6 Report Review

Attachment to letter dated 24 May 2002

Project: Educational Exhibits and Support Components at Aquarena Center, San Marcos, Texas for the Conservation of the San Marcos Springs Endangered and Threatened Species, *Gambusia georgia, Etheostoma fonticola, Eurycea nana, Zizania texana, and Eurycea rathbuni.*

Final or interim report? Final

Job #: WER 63

Reviewer's Station: Austin Fish and Wildlife Service Office

Lead station was contacted and concurs with the following comments:
___ Yes ___ No _X_ Not applicable (reviewer is from lead station)

Report: ___ is acceptable as is

___ is acceptable as is for an interim report, but the following comments are made for future reference

_X_ needs revision (listed below)

Comments: (Note to commenter: If you make comments directly on a copy of the report, write legibly and dark so comments will reproduce well when photocopied.)

There are a number of biological and typographical errors in the signs, fact sheets, and workbooks that need to be addressed. In last year's comments on the interim report for this project, transmitted to TPWD on March 11, 2001, the Service commented that we "... would like to coordinate with TPWD and Aquarena by reviewing the draft curricula, signage text, and any information sheets prior to the finalization of the educational content of the project." Although staff at Aquarena spoke to Service staff last summer in general about this project, the Service was not given an opportunity to see and offer suggestions on the draft signs and curricula material.

The pages of the attachment to the final report were not numbered so it is difficult to make precise references. However, we have attempted to identify specifically where our comments should be incorporated.

1) If common names are to be used in the **Signage Text** section on **Sign 3**, then the National List (see reference cited below) of common names should be used. Therefore, "Carolina fanwort" should be used, not "Cabomba"; "wild celery" should be used, not "eelgrass"; "yellow cow-lily" should be used, not "spatterdock"; and "common hornwort" should be used, not "coontail".

Reference Cited

Reed, Porter B. 1988. National list of plant species that occur in wetlands: 1988 Texas. NERC-88/18.43. U.S. Fish and Wildlife Service publication.

2) On the first page of the "**Life Times Ten**" lesson plan, the scientific name for the Texas blind salamander "Tymphlamloge rathbunii" is spelled incorrectly. The correct spelling is "Tymphlomolge rathbunii." In addition, please be aware that the Genus "Tymphlomolge" is in the process of being changed to "Eurycea", so you may want to revise the text to say *"Eurycea rathbuni"* when referring to the Texas blind salamander.

3) On the one page informational sheet for the fountain darter, under the "Distribution and Habitat" section, it should be noted that in the 3rd sentence, the loss of springflow at Comal Springs was due to drought and groundwater pumping. In the 6th sentence of the same section, it should be noted that fountain darters may occur downstream of the confluence of the San Marcos and Blanco rivers.

In the second paragraph of the "Threats and Reason for Decline" section, there is a typographic error in the scientific name for the giant ramshorn snail; the correct name is *Marisa cornuarietis*.

4) On the one page informational sheet for San Marcos gambusia, the description of critical habitat in Spring Lake is incorrect. The text should be changed to read: "San Marcos River from Highway 12 bridge downstream to approximately 0.5 miles below Interstate Highway 35 bridge."

5) On the one page sheet for Texas blind salamander, you may want to change the scientific name to *Eurycea rathbuni*, as described above under comment # 2. In addition, the description of critical habitat is incorrect. There is no federally designated critical habitat for the Texas blind salamander.

6) Under "The Fountain Darter" section on page 7 of the "**Rare! Endangered Species**" Curriculum for Grades 4, 5, & 6, it should be noted that not all darters lack swim (gas) bladders.

7) On page 23 of the "**Rare! Endangered Species**" Curriculum for Grades 4, 5, & 6, the description of critical habitat is incorrect. There is no federally designated critical habitat for the Texas blind salamander.

8) In the "Texas Endangered and Threatened Species" table on page 30 of the "**Rare! Endangered Species**"Curriculum for Grades 4, 5, & 6, it is unclear whether the column labeled "Status" refers to the State of Texas' list of T&E species or the federal list of T&E species, or both. The table should advise the reader that the State and federal lists are not the same.

Under the "Some Reasons for Rarity" column, the text for the Pecos pupfish should be changed to "Hybridization with an introduced sister species".

Under the "Species" column, "Toothcave spider" should be changed to "Tooth Cave spider".

9) The **Appendix B Texas Threatened and Endangered Species, March 1999** is out of date and several species' status have changed. For example, on page 3 the status of the Pecos pupfish should be changed to reflect that it is no longer proposed as endangered, and on page 4 under "Spiders" several of the species listed as "PE" should be changed to "LE" to

reflect that they have been federally listed.

10) On the 2nd page of "**Appendix C <u>Introduction to the San Marcos Springs Ecosystem</u>**" under the "Flow Characteristics" paragraph, the text should be revised to state that "The San Marcos River baseflow provides some stability that decreases as one goes downstream." Stability is not lost at the Blanco confluence, as the current text implies.

On the 4th page under the "Texas wild rice (Zizania texana)" section, the distribution as written is inaccurate. Texas wild rice does currently occur in Spring Lake

"The Endangered Species Act of 1973 Terms" section on page 8 of this section needs to be eliminated or entirely rewritten. The discussion contain errors in virtually each term presented. This page amounts to legal advice and needs serious revision.

FINAL REPORT

As Required by

THE ENDANGERED SPECIES PROGRAM

TEXAS

Grant No. E-1-13

Endangered and Threatened Species Conservation

Project WER63 -- Educational Exhibits and Support Components at Aquarena Center, San Marcos, Texas for the Conservation of the San Marcos Springs Endangered and Threatened Species, *Gambusia georgei, Etheostoma fonticola, Eurycea nana, Zizania texana, and Eurycea rathbuni.*

Prepared by: John Powell
and
Margaret Russell

TEXAS PARKS & WILDLIFE

John Herron
Program Director, Wildlife Diversity

Robert Cook
Executive Director

March 31st, 2002

FINAL REPORT

STATE: Texas **GRANT NO:** E – 1 – 13

PROGRAM TITLE: Endangered and Threatened Species Conservation

PERIOD COVERED: September 1, 1999 – August 31, 2001

PROJECT NUMBER: WER63

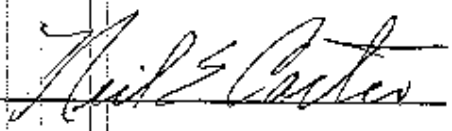
SEGMENT COST:
TOTAL - $8,986.59
FEDERAL SHARE - $6,739.94

PROJECT TITLE: Educational Exhibits and Support Components at Aquarena Center, San Marcos, Texas for the Conservation of the San Marcos Springs Endangered and Threatened Species, *Gambusia georgei, Etheostoma fonticola, Eurycea nana, Zizania texana, and Eurycea rathbuni.*

PROJECT OBJECTIVES:

To refocus classroom and public attention to our own back yard when discussing threatened unique fragile environments and the needs of the endangered plants and animals.

PREPARED BY: John Powell and Margaret Russell 11/30/01

APPROVED BY:  03/22/02

Neil E. Carter
Federal Aid Coordinator

Date

PROJECT TITLE: Educational Exhibits and Support Components at Aquarena Center, San Marcos, Texas for the Conservation of the San Marcos Springs Endangered and Threatened Species, Gambusia georgei, Etheostoma fonticola, Eurycea nana, Zizania texana and Eurycea rathbuni.

(i) The problem or need which prompted the project

The suite of endangered and threatened species of the San Marcos Springs system exist almost solely within the city of San Marcos, and thus are impacted by human activity, as well as affected by human population pressures on the Edwards Aquifer throughout the central Texas area. Because of the species dependency on the continued flow of spring waters, which in turn are affected by growing municipal water use, education of the public to the plight and needs of these species becomes critical.

(ii) Evidence of a review of prior projects and other works-in-progress related to this project

At the time of the grant submittal, available education materials on endangered and threatened species focused on international charismatic animals. The very good NatureScope activities illustrated underlying principles of rarity with a world-wide view. A more recent project by the National Wildlife Federation was Animal Tracks, a fun book for conservation education at a fourth grade level, which included a chapter on endangered species. Some of the animals in the activities were panda bears, moas, bald eagles, and passenger pigeons. World Wildlife Fund's excellent curriculum on biodiversity examines the need for endangered species protection as necessary for maintaining diversity for healthy ecosystems. "Going, Going, Almost Gone! Animals in Danger" was a joint project between HBO and World Wildlife Fund as part of the Windows on the Wild curriculum, with an elementary educators guide for use after viewing the video. Again, this curriculum has a national scope with an international array of species.

Previous use of the Endangered Species trunks from the U.S. Fish and Wildlife Service's Austin office for teacher training was an experience in huge amounts of resources without a clear plan on use and instruction. Teachers expressed reluctance for taking responsibility for valuable artifacts and for creating lesson plans for their students (ESC, Region XIII, Regional collaborative training at Aquarena Center, 1996.)

Texas Parks and Wildlife Department's resources for the state's endangered and threatened species at the time of the grant application were rich with background information sheets and lists. There was a Jeopardy game to reinforce species information, and a traveling display with striking pictures of threatened and endangered

species of Texas. The TP&W office also distributed fun salamander cutouts for creating headbands. Ann Miller did endangered species training for teachers that included classroom activities. Information about the animals and plant species at Spring Lake is presented in an attractive pamphlet "Edwards Aquifer Species", with limited copies available for distribution.

(iii) The objectives addressed

OBJECTIVE:

To refocus classroom and public attention to our own backyard when discussing threatened unique fragile environments and the needs of threatened and endangered (T&E) plants and animals.

I. Segment Objectives:

A. Visitors view the interconnections of habitat and species and come to appreciate the uniqueness of the San Marcos River System and its flora and fauna.

B. Refocus classroom attention to our own backyard when discussing threatened unique fragile environments and the needs of the endangered species.

(iv) The approach or procedures utilized

Approach: 1. Develop an exhibit "Life at 100" representing Spring Lake at 100 times magnification.
Objectives met: The exhibit contains 8' x 24' mural of life in Spring Lake magnified ten times. Visitors see wild rice, salamanders, gambusia and darters, with prey species and locations in relationship to other lake fauna and flora. Interactive components include: *Passing Gas*, which emphasizes the importance of surface area in plants for gas and nutrient exchange, a large salamander puppet under bean bag substrate, for relative sizes and habitat display, *Salamander Maze*, an activity that depicts the small spaces salamanders move through in the aquifer and spring openings, mussel puppets and snail vacuums to demonstrate the diversity of feeding strategies, *Water Weight* and *Jump In* showing loss of structure needs by plants and animals in buoyant water, *Moving Through Water*, exhibiting mounted fish puppets demonstrating fish shape and jobs of fins, a *Stream Table* for water wigglers to investigate moving through water, *Surface Tension*, giving visitors a membrane to walk bug models across, and a *Life Times Ten* area for magnifying a variety of lake plants and animals for a closer look.

Approach: 2. Write 5 endangered and threatened species of San Marcos Springs information sheets.
Objectives met: The single sheet information sheets support the curriculum activities, and are used in educating visitors at special programs, such as Scientific Divers and Great Backyard Bird Count.

Approach: 3. Develop curriculum with pre and post visit activities.

Objectives met: The curriculum for grades 4,5, and 6 (Rare!Endangered Species) contains 4 pre visit activities, 2 on site activities, and 4 post visit activities. These are aligned with state content requirements and contain an in depth explanation of the Spring Lake ecosystem for teachers. The curriculum for grades 7, 8, and 9 (Vanishing! Endangered Species) also contains the same number of activities.
(The Vanishing! draft sent to U.S. Fish and Wildlife Service's Pat Conner in Spring 2001)
Teachers receiving the preliminary drafts are listed.

Approach: 4. Install signage replacing duck feeders that emphasize the uniqueness of the San Marcos spring system, the food chain, and essential elements of the habitat.
Objectives met: The seven signs follow the lake's shoreline from the glass bottom boat dock to the overlook at the old Historic Inn, past the headwaters. The signs meet several objectives.

a.) Discourage people from feeding birds and fish and adding additional nutrients to the lake.
b.) Instruct visitors in the balance of nature in the lake with the natural food chain.
c.) Include the endangered and threatened species in the presentation of a balanced ecological system, and the part they play.

(The signage text was sent to U.S. Fish and Wildlife Service's Pat Conner in Spring 2001)

(v) Discussion of the project outcomes, related to the objective(s) and the problem or need.

Both the signage and the Life Times Ten exhibit room are visited by thousands yearly. Approximately 50 % of the visitors read the first 3 panels near the boat dock as they wait for their glass bottom boat rides to begin. Questions to the boat drivers during the tours indicate processing of the material presented in the signage.

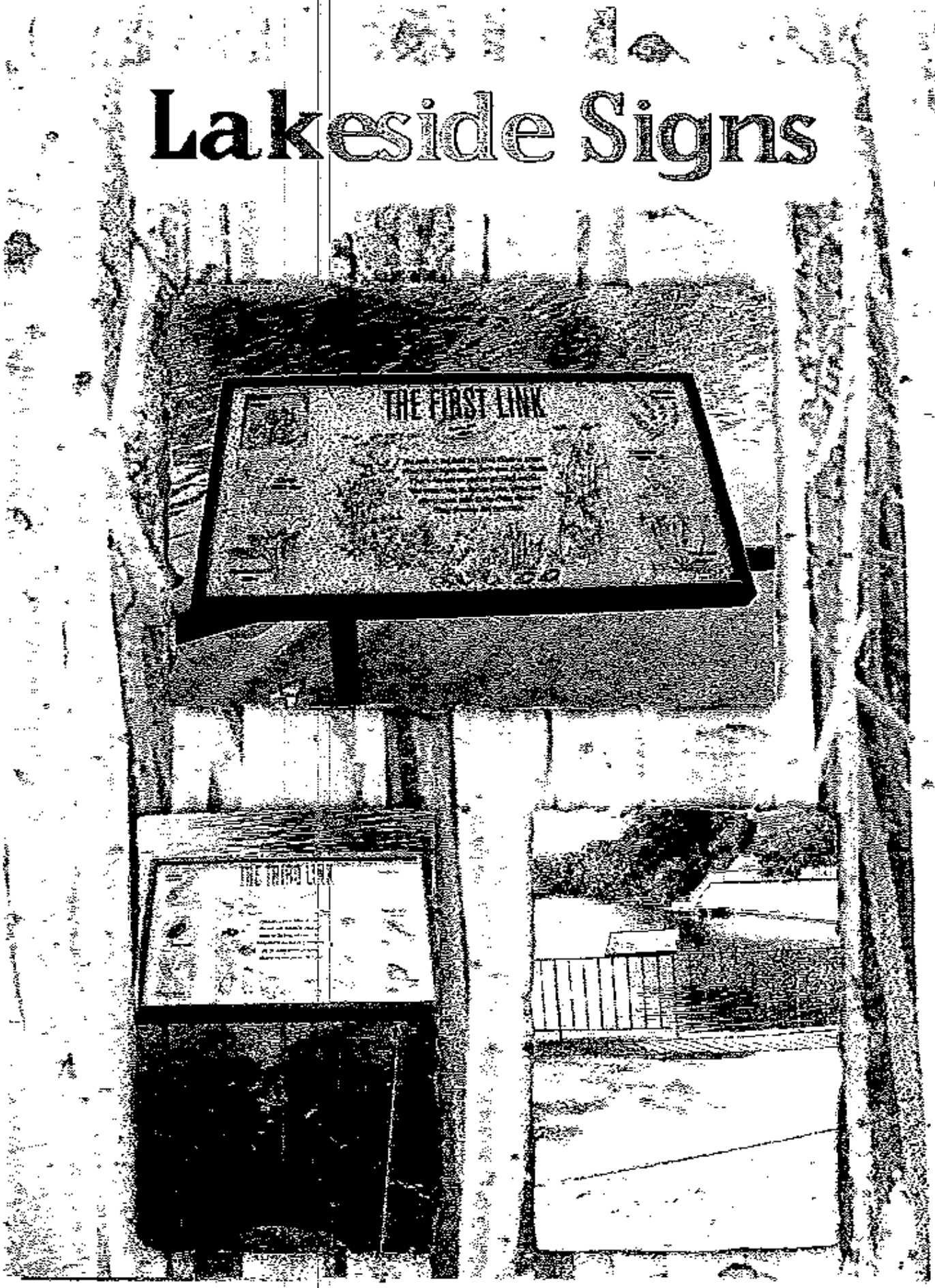
All school groups visiting Aquarena go through the aquarium. Even if they come without booking a tour, school children will enter the free endangered species exhibit. Currently, groups investigate the interactive components on their own, but programs based on Life Times Ten are being developed. Especially engaging to children are Water Weight activities, and the puppets and wind-up swimmers.

The curriculum is organized to cover topics required for the classroom, while incorporating important knowledge for understanding endangered species issues. Teachers are excited about the activities, which increases the likelihood of classroom inclusion.

This project by Aquarena Center with Section 6 Grant funding is a comprehensive approach that enriches the public's knowledge and experiences with rare species in their own back yards.

Lakeside Signs

Lakeside Signs



Lakeside Signs

Aquarena Center
601 University Drive
San Marcos, Texas 78666
Margaret Russell
512-245-7557
October 6, 2000

Signage Text
Endangered Species and Food Chain

Refer to numbered copies of artwork for text placement and order.
Sign 1

Please don't Break the Food Chain Link
It's more important than you think

Sign 2

When animals get used to taking handouts from people, they become pests.
SPRING LAKE has lots of food for the ducks, turtles, fish and all its animals.
What is on the SPRING LAKE MENU?

Pyramid: (Top layer) FOURTH LINK
(Second layer from top) THIRD LINK
(Third layer from top) SECOND LINK
(Bottom layer)FIRST LINK

Sign 3

THE FIRST LINK
Plants and Algae
The bulk of the food in a food chain is green. Plants and algae make their own food. Some rivers depend on plants growing outside the water, but at Spring Lake, algae and plants grow well in the clear water. They provide the first link.

Hydrilla
Non native
Cabomba
Native
Eelgrass
Native
Chara
Native algae
Spatterdock
Native

Coontail
Native

Sign 4

THE SECOND LINK
Grazers
Grazers are animals that eat algae growing on plants and rocks, or take bites of leaves and stems. Grazers think green is great. After filling up on green, the smaller animals make a tasty snack for the next link.

Snails
Scud
Mayfly larvae
Tilapia
Non native
American Wigeon
Migratory Native
Nutria
Non native

Sign 5

THE THIRD LINK
Predators
Predators come in different sizes. One-inch long dragonfly larvae will gobble up the bugs and small fish. Mosquito fish eat mosquito wrigglers, and the salamanders eat scuds. What is the next link on the chain?

Dragonfly larvae
Diving beetle
Mosquito fish
San Marcos salamander
Threatened
Fountain darter
Endangered
Sunfish

Sign 6

THE FOURTH LINK
Big Predators
Large predators at Spring Lake include bass, gar, birds, turtles, mammals and eels. Since most of these creatures start out small, they themselves might be a dinner item early in life for a predator.

Raccoon
Spotted Gar
Large mouth bass
Great Blue Heron
Double-crested Cormorant
Snapping turtle

Sign 7

MISSING LINKS
Filterers, Decomposers, Scavengers, Scrapers, Shredders
There are other links in the aquatic food chain. Some animals spin nets or hang out bristles to catch small bits of food passing by. Some only eat dead leaves, or strain bottom mud. The very smallest, bacteria, turn the dead into a fresh pool of nutrients. These nutrients, in turn, are used by plants and algae, the first link of the food chain.

Blackfly larvae
  Filterer
Stonefly larvae
  Shredder
Riffle beetle
  Detritivore
Crayfish
  Scavenger
Case building Caddisfly
  Scraper
Net building Caddisfly
  Filterer

Text mostly left aligned, ragged right margins, 28 to 36 points. Headline font to use is Industria. Smaller body font to have serif and match as close as possible to Industria. Use discretion in placement and proportions. Reading distance 18 inches to 28 inches away.

LIFE TIMES TEN

RATIONALE

The five small rare animal species in Spring Lake live within crevices and among vegetation, so their lives are not visible. The phenomena of flagship species, an animal or plant whose charisma insures support by the public, does not usually extend to cold blooded animals. Not well known, not easily found, and without immediate appeal, Spring Lake rare species need to become larger than life for their stories to be heard and for the public to relate to *Gambusia georgei*, *Eurycea nana*, *Tymphamloge rathbunii*, *Etheostoma fonticola*, *Zizania texana,* and *Heterelmis comalensis*.

The patterns in life times ten, or life visible under ten power of magnification, is both familiar and bizarre. The foundation of life cycles, with food chains and predator-prey relationships is similar on both land and in the water. The struggle of life forms to meet their needs in a water world, where water molecule properties especially impact moving and breathing strategies at a smaller dimension, has created bizarre and unique adaptations.

Formal educational curriculum guides for grades K through 6 include requirements for a basic knowledge strand that identifies components of the natural world, basic needs of an organism, how living things depend on each other and their environment, habitats, competition, inherited traits, adaptations and how adaptations improve survival, an organism's niche and living things' life processes. The physical aspects the processes life depends on, such as watersheds, states of matter, and water cycle, play an important role in explaining Life Times Ten.

TARGET AUDIENCE

The exhibit will target children 5 to 12 years old, while reaching families and all ages. [1]

OBJECTIVES

By visiting this exhibit, the audience will:

1.) Look for and recognize ways organisms adapt to living in water.
2.) Compare life at different scales
3.) Make new connections between prior knowledge and experiences of larger land animal ecologies with smaller aquatic ecologies.
4.) View rare species of Spring Lake as important components of the ecology.

[1] Seven Characteristics of Family Friendly Exhibits:

Multi-sided - family can cluster around exhibit
Multi-user - interaction allows for several sets of hands or bodies
Accessible - comfortably used by children and adults
Multi-outcome - observation and interaction foster group discussion
Multi-modal - appeals to different learning styles and levels of knowledge
Readable - text is arranged in easily understood segments
Relevant - providing cognitive links to visitors existing knowledge and experience

Family Learning in Museums: The PISEC Perspective. Philadelphia/Camden Informal Science Education Collaborative, The Franklin Institute, 1998.

LIFE TIMES TEN

MAIN MESSAGE

Even the smallest animals play an important role in Spring Lake.

POTENTIAL EXHIBIT COMPONENTS AND VISITOR EXPERIENCES

DIVERSITY

There is variety among the life in Spring Lake.

LIVING IN LIQUID

Plants and animals in water differ from land organisms because of where they live.

Buoyancy… Things weigh less in water. Less support is needed in plant structure because of the water support

- Lower an item attached to a spring scale in and out of water to compare different weights
- Stand on a scale to determine how much you weigh in the water

Surface tension…The water surface to small bugs is a physical barrier

- Lid of thick stretchy film for visitors to push down on and try to enter drum
- Stretchy film to lower bugs down on to push on.

Transfer of gases…Less oxygen and carbon dioxide in water, slower to diffuse so it is harder to get gases in water. Plant tissue and gills are finely branched to increase surface area.

- Maze of branching to find where the air bubble can enter
- Measurement of surface area of gills with magnetic wand and chain inside plexiglass

LAKE LOCOMOTION

Animals have a variety of ways to move.
Moving water is a large force for small animals.

- Scraping along the bottom done by snails shown with push snail figures
- Wind up paddle shapes used in water basin.

LIFE TIMES TEN

LAKE DINING

Animals feed in a variety of ways.

Even small animals can be aggressive predators.

- Dragonfly larvae's grabbing and killing apparatus in a scoop apparatus.
- Comparing dragonfly larvae to Tyranasaurus Rex on a reduced scale.

Instead of carnivore and herbivore food chains, small animals in the Lake are sorted into scrapers, shredders, collectors, filterers, scavengers, and predators.

- Food chain signage along the lake's edge.
- Show predators smaller than plant eaters in lake.

NICHES

Life magnified fits in specific places in the environment of Spring Lake.

TINY PLACES

Aquifers and spring openings provide small places for small animals.

Aquifers are places of cracks, crevices.

- Salamander maze with magnetic wand to guide salamander through the crevices.
- Burrow through the gravel pit of different sized bean bags.

Aquifers are places of darkness and no plants.

- "Getting rid of extras" animals living in specific environments, such as island birds, lose unnecessary traits, such as flight, (or pigmentation and eyes in the darkness)...chose the extras to lose.

LIFE TIMES TEN

EXHIBIT RESOURCES

Exhibit Design/Fabricators

Margaret Russell, Education Coordinator, Aquarena Center

Joe Doherty, Director of Exhibits, Austin Children's Museum

Camille Larrey, Bouldin Creek Woodworkers,

Maria Thompson, Muralist

Advisors

Tom Arsuffi, Ph.D.
Aquatic biologist
Southwest Texas State University

Paula Williamson, Ph.D.
Botanist
Southwest Texas State University

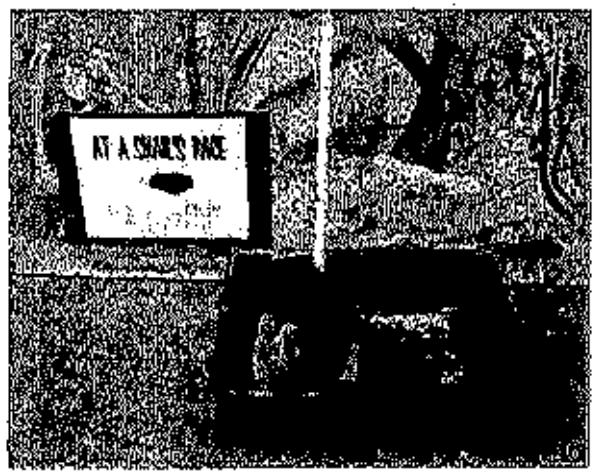
Life Times Ten Exhibit

An exhibit interactive showing the buoyancy of water. The weight attached [illegible] can be lifted in and out of water

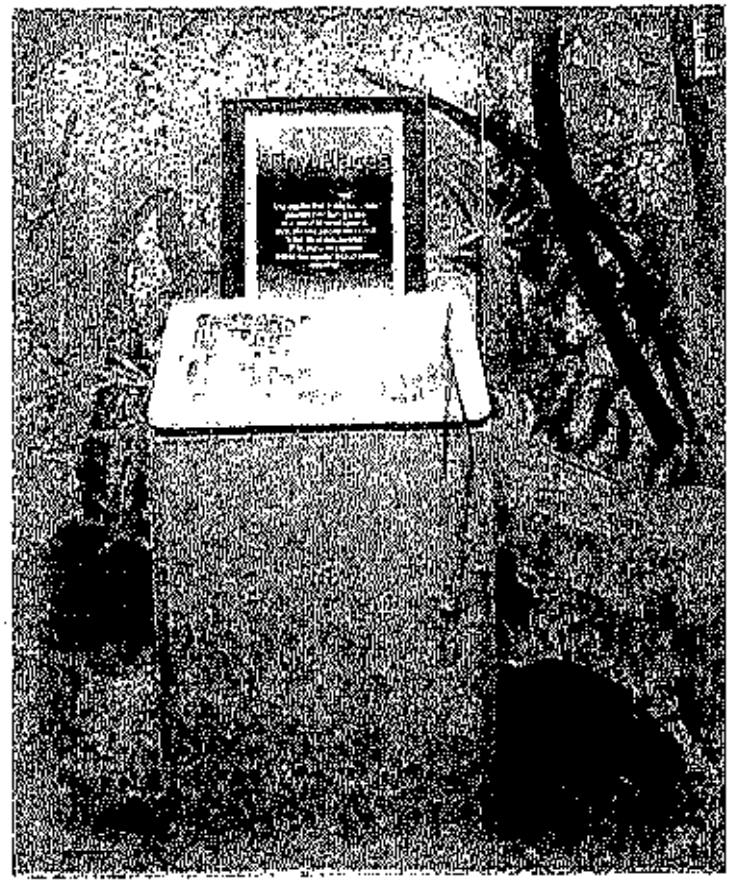
Mural of Spring Lake with life magnified by the power of ten.

[illegible] of typical [illegible] plants and animals of Spring Lake.

Life Times Ten Exhibit

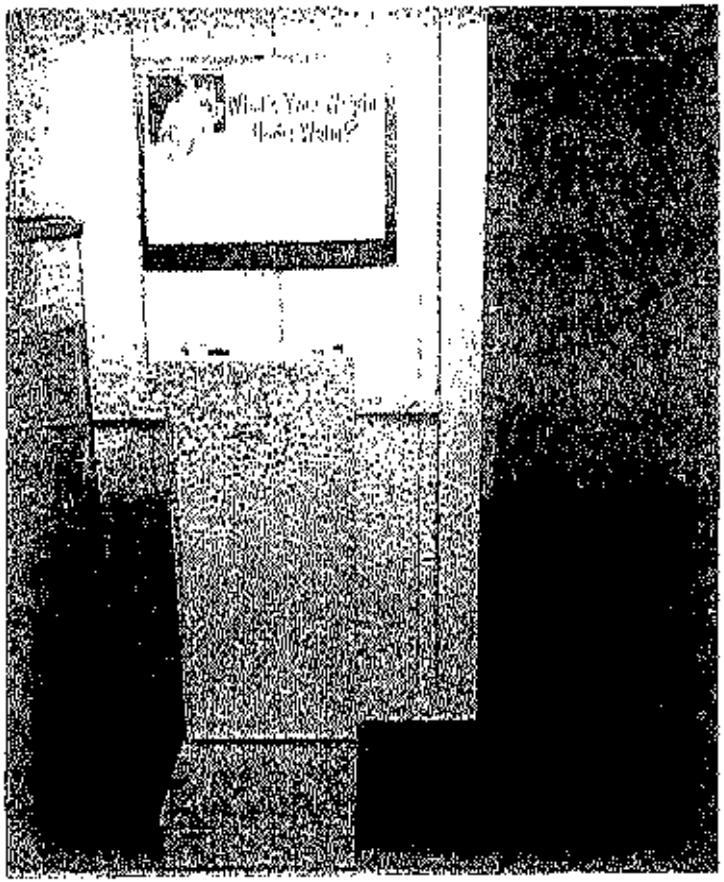


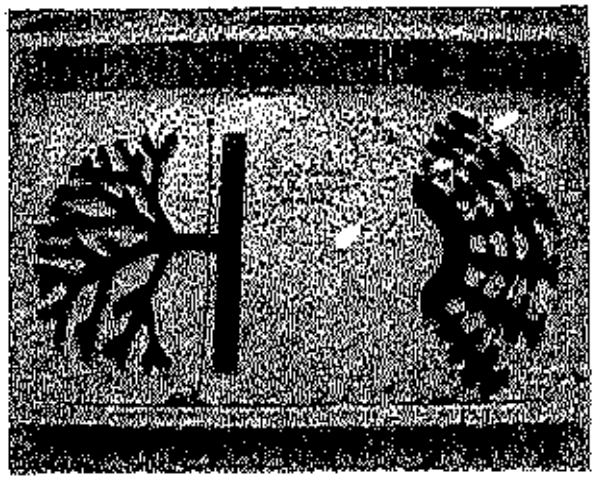
Life Times Ten Exhibit

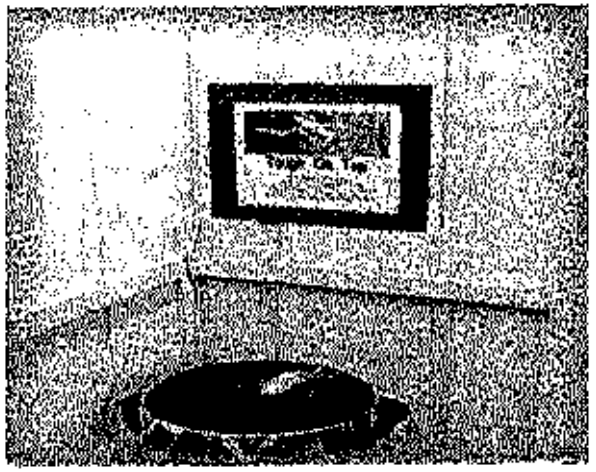


The shape of fish depends on where they live. Adaptable mudskippers breathe like fish or like

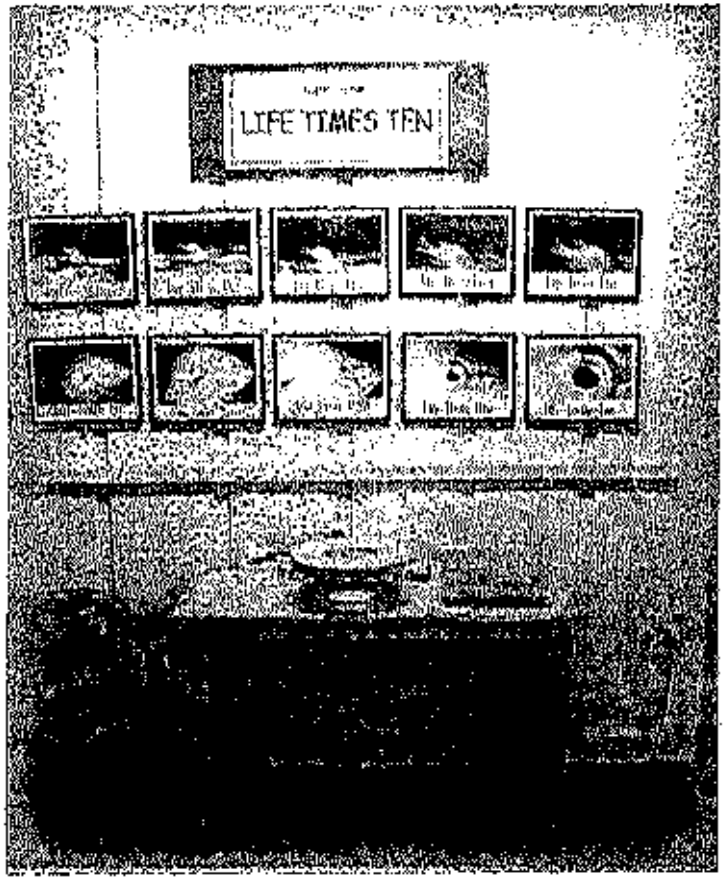
Life Times Ten Exhibit

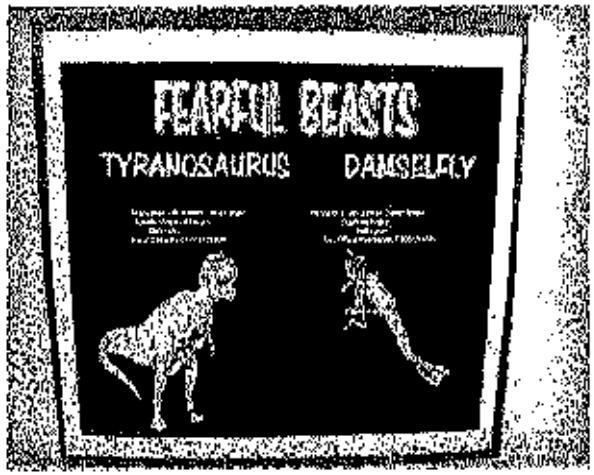


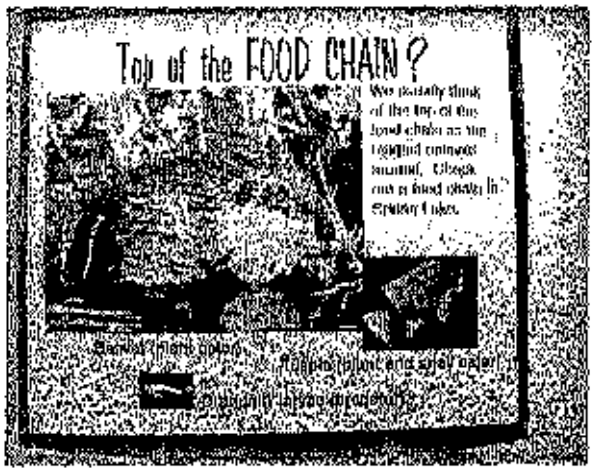




Life Times Ten Exhibit







Signage for the **Life Times Ten** Exhibit at Aquarena Center

Station 1 (magnification table)

LIFE TIMES TEN
It's a whole new world with a closer look.

Life Size Life Times Two Life Times Three Life Times Four
Life Times Five Life Times Six Life Times Seven Life Times Eight
Life Times Nine Life Times Ten

Station 2 (lowering the scale into tank)

LOSE WEIGHT? JUMP IN!
The support of water actually reduces the weight of objects in Spring Lake.

Station 3 (Fitness scale, remarked)

WHAT'S YOUR WEIGHT UNDER WATER?
People weigh about one fifth as much in water.
Just as weightless astronauts in space
need less bone for support, things in water
need less internal structure to support their weight.

Station 4 (stretched film top)

TOUGH ON TOP
Push down on the surface.
For small bugs like water striders,
water tension is tough. This surface tension
works to walk on, but when it comes time
to catch dinner, striders have to break through.

Signage for the **Life Times Ten** Exhibit
at Aquarena Center

Station 5 (plastic shapes to trace with chain)

PASSING GAS
Dissolved gases needed by plants and animals
pass by in the moving water. To gather as much as possible,
animal gills and plant leaves have
lots of surfaces to come in contact with the water.
Use the chains to trace the gill and leaf outlines
and see how many places water with dissolved
gases and dissolved nutrients can touch.

Station 6 (water table)

WATER WIGGLERS
What parts move to push each toy forward?
What parts do you move when you swim?

SOME WAG AND SOME ROW
Lots of animals living in water make an "S" shape to move forward.
Then there are those bugs with long oar shaped legs
that row through the water.

Station 7 (snail on a bizzel)

AT A SNAIL'S PACE
With their mouth in their foot, snails can
taste as they travel. Their hard rasp will
scrape up the green film of algae.

Station 8 (Clam puppets)

Slip on for CLAMMY Hands!

Fresh water mussels live in the gravel and mud. They filter
food from passing water with their siphon tubes.

Signage for the **Life Times Ten** Exhibit at Aquarena Center

Station 9 (Predator Lever)

SNAPPING JAWS
Dragonfly and damselfly larvae are great hunters. Their hinged bottom jaws unfold and spring out to grab other bugs and small fish.

FEARFUL BEASTS

Gomphidae	Tyranosaurus
Strong jaws, kills animals 2 times larger	Strong jaws, kills animals 2 times larger
Rapid movement from jet stream	Speeds of up to 45 m.p.h.
Stalks prey	Stalks prey
Top of Pond invertebrate FOOD CHAIN	Top of Cretaceous FOOD CHAIN

TOP OF THE FOOD CHAIN?

Beaver (plant eater)

Tilapia (plant and snail eater)

Dragonfly larvae (predator)

Station 10 (marble maze)

TINY PLACES
The aquifer that holds the water pouring into Spring Lake is a place of small spaces. San Marcos salamanders and Texas blind salamanders fit in these tiny spaces inside the aquifer and at spring openings.

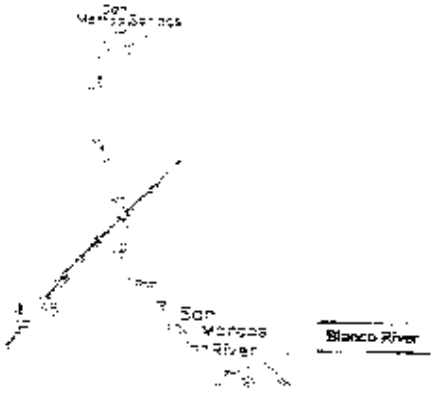
KINGDOM	PHYLUM	ORDER	GROUP	CLASS	FAMILY
Animal	*Chordata*	*Perciformes*	*Fish*	*Osteichthyes*	*Percidae*

Fountain Darter
Etheostoma fonticola

IUNC Red List: Endangered, listed 1977
Federal Status: Endangered, listed 1970
State Status: Endangered
Critical Habitat: Spring Lake and
San Marcos River ,5 miles beyond IH-35 bridge

Description
The fountain darter is a reddish brown fish with an average size of one inch, and is the smallest darter species. It displays a series of dark, horizontal dash lines along its sides and three dark spots at the base of the tail. Dark bars appear below, behind and in front of the eyes. Breeding males have a conspicuous banding pattern on the first dorsal fin. This banding pattern is five distinct bands of black, clear, red, clear and black. The fountain darter was first collected and described in 1884 by Gilbert.

Life History
Fountain darters feed during the day and rely on movement by prey to locate their food. Some of the invertebrates found in the stomachs of darters are copepods and insect larvae. Breeding occurs in aquariums year round, but in the natural environment of the river it appears to increase during August and early spring. The female attaches eggs to mosses and algae where the young emerge in approximately six days.



Distribution and Habitat
Originally, *Etheostoma fonticola* could be found in the San Marcos and Comal Rivers. It was first collected in the San Marcos River in 1884 by Jordan and Gilbert, and in the Comal River by Kendell and Evermann in 1891. The last of the Comal River population was collected in 1954, before the drought of the 1950's caused Comal Springs to cease flowing. An exhaustive search in 1973 and 1974 did not locate any remaining individuals of the Comal population. Scientists released fountain darters from the San Marcos system into the Comal River in 1975 and 1976 and it is believed all of today's population originated from these released darters. Currently, fountain darters are located along the entire length of the Comal River and in the upper San Marcos River before the confluence with the Blanco River. Estimated number of fountain darters in the San Marcos River was 45,900 (1993), and in 168,000 in the Comal River (1993). Most of the darters can be located in vegetation growing close to the substrate, such as filamentous algae, moss, hydrilla, and primrose.

Threats and Reason for Decline
Of great concern to scientists is the introduction of a fluke in the Comal River whose larval form infests the gills of fountain darters. The increased stresses from the infections cause increased mortality rates and reduced offspring numbers.

Higher temperatures, due to diminished stream flow, is a limiting factor for fountain darters in the Comal River. For both river systems, the structure of the aquatic plant communities providing critical habitat is threatened by invasive exotic plants, and a non-native snail *Marisa cornuetis*, introduced in 1983, as well as people swimming and tubing in the river.

Recovery Efforts
Minimum flow requirements for the darter are established and when the spring flow drops below this level, the Edwards Aquifer Authority must reduce the amount pumped from the aquifer by its users. Aquatic plant patches have been surveyed and will be monitored for impacts due to dam repairs and recreational use of the river.

Where to See
Fountain darters are maintained in captivity as a reserve population. These populations are kept in Uvalde and at the San Marcos National Fish Hatchery and Technology Center in the event of a catastrophic event to the critical habitat. They are also on display at the Endangered Species Aquarium at Aquarena Center.

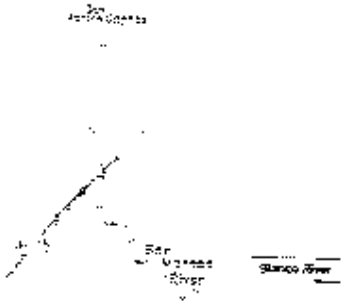
KINGDOM	DIVISION	ORDER	GROUP	CLASS	FAMILY
Plant	*Magnoliophyta*	*Cyperales*	*Angiosperma*	*Liliopsida*	*Poaceae*

Texas Wild-Rice
Zizania texana

IUNC Red List: Vulnerable
Federal Status: Endangered, listed 1978
State Status: Endangered, listed 1983
Critical Habitat: Spring Lake and San Marcos River from the headwaters to confluence with Blanco River

Description
Texas wildrice is an aquatic grass with thin, flat, elongated leaves as long as one and half meters, typically immersed and long-streaming in river currents. First collected in 1892 by G.C. Neally, it was correctly identified as a unique species by Hitchcock in 1933.

Life History
The plant flowers and sets seeds from April to November. Seeding plants have become increasingly rare in the wild. Profuse seeding has been observed in the river recently, but biologists are uncertain what factors triggered the seeding. The plant depends on vegetative reproduction from rhizomes, forming large clones.



Distribution and Habitat
This wildrice was once abundant in Spring Lake, the San Marcos River, and in irrigation ditches with constant flows. In the 1930's it was considered it a problem plant that clogged irrigation ditches. Texas wildrice is currently distributed along the upper four miles of the river in the city of San Marcos, in gravel shallows near the middle of the river. This plant is adapted to fast-flowing water of high quality and constant year-round temperatures as provided by adequate spring flows. Silting, disturbance of the bottom, or stagnant water will kill off plants.

Threats and Reasons for Decline
The major threat to the San Marcos River habitat is increased pumping of Edwards Aquifer groundwater. Decreased spring outflow lowers the water level of the river and exposes the shallows where Texas wildrice typically would grow. Other threats to wildrice include recreational use of the river by tubers and dogs, herbivory by introduced species, reduced photosynthesis from floating vegetation mats, and competititon by exotic plant species. Recent losses of established plants from a 500 year flood event and a downstream dam failure that lowered river water levels has concerned biologists. Riverside construction and bottomland cultivation have destroyed plants, altered stream flows and temperature, or increased siltation.

Recovery Efforts
Efforts to grow Texas wildrice from 1972 to 1982 in other stream settings were not successful. No new populations resulted. Recreational disturbance of wildrice is being reduced with educational signage at the tubing rental location. During 1999's partial dam failure that lowered the water levels in wildrice habitat, biologists transplanted wildrice into more optimal zones. Texas Parks and Wildlife Department conducts a yearly monitoring survey of the wildrice patches to measure changes in population size. At the beginning of the new century, there is approximately 1,800 square meters of wildrice in Spring Lake and San Marcos River.

Where to See
Texas wildrice is successfully under cultivation at the San Marcos National Fish Hatchery and Technology Center, with additional plants in refugium at the Freeman Biology Building at Southwest Texas State University, and future refugium at the Lady Bird Johnson Wildflower Center.

KINGDOM	PHYLUM	ORDER	GROUP	CLASS	FAMILY
Animal	*Chordata*	*Caudata*	*Amphibian*	*Amphibia*	*Plethondontidae*

San Marcos Salamander
Eurycea nana

IUNC Red List: Rare
Federal Status: Threatened, listed 1980
State Status: Threatened, protected nongame
Critical Habitat: Spring Lake and
50 meters of San Marcos River below dam

Description
The minature San Marcos salamander is about two and a half inches long and displays a prominent gill fringe behind the head. It is neotenic, meaning it remains in the amphibian larval form and will not metamorphisize. There are no external ears, the eyes are large with a dark ring and the limbs are short and slender. This small salamander's specific name "nana" is from the Greek nanos, meaning dwarf.

Life History
The San Marcos salamander breeds and lays eggs in dense aquatic vegetation, from which the larvae emerge in three and a half weeks. This species is carnivorous and feeds on amphipods, insect larvae, and aquatic snails by remaining stationary until the prey passes closely by, and then snapping. Salamanders, in turn, are food to sunfish, turtles, bass, blue tilapia, and catfish.

Distribution and Habitat
The species' range extends from Spring Lake to right below the two spillways of Burleson dam.
The San Marcos salamander is found in spring openings among sand and gravel substrates where aquatic vegetation is profuse. Flowing clear spring water with a constant temperature near 21 degrees Centigrade is a habitat requirement for San Marcos salamanders, since no individuals are found in still parts of the lake. Estimated population by Nelson in 1993 was 53,200 salamanders.

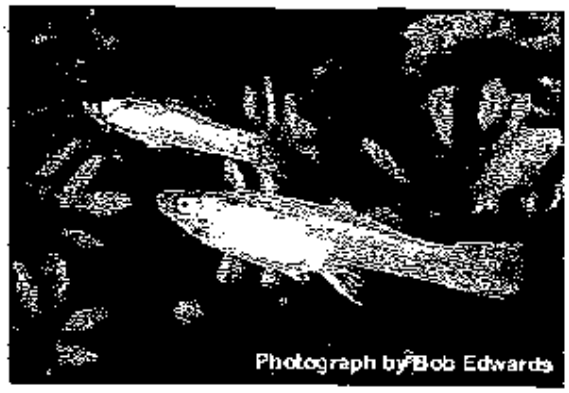
Threats and Reason for Decline
The salamander is threatened by degradation of its very limited habitat. Increase pumping of the aquifer due to rising demand for water for homes and agriculture threatens the salamander by lowering spring flow. Siltation of the habitat is also a concern.

Recovery Efforts
Breeding of the San Marcos salamander in captivity is successful in refugium aquariums. A set number of salamanders are maintained in captivity as insurance against habitat destruction or disease that might imperil the population in the wild.

Where to See
San Marcos salamanders are kept in refugium at the San Marcos National Fish Hatchery and Technology Center, at Uvalde, and on display at Aquarena Center's Endangered Species exhibit.

KINGDOM	PHYLUM	ORDER	GROUP	CLASS	FAMILY
Animal	*Chordata*	*Atheriniformes*	*Fish*	*Osteichthyes*	*Poecilidae*

San Marcos Gambusia
Gambusia georgei



IUNC Red List: Endangered, listed 1977
Federal Status: Endangered, listed 1980
State Status: Endangered 1977
Critical Habitat: Spring Lake and San Marcos River .5 miles beyond IH-35 bridge

Description
Last seen in 1983, the San Marcos gambusia is considered very likely extinct by aquatic biologists. It ranged in length from 2.5 to 4 centimeters (1 to 1.6 inches), was dark with a bluish sheen and had strong crosshatching on the scales. It closely resembled the Western mosquito fish, *Gambusia affinis*.

Life History
This fish was a livebearer whose eggs, up to sixty, hatched inside the female's body with the young emerging alive. It is assumed this gambusia resembled other stream dwelling gambusia species and fed on insect larvae and other invertebrates found in the preferred habitat of slow-moving waters shaded by overhanging trees or bridges.

Distribution and Habitat
The gambusia's entire known range is restricted to a 1 kilometer (0.6 miles) stretch of the San Marcos River below the headwaters between the Interstate Highway 35 and Thompson's Island. It was one of three Gambusia species in the river, along with *Gambusia affinis* and *Gambusia geiseri*, and was by far the rarest of the three with the most restricted range. First described by Hubbs and Peden in 1969, its population was estimated at 1,000. When a survey of gambusia species was done in 1978 and 1979, only 18 of the 20,000 netted gambusias were the San Marcos gambusia.

The San Marcos gambusia preferred quiet backwaters, adjacent to the main river currents, with shading and minimal vegetation. Habitat requirements by the more generalist species of gambusia in the river are shallow edges with dense vegetation (*Gambusia affinis*) and deeper midwater locations with increased flow (*Gambusia geiseri*). *Gambusia georgei's* primary habitat requirements appeared to be clean and clear water of a constant temperature. Temperatures in the river vary by only a few degrees throughout the year, averaging about 23 degrees Centigrade.

Threats and reason for decline
The original range of *Gambusia georgei* became a heavily utilized and channeled section of the river in the city of San Marcos. Alteration of the river habitat created a two-part problem for the endangered species. The change of the muddy bottoms by siltation from increased runoff, the change in stream flow from increased aquifer pumping, the change in embankment vegetation by invading exotic elephant ear plants (*Colocashia escuelata*) decreased habitat for *Gambusia georgei*, and at the same time, increased habitat for the other gambusias. The collision of gambusia species with the resultant genetic contamination of *G.georgei* by interbreeding with *G.affinis* was the death knoll for the San Marcos gambusia.

Recovery Efforts
San Marcos gambusia were captured alive and artificial cultures established in 1979 and 1980. Both of these cultures were contaminated by *G.affinis* in the early 1980s and the last individual taken from the wild was captured in 1982. Despite considerable collecting efforts to secure this species since then, none have been taken.

Where to See
There are no existing Gambusia georgii on display or in refugium. The very similar species of gambusia, Western mosquitofish, is common in many waterways.

KINGDOM	PHYLUM	ORDER	GROUP	CLASS	FAMILY
Animal	*Chordata*	*Caudata*	*Amphibian*	*Amphibia*	*Plethondontidae*

Texas Blind Salamander
Tymphlomolge rathbuni

Federal Status: Endangered, listed 1967
State Status: Endangered
Critical Habitat: Edwards Aquifer in Hays County, 25 square miles underlying San Marcos

Description
The Texas blind salamander is a sightless cave-dwelling amphibian that grows up to 5 inches in length. It is slender with toothpick-like legs, translucent white skin and with a fringe of red external gills. Two eyespots mark the location of vestigial eyes on the flattened head and snout. The Texas blind salamander was first collected in 1895, at the Federal Fish Hatchery in San Marcos, Texas where it was expelled from an artesian well drilled to supply water to the hatchery.

Life History
This totally aquatic species feeds on small invertebrates living in underground waters. Observations of the salamander indicate that it moves through the aquifer by walking along ledges underwater and swimming short distances before spreading its legs and settling to the bottom. It spends its life in complete darkness. It is believed that the salamander is sensitive to water temperature changes. Little else of its natural history is known because of the hidden nature of its habitat. Pregnant females have been observed throughout the year. The species is neotenic; it does not transform into a lunged adult.

Distribution and Habitat
Biologists know of only one population of the Texas blind salamander, which occurs in the Edwards Aquifer beneath San Marcos. The current population is apparently stable, although of limited numbers. They have been found in seven locations in the San Marcos Springs fault and Purgatory Creek, after being ejected from spring openings. The Texas blind salamander is endemic to the underground water system of the limestone caverns of the Edwards Plateau. It is believed to occupy 25 square miles under the city of San Marcos.

Threat and Reasons for Decline
In the years immediately following the drilling of the well, 100 blind salamanders were recovered from the opening each year. Numbers were reduced to just a few ejected each year soon afterwards. Survival of this salamander depends upon the stability and continued purity of the Edwards aquifer spring flows, which is threatened by increasing demand for water and pollution of groundwater.

Recovery Efforts
A large aquifer cavern was purchased by the Nature Conservancy and is being monitored by a steward for water quality in a protected portion of the salamander's habitat.

Where to See
Texas blind salamanders are kept in refugium at the San Marcos National Fish Hatchery and Technology Center and in Uvalde. Specimens can be seen at the Freeman Biology Building on Southwest Texas State University campus, when recovered by Edwards Aquifer Research and Data Center, and on display in aquariums at Aquarena Center.

August 1, 2002
Pages, including this cover page **10**

To: Gareth Rowell
Fax# 912 - 7058
From: Margaret Russell
Aquarena Center
512-835-6657

RE:
GRANT Number E-1-12
GRANT TITLE Endangered and Threatened Species Conservation
PROJECT NUMBER WER63

Gareth

The accompanying pages reflect the changes made in response to USFW comments. Comments regarding Item numbers that are not included in the pages are:

#1. Comment regarding the usage of common plant names on signage. The signs were fabricated in the fall of the first year of the grant, as was noted to Pat Conner in the summer of 2001, following his request for review. The common names used to identify the small botanical pictures on the sides of "The First Link" sign reflect the names in use at this facility and in this area. All common names for birds in subsequent signs were verified with Marsha Reimer to follow the standard naming. The cost of redoing this sign would exceed $800.00.

9. Comment regarding the updating of Texas Endangered and Threatened Species. These pages are inserts using the TP&W issued list. When the March 1999 edition is updated and made available by TP&W, it can be inserted into the document.

#10. Comment regarding the Endangered Species Act of 1973 Terms. This page was eliminated from the document.

LIFE TIMES TEN

RATIONALE

The five small rare animal species in Spring Lake live within crevices and among vegetation, so their lives are not visible. The phenomena of flagship species, an animal or plant whose charisma insures support by the public, does not usually extend to cold blooded animals. Not well known, not easily found, and without immediate appeal, Spring Lake rare species need to become larger than life for their stories to be heard and for the public to relate to *Gambusia georgei, Eurycea nana, Eurycea rathbunii, Etheostoma fonticola, Zizania texana,* and *Heterelmis comalensis.* See item # 2

The patterns in life times ten, or life visible under ten power of magnification, is both familiar and bizarre. The foundation of life cycles, with food chains and predator-prey relationships is similar on both land and in the water. The struggle of life forms to meet their needs in a water world, where water molecule properties especially impact moving and breathing strategies at a smaller dimension, has created bizarre and unique adaptations.

Formal educational curriculum guides for grades K through 6 include requirements for a basic knowledge strand that identifies components of the natural world, basic needs of an organism, how living things depend on each other and their environment, habitats, competition, inherited traits, adaptations and how adaptations improve survival, an organism's niche and living things' life processes. The physical aspects the processes life depends on, such as watersheds, states of matter, and water cycle, play an important role in explaining Life Times Ten.

TARGET AUDIENCE

The exhibit will target children 5 to 12 years old, while reaching families and all ages.[1]

OBJECTIVES

By visiting this exhibit, the audience will:

1.) Look for and recognize ways organisms adapt to living in water.
2.) Compare life at different scales
3.) Make new connections between prior knowledge and experiences of larger land animal ecologies with smaller aquatic ecologies.
4.) View rare species of Spring Lake as important components of the ecology.

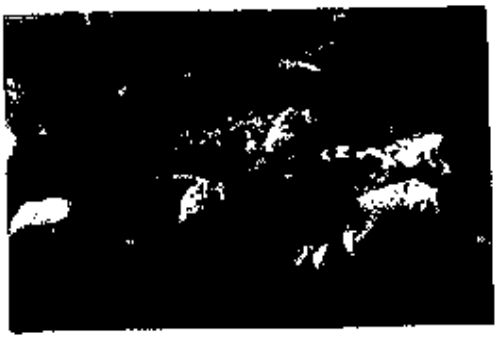
[1] Seven Characteristics of Family Friendly Exhibits:

Multi-sided - family can cluster around exhibit
Multi-user - interaction allows for several sets of hands or bodies
Accessible - comfortably used by children and adults
Multi-outcome - observation and interaction foster group discussion
Multi-modal - appeals to different learning styles and levels of knowledge
Readable - text is arranged in easily understood segments
Relevant - providing cognitive links to visitors existing knowledge and experience

Family Learning in Museums: The PISEC Perspective. Philadelphia/Camden Informal Science Education Collaborative, The Franklin Institute, 1998.

KINGDOM	PHYLUM	ORDER	GROUP	CLASS	FAMILY
Animal	*Chordata*	*Perciformes*	*Fish*	*Osteichthyes*	*Percidae*

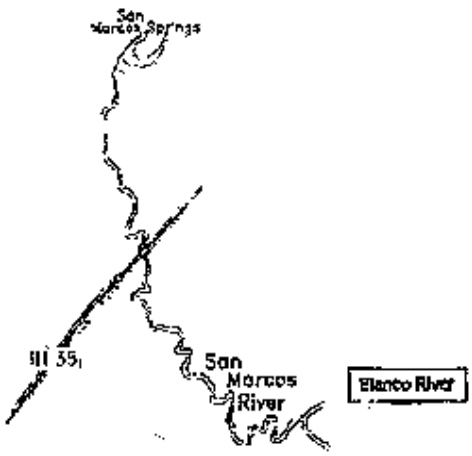
Fountain Darter
Etheostoma fonticola



IUNC Red List: Endangered, listed 1977
Federal Status: Endangered, listed 1970
State Status: Endangered
Critical Habitat: Spring Lake and
San Marcos River .5 miles beyond IH-35 bridge

Description
The fountain darter is a reddish brown fish with an average size of one inch, and is the smallest darter species. It displays a series of dark, horizontal dash lines along its sides and three dark spots at the base of the tail. Dark bars appear below, behind and in front of the eyes. Breeding males have a conspicuous banding pattern on the first dorsal fin. This banding pattern is five distinct bands of black, clear, red, clear and black. The fountain darter was first collected and described in 1884 by Gilbert.

Life History
Fountain darters feed during the day and rely on movement by prey to locate their food. Some of the invertebrates found in the stomachs of darters are copepods and insect larvae. Breeding occurs in aquariums year round, but in the natural environment of the river it appears to increase during August and early spring. The female attaches eggs to mosses and algae where the young emerge in approximately six days.



Distribution and Habitat
Originally, *Etheostoma fonticola* could be found in the San Marcos and Comal Rivers. It was first collected in the San Marcos River in 1884 by Jordan and Gilbert, and in the Comal River by Kendall and Evermann in 1891. The last of the Comal River population was collected in 1954, before drought and groundwater pumping caused Comal Springs to cease flowing. An exhaustive search in 1973 and 1974 did not locate any remaining individuals of the Comal population. Scientists released fountain darters from the San Marcos system into the Comal River in 1975 and 1976 and it is believed all of today's population originated from these released darters. Currently, fountain darters are located along the entire length of the Comal River and in the upper San Marcos River to the confluence with the Blanco River, and beyond. Estimated number of fountain darters in the San Marcos River was 45,900 (1993), and in 166,000 in the Comal River (1993). Most of the darters can be located in vegetation along the bottom, such as filamentous algae, moss, and hydrilla.

See item #3

Threats and Reason for Decline
Of great concern to scientists is the introduction of a fluke in the Comal River whose larval form infests the gills of fountain darters. The increased stresses from the infections cause increased mortality rates and reduced offspring numbers.

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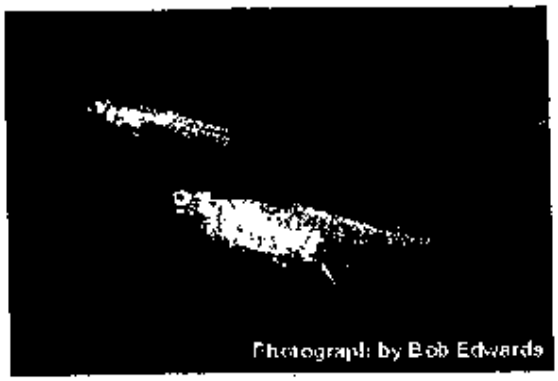
See item #3

Recovery Efforts
Minimum flow requirements for the darter are established and when the spring flow drops below this level, the Edwards Aquifer Authority must reduce the amount pumped from the aquifer by its users. Aquatic plant patches have been surveyed and will be monitored for impacts due to dam repairs and recreational use of the river.

Where to See
Fountain darters are maintained in captivity as a reserve population. These populations are kept in Uvalde and at the San Marcos National Fish Hatchery and Technology Center in the event of a catastrophic event to the critical habitat.

KINGDOM	PHYLUM	ORDER	GROUP	CLASS	FAMILY
Animal	*Chordata*	*Atheriniformes*	*Fish*	*Osteichthyes*	*Poecilidae*

San Marcos Gambusia
Gambusia georgei



IUNC Red List: Endangered, listed 1977
Federal Status: Endangered, listed 1980
State Status: Endangered 1977
Critical Habitat: San Marcos River from Hwy 12 bridge to .5 miles beyond IH-35 bridge

See item #4

Description
Last seen in 1983, the San Marcos gambusia is considered very likely extinct by aquatic biologists. It ranged in length from 2.5 to 4 centimeters (1 to 1.6 inches), was dark with a bluish sheen and had strong crosshatching on the scales. It closely resembled the Western mosquito fish, *Gambusia affinis*.

Life History
This fish was a livebearer whose eggs, up to sixty, hatched inside the female's body with the young emerging alive. It is assumed this gambusia resembled other stream dwelling gambusia species and fed on insect larvae and other invertebrates found in the preferred habitat of slow-moving waters shaded by overhanging trees or bridges.

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Threats and reason for decline
The original range of *Gambusia georgei* became a heavily utilized and channeled section of the river in the city of San Marcos. Alteration of the river habitat created a two-part problem for the endangered species. The change of the muddy bottoms by siltation from increased runoff, the change in stream flow from increased aquifer pumping, the change in embankment vegetation by invading exotic elephant ear plants (*Colocashia escuelata*) decreased habitat for *Gambusia georgei*, and at the same time, increased habitat for the other gambusias. The collision of gambusia species with the resultant genetic contamination of *G.georgei* by interbreeding with *G.affinis* was the death knoll for the San Marcos gambusia.

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Where to See
There are no existing *Gambusia georgei* on display or in refugium. The very similar species of gambusia, Western mosquitofish, is common in many waterways.

KINGDOM	PHYLUM	ORDER	GROUP	CLASS	FAMILY
Animal	*Chordata*	*Caudata*	*Amphibian*	*Amphibia*	*Plethodontidae*

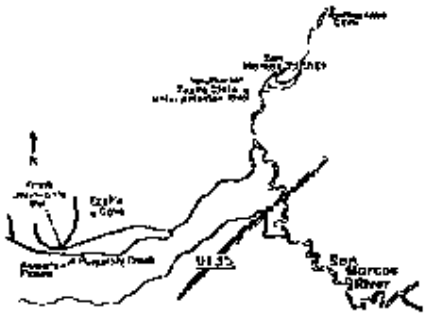
Texas Blind Salamander
Eurycea rathbuni

Federal Status: Endangered, listed 1967
State Status: Endangered
Habitat Range: Edwards Aquifer in Hays County, 25 square miles underlying San Marcos

See item #5

Description
The Texas blind salamander is a sightless cave-dwelling amphibian that grows up to 5 inches in length. It is slender with toothpick-like legs, translucent white skin and with a fringe of red external gills. Two eyespots mark the location of vestigial eyes on the flattened head and snout. The Texas blind salamander was first collected in 1895, at the Federal Fish Hatchery in San Marcos, Texas where it was expelled from an artesian well drilled to supply water to the hatchery.

Life History
This totally aquatic species feeds on small invertebrates living in underground waters. Observations of the salamander indicate that it moves through the aquifer by walking along ledges underwater and swimming short distances before spreading its legs and settling to the bottom. It spends its life in complete darkness. It is believed that the salamander is sensitive to water temperature changes. Little else of its natural history is known because of the hidden nature of its habitat. Pregnant females have been observed throughout the year. The species is neotenic; it does not transform into a lunged adult.



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Recovery Efforts
A large aquifer cavern was purchased by the Nature Conservancy and is being monitored by a steward for water quality in a protected portion of the salamander's habitat.

Where to See
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FIT the NICHE

THE SAN MARCOS SALAMANDER

The San Marcos salamander lives in the gravel at spring openings, or under rocks in Spring Lake and San Marcos River. Because it is so small, it needs a good place to hunt bugs and stay hidden from bigger animals that are hungry. Sometimes the salamander comes out into the open, but it matches the colors of the plants on the bottom.

THE FOUNTAIN DARTER

The fountain darter, similar to many darter species, lacks a swim bladder and lives on the bottom of the stream. Without a flotation device, the fish must push off the bottom to swim away from predators. It mostly depends on remaining still in vegetation to stay hidden from those fish that would eat it.

See item #6

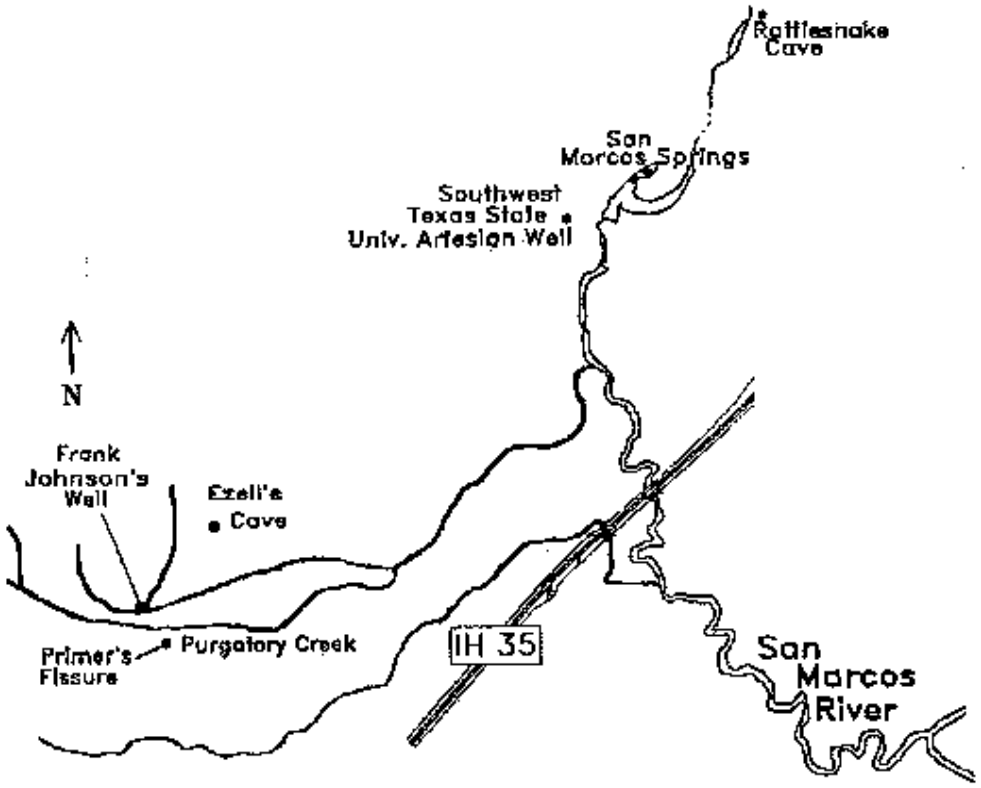
6. Hand out the FIT the NICHE worksheets or make an overhead to use. Ask the students to make choices of different structures that would work best in the niche described for each animal.
7. Put together composites of the San Marcos salamander and the fountain darter. Have students draw the two animals. Next, show them actual pictures of these animals. Look on the website Endangered species in the San Marcos River, facts and photos at San Marcos River Foundation http://www.sanmarcosriver.org/endanger.htm#1. How closely did their constructed animals fit the real animals?
8. Challenge the students to make a FIT the NICHE choice sheet for another endangered animal. They will first have to learn about the animal to understand what it needs.

Mapping Reduced and Rare Species

→ Home Range
of Texas Blind Salamanders

See Item #7

Well and Spring locations of
Texas Blind Salamanders ejected from the aquifer.



Texas Endangered and Threatened Species

Species	Status	Location	Some Reasons for Rarity
Greater Long Nosed Bat	E	Trans Pecos	Particular feeder
Texas Kangaroo Rat	T	Rolling Plains	Loss of habitat, limited range
Atlantic Bottlenose Dolphin	T	Marine	Over harvested, disease
Red Wolf	E	East Texas	Over harvested
Jaguarundi	E	South Texas brush	Loss of habitat
Whooping Crane	E	Gulf Coast Prairie	Loss of nesting habitat, migration dangers, limited offspring
American Peregrine Falcon	E	Central and West Tx	Drop in offspring from DDT
Attwater's Greater Prairie chicken	E	Gulf Coast Prairie	Loss of habitat, particular about habitat
Ivory billed woodpecker	E	Piney woods	Loss of habitat, particular about nests
Golden cheeked warbler	E	Edwards Plateau	Loss of habitat, particular about nests, migratory
Kemp's Ridley sea turtle	E	Marine	Migratory, over harvested
Texas tortoise	T	Coast and South Tx	Loss of habitat, over collected
Texas horned lizard	T	All but piney woods	Loss of preferred food item, habitat degradation
Indigo snake	T	Coast, South Tx	Loss of habitat, over harvested
San Marcos salamander	T	Edwards Plateau	Limited range
Texas blind salamander	E	Edwards Plateau	Limited range
Houston toad	E	Prairie and E. Tx.	Limited range
Toothless blind catfish	T	Edwards Plateau	Limited range
Leon Springs pupfish	E	Trans Pecos	Limited range
Comanche Springs pupfish	E	Trans Pecos	Limited range
Pecos pupfish	E	Trans Pecos	Limited range, mating with sister species
Fountain darter	E	Edwards Plateau	Limited range
San Marcos gambusia	E	Edwards Plateau	Limited range
Big Bend gambusia	E	Trans Pecos	Limited range
Comal Springs riffle beetle	E	Edwards Plateau	Limited range
Tooth Cave spider	E	Edwards Plateau	Limited range
Tobush fishhook cactus	E	Edwards Plateau	Loss of habitat, over harvested
Texas wildrice	E	Edwards Plateau	Exotic species, loss of habitat

* E = Texas listed Endangered Species
* T = Texas listed Threatened Species

See item #8

See item #8

See item #8

Physical Parameters

The unique and diverse assemblage of plants and animals in the river likely results from long term stable physical and chemical factors of the upper river or spring run. The headwaters of San Marcos River begins from a series of over two hundred spring orifices that issue from the Edward Artesian Aquifer where the San Marcos Spring Fault intersects with the Balcones Fault. The river was impounded in 1849 forming Spring Lake. From there the river flows through an urban setting 4.5 miles to its confluence with the Blanco River and then flows about 75 miles to its confluence with the Guadalupe River. The spring-run is defined as the upper river to its confluence with the Blanco River and it is here that physical stability is most evident. The Blanco River provides an interesting contrast to the spring run as well as defining its downstream limit.

Flow Characteristics

Discharge of water from San Marcos Springs has been remarkably stable over time. The lowest flow ever recorded was 45cfs during the 1956 drought and the highest recorded was 452cfs in 1992. This is a very narrow range of discharge for a river. The maximum and minimum discharge for the San Marcos River and the Upper Blanco River during drought conditions and after substantial rain has recharged the aquifer will track very closely. Compare this to discharge in the Blanco River. The total range, from zero to 19,600cfs varies considerably about the mean flows. Flood events of a large magnitude on the Blanco River and all other hill country rivers often scour the channel and substrate and substantially reduce the biological community. The upper San Marcos River is somewhat buffered from the effects of severe flooding and provides a more stable physical environment. At the confluence of the two rivers, that stability is reduced. ← See item # 10

Thermal Characteristics

Water issuing from the springs remains a constant temperature of about 22 °C (70 °F) year round because of its long term contact with stable sub-surface temperatures. It takes a significant amount of energy to change the temperature of water and so a large volume of water will remain fairly constant in temperature for several miles downstream before ambient air temperature and solar radiation begin to affect it. Compare this seasonally stable condition to unstable thermal characteristics of the upper Blanco River and the area below the confluence of the two streams. Stable thermal conditions are limited to the spring-run above the confluence.

Water Clarity

Water clarity plays an important role in determining the depth to which various spectra of light can penetrate and therefore, the depth to which photosynthesis can occur. This is called the photic zone. Water clarity is affected by suspended particles, dissolved organic and inorganic compounds, and phytoplankton production.

Stable Ecosystems

Large volume spring systems were described by ecologist Howard T. Odum as natural laboratories because variability in certain physical factors (temperature, flow, chemical constituents) is greatly reduced compared to other types of systems. This does not mean they are superior to other systems, but that reduced variability make it easier for ecologists to examine the whole system. In a system like the San Marcos River where temperature and flow are fairly constant and primary production is more or less continuous, seasonal variation in food resources is greatly reduced and there is less pressure for timing reproduction to take advantage of changing resources. Many aquatic organisms in more variable systems, particularly insects, have evolved highly synchronized life cycles timed to seasonal pressure. Since these pressures are reduced in the upper San Marcos River, the assortment of organisms here is quite different than that found in other streams.

Very stable ecosystems that are physically isolated tend to have a higher number of species that are peculiar to that system.

Rare Species and Spring Systems

An endemic species is one that is limited in its distribution of a specific geographical area. It is important to define the spatial limits of distribution when talking about endemism because it can be quite large or quite small. The kangaroo can be said to be endemic to Australia, a continent comprised of almost 3 million square miles, while certain fish may be endemic to a single spring comprised of a few square yards. Caves and spring systems are noted for a high degree of endemism on a very small spatial scale. This probably results from the fact that such species have become isolated over time from their ancestral stock and closely related species, and natural selection processes have caused the evolution of distinct species. All of the protected plants and animals of the San Marcos River are endemic species with very limited distribution.

Threatened and Endangered Species of the San Marcos River

The U.S. Fish and Wildlife Service and Texas Parks and Wildlife Department presently recognize five endangered species and one threatened species in the springs and river. A sixth endangered species is a cave dwelling animal that is not normally found in the surface waters.

Texas wild rice (*Zizania texana*)

Texas wild rice is a perennial aquatic grass that occurs on the headwaters of the San Marcos River. Its historical distribution included much of Spring Lake, the river below the lake and irrigation ditches. It currently is found in Spring Lake near the dam and spillway and grows downstream about 2.7 miles to a point just upstream of the waste water treatment plant. It occurs in small to large clumps in gravel, sand, and silt substrates. An excellent place to view the rice is from the bridge where Aquarena Springs Drive intersects University Drive.

See Item #10