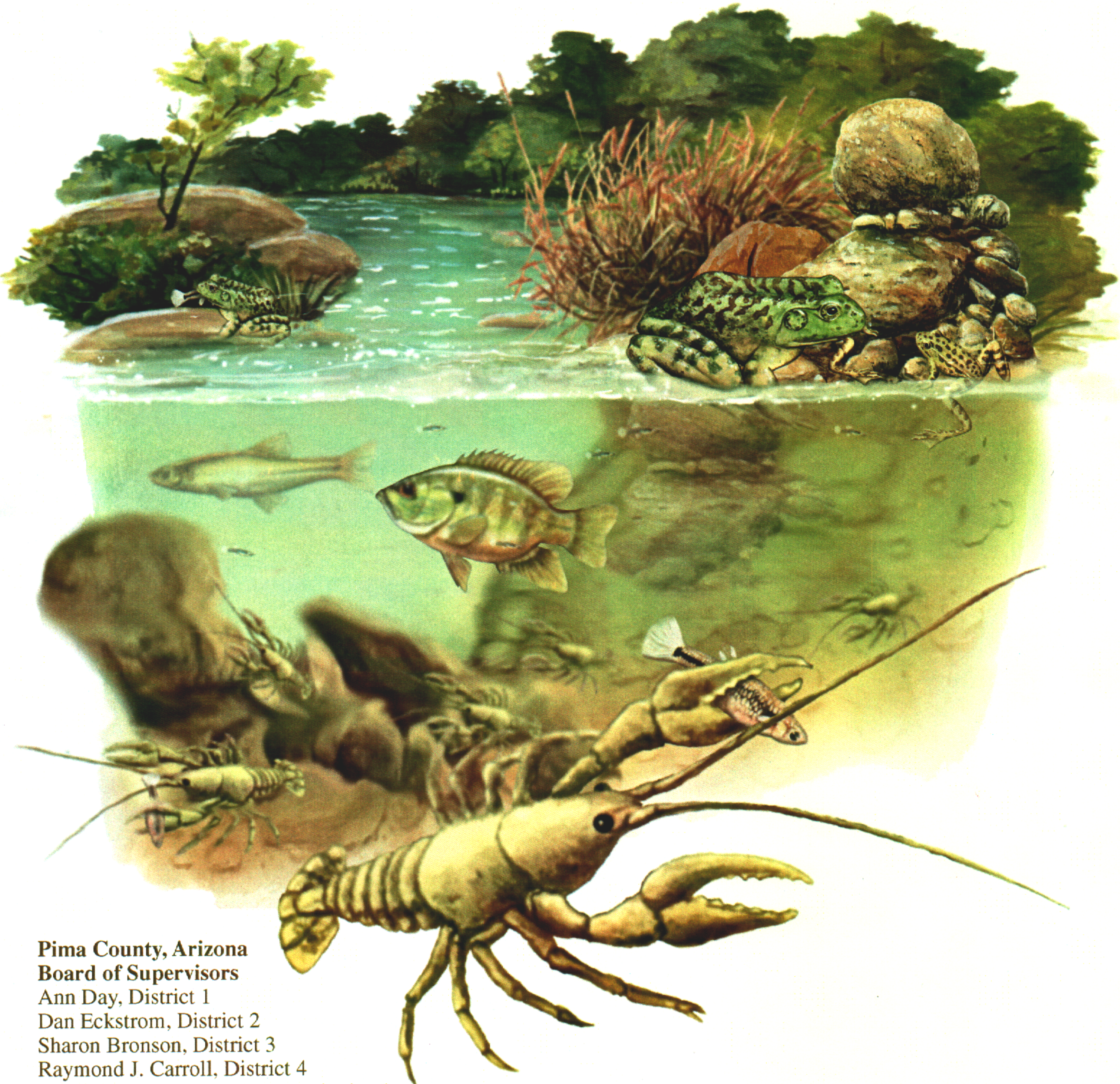
Aquatic Species Threat in Pima County

DRAFT

Sonoran Desert Conservation Plan May 2001



Pima County, Arizona
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County Administrator
Chuck Huckelberry

MEMORANDUM

Date: May 30, 2001

To: The Honorable Chair and Members
Pima County Board of Supervisors

From: C.H. Huckelberry
County Administrator

Re: **Aquatic Species Threat In Pima County**

Background

Earlier this month we issued studies from the Science Technical Advisory Team on the priority vulnerable species proposed for coverage under the Sonoran Desert Conservation Plan, and maps of the areas where these 56 plants and animals can be found. The science community has also started to identify tiers of protection, from the areas that should be included in a future reserve to areas that can be enhanced and restored. This information frames discussion of alternatives at both the technical and community level. Inherent in the discussions of future process are recommendations about management within reserve areas. The attached report on *Reducing the Aquatic Species Threat in Pima County* will inform such management discussions.

Report -- Aquatic Species Threat In Pima County

Pima County in conjunction with the Pima Association of Governments held a workshop in February of this year to gather a range of perspectives from the expert community on aquatic species management issues. Summaries of the fifteen presentations are found within the attached study. Some of the major points for future discussion and consideration include:

- Land managers are constrained in efforts to control the negative impact of non-native aquatic species by a limited fiscal commitment to carry out such plans and strategies.
- Native habitats are supportive of native species and are the least supportive of non-natives.
- Exotic species thrive in larger slow flowing bodies of water.
- Some exotic species present more of a threat to native species than others; and some exotic species are currently difficult or impossible to eradicate from aquatic habitat.
- Significant future threats exist for introduction of new exotic species from interbasin water transfers.

As we have seen in the draft adaptive management plans for cultural, biological, and open space resources, sufficient information exists to develop guidelines and best management practices, but coordination and cooperation among government entities and landowners is needed to effectively design and implement such strategies. Management proposals for aquatic and non-native species will be discussed and considered as part of the Sonoran Desert Conservation Plan.

Attachment

Backyard Ponds and Exotic Pests

A new danger is threatening what's left of Arizona's streams and wetlands.

This threat has a direct link to some of us who love aquatic plants and animals. Bullfrogs and crayfish are non-native, aquatic animals that don't fit into the complex, natural cycle of Southwestern river systems. Bullfrogs are voracious predators that eat any animal they can cram into their large mouths. Crayfish will eat any organism they can catch and will strip a stream of its aquatic plants, turning a clear stream into a muddy slough. Both reproduce prolifically and both have been released into natural riparian areas by well-meaning individuals, intentionally and accidentally.

Why you don't want a bullfrog in your pond

- Bullfrogs eat desired wildlife like birds, small mammals, dragonflies, butterflies, native frogs, fish and turtles.
- Bullfrogs reproduce prolifically. One egg mass will typically contain thousands of eggs.
- Bullfrogs spread to neighboring wetlands and gardens. The thousands of eggs hatch into thousands of tadpoles, and the tadpoles transform into thousands of juvenile bullfrogs, which may disperse as soon as the rainy season starts. Some of these frogs travel over 3 miles in search of a new home.
- Bullfrogs, unlike native leopard frogs, have a loud call that may disturb you or your neighbors at night.

Why you don't want Crayfish in your pond

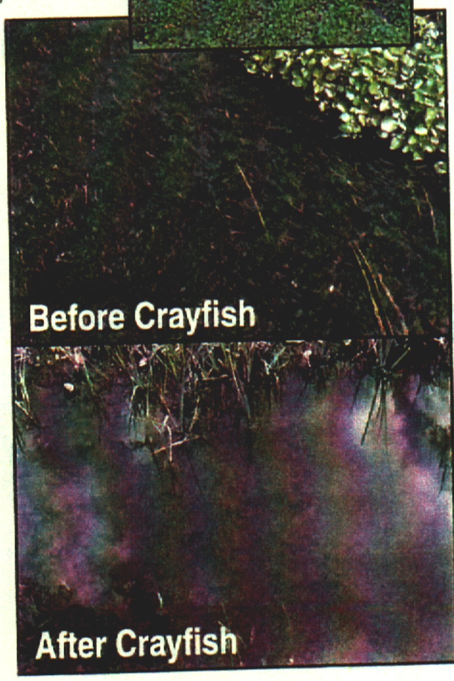
- Crayfish, also known as crawdads, eat aquatic plant and animal life, including lily pads, iris, snails, tadpoles, frogs, baby turtles and fish.
- Crayfish cloud water by destroying the plants that filter and oxygenate it.
- Crayfish erode edges of ponds by digging tunnels and uprooting plants.


C. Schwalbe

Bullfrogs raise havoc with Arizona's native animals. This adult bullfrog was caught while eating a bat.


P. Rosen

A stream in northern Arizona before an unsuspecting fisherman dumped in his bait bucket of crayfish. Two years later, hungry crayfish have denuded the stream of vegetation and clouded the water. Efforts have been underway since 1995 to remove the crayfish, but the task is proving to be next to impossible.



J. Rosen
P. Fernandez

Why bullfrogs and crayfish are a threat to Arizona's wetlands.

As more southern Arizonans build homes closer to natural wetlands and mountain canyons, these aquatic pests are escaping from garden ponds and golf course lakes and spreading to wild areas. Once these animals are established, ongoing efforts to remove them from natural wetlands are proving to be extremely difficult.

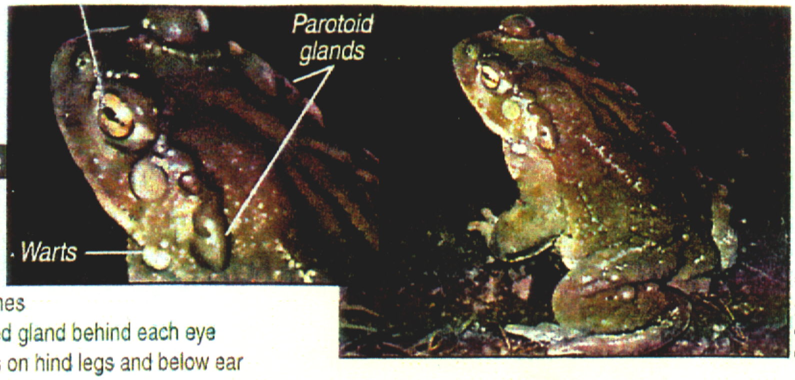
Introduced species disrupt the delicate balance of life. Many species of Arizona's native frogs are in danger of extinction. Many other native animals, like the black hawk, rely on abundant populations of leopard frogs as a regular food source. Crayfish kill small leopard frogs, tadpoles and eggs, while bullfrogs can eat even the largest adult leopard frogs. This, in combination with widely introduced non-native fish and loss of habitat has wiped out most populations of leopard frogs in Arizona. Gone are the days of seeing thousands of leopard frogs hopping from the banks of a stream like popcorn.

Arizona laws regarding crayfish and bullfrogs

- It is against the law to release any organism (plant or animal) into Arizona waters without permission from the state.
- It is illegal to transport live bullfrogs or crayfish throughout almost all of Arizona.
- You can legally harvest unlimited numbers of bullfrogs and crayfish with a valid Arizona fishing license (see reptile and fishing regulations for current limitations).

What you can do

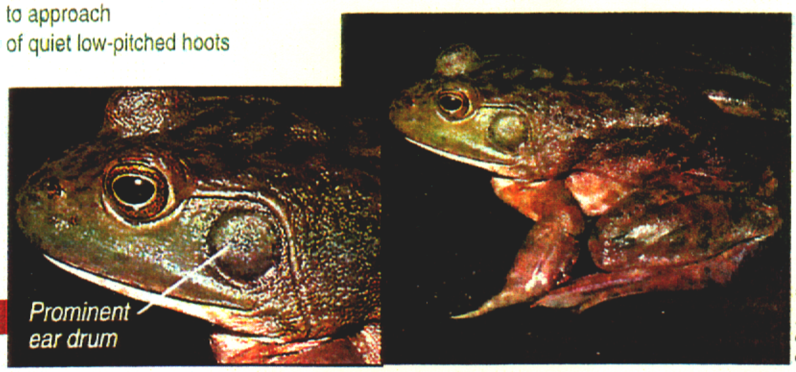
- Be a responsible water gardener. If you have a pond or water garden, and don't have bullfrogs, bullfrog tadpoles, and/or crayfish, take precautions to keep them out. If you fear a neighbor might be less cautious, you can install a smooth-surfaced three to four foot garden wall as a barrier to keep out unwanted exotics.
- If you already have bullfrogs, bullfrog tadpoles and/or crayfish, take appropriate measures to eliminate them before they can do any damage. Small ponds should be drained, letting the liner dry out completely to ensure that any pests have been eliminated. This might take as long as 3 weeks. Do this during the summer dry season (May-June) to reduce the likelihood of these animals relocating in your neighbor's yard or a nearby natural area. You should also transplant your water plants, as crayfish often burrow into water plant containers.
- If you have concerns about a large pond, it would be best to consult a professional. You can call the Arizona Game & Fish Department or the University of Arizona to get help (the phone numbers are listed below). Bullfrog and crayfish eradication is of great concern and state biologists will enthusiastically help you evaluate the undertaking.
- Help spread the word among other water gardeners and water garden retailers. Most bullfrogs and crayfish come into the state unintentionally with shipments of water plants and fish from the southeastern United States. Some animals are sold or given away as pets and others stowaway on water plants to someones backyard pond.



Arizona Native

Sonoran Desert Toad

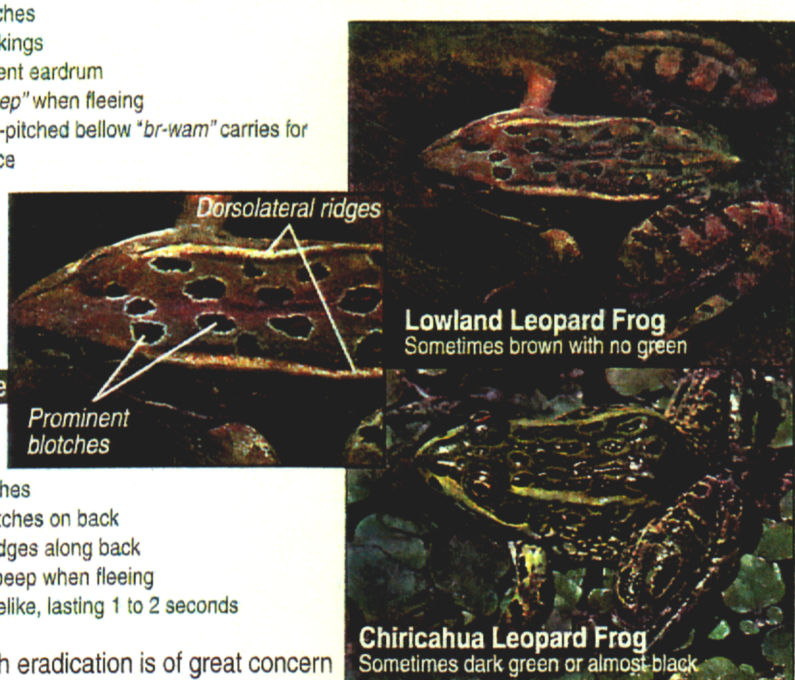
- Size 4 to 7 inches
- Large elongated gland behind each eye
- Enlarged warts on hind legs and below ear
- Slow and easy to approach
- Call is a series of quiet low-pitched hoots



Introduced

Bullfrog

- Size 3 to 8 inches
- Indistinct markings
- Large prominent eardrum
- Young will *"peep"* when fleeing
- Call is a deep-pitched bellow *"br-wam"* carries for quite a distance



Arizona Native

Leopard Frogs

- Size 2 to 5 inches
- Prominent blotches on back
- 2 prominent ridges along back
- Young do not peep when fleeing
- Calls are snorelike, lasting 1 to 2 seconds

Introduced

Crayfish

- Size 0.25 to 5 inches
- Coloration is usually gray or brown, but sometimes red or green.

For More information

Arizona Game and Fish Department
Fisheries Branch (602) 789-3500
Non-Game Branch (602) 789-3500

University of Arizona, Department of Ecology (520) 621-3187

This information is a cooperative venture between Pima County, the Tucson Herpetological Society and the Department of Ecology and Evolutionary Biology, Wildlife and Fisheries Resources in the School of Renewable Natural Resources, University of Arizona. Funded by Arizona Game and Fish Department and Pima County Flood Control District. Written and designed by Dennis Caldwell, 2001

SDCP
Sonoran Desert Conservation Plan

PRINTED ON RECYCLED PAPER

Reducing the Exotic Aquatic Species Threat in Pima County

Proceedings

February 27th, 2001

Prepared by

Pima Association of Governments

for

Pima County Flood Control District
and the Sonoran Desert Conservation Plan

Acknowledgements

Appreciation goes to the following people who envisioned this workshop and made it a reality: Julia Fonseca and Neva Connolly from Pima County Flood Control District, Barbara Tellman from the University of Arizona Water Resources Research Center and Greg Hess and Claire Zucker from Pima Association of Governments. Technical support before and during the meeting was provided by Pima County and PAG staff, particularly Neva Connolly, David Scalero, Jacki Ontiveros, Staffan Schorr, and Jason Bill. Special thanks goes to the speakers who presented at the meeting: Heidi Blasius, Arizona Game and Fish; Dennis Caldwell, Tucson Herpetological Society; Julia Fonseca, Pima County Flood Control District; Will Hayes, Arizona Game and Fish; Dr. Keneth Kingsley, SWCA Environmental Consultants; Amy Loughner, Pima County Parks and Recreation; Dr. William Matter, University of Arizona; Bruce Prior, Tucson Water; Larry Riley, Arizona Game and Fish; Steve Romero, National Forest Service; Dr. Phil Rosen, University of Arizona; Dr. Cecil Schwalbe, United States Geological Survey; Jeff Simms, Bureau of Land Management; Sally Stefferud, U.S. Fish and Wildlife; and Don Swann, National Park Service.

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Reducing the
Exotic Aquatic Species Threat in Pima County

Summary

Exotic species and their effect on Pima County's aquatic environments have become a priority issue for those involved with managing aquatic ecosystems in eastern Pima County. Research conducted as part of the Sonoran Desert Conservation Plan (SDCP) showed that invasion of exotic aquatic species presents a major challenge when preserving and restoring native aquatic species in the region. Pima County's efforts to support and re-establish aquatic habitats and native aquatic species are being pursued as part of the SDCP.

On February 27, 2001, Pima County Flood Control District in conjunction with Pima Association of Governments held an information-sharing symposium/workshop entitled ***Reducing the Exotic Aquatic Species Threat in Pima County***. Speakers were invited to present information from a variety of perspectives. Session I included several overview presentations. Session II contained presentations on control and management challenges in existing reserves: Saguaro National Park, Cienega Creek, Sabino Canyon, Arivaca Canyon, and upper Altar Valley. In Session III, presentations were made on species control in man-made waterbodies: Sweetwater Wetlands, Central Arizona Project, backyard ponds, and Agua Caliente Park. Invitations to the symposium were sent to staff at local, state, and federal agencies that manage lands with aquatic habitat or that run programs regulating aquatic systems. Also, members of the SDCP Steering Committee and Science Technical Advisory Team were informed about the workshop.

The following report presents the proceedings of the February 2001 Exotic Aquatic meeting. Because this document is based solely on remarks made at the meeting, issues that were not discussed are not covered in the document. The 15 speakers presented a wide range of information, and several key points emerged during the day.

1) Land management agencies, as represented at the meeting, are aware of, and are attempting to deal with the threat of exotic species on their lands. However, the extent of their efforts is largely governed by their fiscal resources and competing priorities.

2) Although some exotic species can also thrive in natural habitats, in general, natural desert aquatic habitats are most supportive of native species and are the least compatible with exotic species. Natural habitat types include small flowing streams, shallow small ponds, and springs. These habitats dry up during drought years or dry seasons, and they are subject to scouring during large flood events. Native species have adapted to handle these types of events.

3) Exotic species are often especially well adapted to large, deep, slow-flowing water bodies. These include stock ponds with year-round water, backyard ponds, lakes, deep marshes, and slow-flowing ditches.

4) Some exotic species pose a much greater threat to native species than others do. Bullfrogs, crayfish, and green sunfish were identified during the workshop as high-threat species that are causing problems in aquatic habitats in eastern Pima County.

5) Different control methodologies are needed to eradicate each exotic species. The choice of control methods should be based on the species' ability to disperse overland, their resistance to chemical eradication, their fecundity, and their adaptability, as well as the possible negative impacts on native species. No effective method has been identified to eradicate crayfish from aquatic habitat. Eradication of bullfrogs may not be feasible at many locations, due to reintroduction of the species from neighboring habitats.

6) Currently, enough information is available about exotic and native species to start to develop design guidelines and best management practices for different types of constructed water bodies.

7) Management agencies should coordinate control policies for exotic species to increase the effectiveness of their efforts.

8) Human introduction of exotic species and inter-basin water transfers (CAP) present the biggest means of introducing new exotic species to the region. Human introduction may occur through stocking backyard ponds and water gardens, bait-bucket releases and amateur fisheries management in streams and stock ponds, the release of pets into native habitats, and unintentional or accidental released (e.g., snails or clams carried along with the intended species). Also, introduction may occur when a species migrates independently, for example, bullfrogs travel overland from one water source to the next.

9) The fact that native plants and animals are unavailable in stores and illegal or difficult to collect means that backyard-pond owners are mainly using exotic fauna and flora in their water features.

Contact information for the symposium speakers is summarized in Appendix A of this report. A questionnaire was distributed during Session III of the meeting. Responses are summarized in Appendix B of this report. Appendices C through E contain supplemental information provided by some of the speakers.

Symposium Speakers and Attendees List

Reducing the Exotic Aquatic Species Threat in Pima County

Meeting Date: February 17, 2001

Meeting Place: Pima Association of Governments' Conference Room
177 North Church, Tucson Arizona, 85701

Speakers

Heidi Blasius, Fishery Biologist, Arizona Game and Fish
Dennis Caldwell, Tucson Herpetological Society
Julia Fonseca, Program Manager, Pima County Flood Control District
Will Hayes, Fisheries Program Manager, Arizona Game and Fish
Dr. Kenneth Kingsley, Senior Scientist, SWCA Environmental Consultants
Amy Loughner, Natural Resource Specialist, Pima County Parks and Recreation
Dr. William Matter, Associate Professor, Wildlife and Fishery Science, University of Arizona
Bruce Prior, Hydrologist City of Tucson, Tucson Water
Larry Riley, Arizona Game and Fish
Steve Romero, Wildlife Staff Officer, Santa Catalina Ranger District, National Forest
Dr. Phil Rosen, University of Arizona
Dr. Cecil Schwalbe, Research Ecologist, U.S. Geological Survey, Saguaro National Park
Jeff Simms, Fishery Biologist, Bureau of Land Management
Sally Stefferud, Fish and Wildlife Biologist, U.S. Fish and Wildlife
Don Swann, Biological Technician, National Park Service

Attendees

Baley, Scott	Tohono O'odham Wildlife
Baird, Branford L.	Pima County H. D. CH & FS
Bill, Jason	Pima Association of Governments
Border, Selinda	Arizona Water Protection Fund
Clarkson, Rob	USBG- Phoenix
Cohen, Ernie	Sonoran Desert Conservation Plan
Connolly, Neva	Pima County
Cripps, Jane	SER
Darling, Mary	Stantec
Davidson, Rebecca	Arizona Game & Fish Dept.
Duncan, Doug	U.S. Fish and Wildlife Service
Fitzsimmons, Kevin	University of Arizona, SWES
Freshwater, Diana	Arizona Open Land Trust
Hall, David	University of Arizona
Hamner, Rome	San Xavier District
Hess, Greg	Pima Association of Governments
Juliani, Jerry	Steering Committee, Sonoran Desert Conservation Plan
King, Chad	University of Arizona
Kreamer, Jeff	Pima County Wastewater Management Dept.
Marsh, Paul	ASU Tempe
McCarthy	PCSC
Ramberg, F	University of Arizona, Entomology Dept
Scalero, David	Pima County Flood Control District
Schorr, Staffan	Pima Association of Governments
Skinner, Tom	Coronado National Forest
Spring, Cari	PCSC
Sredl, Mike	AGFD, Non Game Branch
Swanson, Lisa	Arizona Water Protection Fund
Tellman, Barbara	Water Resources Center, U of A
Wahl, Rex	Entranco
Wallace, Eric	University of Arizona
Watson, Ann	U.S. Fish and Wildlife Service
Winn, Mike	Ecological Restoration & Management Association
Woods, Lori	RECON Consultants
Zucker, Claire	Pima Association of Governments

SESSION I

OVERVIEW PRESENTATIONS

Introduction and Workshop Goals

Presenter: Julia Fonseca
Pima County Flood Control District

The Sonoran Desert Conservation Plan (SDCP) focuses on protecting the biological and cultural heritage of Pima County. The SDCP is concerned about protecting all native species including those listed under the federal Endangered Species Act. It is hoped that the SDCP will result in a network of protected and conserved areas across the landscape. The Science Technical Advisory Team of the SDCP has been working with biologists to develop a knowledge base and to formulate recommendations about which areas should be set aside for protection. The Science Team's larger vision is to restore ecosystem structure and function. Land acquisition alone, will not be enough for aquatic habitat restoration. Base flows in many of the major rivers have been lost and there have been many invasions of non-native species into the remaining aquatic habitat.

Several questions will be posed throughout the symposium. What needs to be known about exotic species to determine how to restore native species, and under what conditions should native-species restoration be done. Both exotic and native species must be managed to solve this problem.

Exotic aquatic species: What makes a species invasive and what makes a habitat sensitive to invasion

Presenter: Dr. Kenneth Kingsley, Senior Scientist
SWCA Environmental Consultants

A species that lives in water for any part of their life is considered to be an aquatic species, even though they may spend much of their lives in non-aquatic habitat. An exotic species is one that exists outside its natural range. For example, although Arizona has no native crayfish, they abound here since being introduced. Other notable exotic aquatic species include giant salvinia, bullfrogs, and green sunfish. Interestingly, the Gila topminnow is considered to be exotic to Pima County because it has been transplanted outside of it's native range. The USGS list of non-indigenous species in Arizona includes 8 plants, 4 mollusks, 4 crustaceans, 7 amphibians, 15 reptiles, and 92 fish (Appendix C).

An exotic species is considered to be invasive if they out compete the native species. Usually one of the following factors are involved: 1) fast growth; 2) high fecundity, producing numerous offspring; 3) no competition, either because competitors have been eliminated or because there were never any present; 4) no predators; 5) or broad environmental tolerances (thermal conditions, water conditions, wide range of diet). In some cases management agencies have purposefully eliminated native fish, so that the introduced sport fish could flourish. The complexity of the habitat may also affect the success of an exotic species at displacing native species.

Exotic species arrived in Arizona's waters in many ways. Some species were introduced by management agencies either to enhance sport activities, or to manage existing problems created by previously introduced exotic species. These were often introduced into non-native ecosystems such as dammed rivers and man-made lakes, and they later escaped into the native habitats. For example, mosquito fish were introduced to control mosquitoes, and crayfish were introduced to eat aquatic plants that were choking off streams and impoundments. Some species were unintentionally introduced, such as escaped ornamentals and pets (goldfish) released by people into aquatic habitats.

Restoration of aquatic vertebrates affected by exotic species and habitat modification

Presenter: Dr. Phil Rosen
School of Renewable Natural Resources, University of Arizona

Habitat modification and the introduction of exotic species have greatly endangered the native southwestern aquatic fauna. Species that were historically located in the Tucson basin include desert pupfish, Gila topminnow, Gila chub, and longfin dace. All of these fishes and most of the other native fishes have been severely jeopardized because of habitat modification and introduction of exotic species.

When a natural habitat is replaced by a modified habitat, a superabundance of some exotic species may occur. Some species are only moderately effected by exotic fishes and bullfrogs, such as the checkered garter snake, the black-necked garter snake, the desert sucker, southwestern woodhouses toad, the narrow-mouthed toad, canyon tree frog and the Sonoran mud turtle. All of these species could readily participate in restored aquatic habitats in, and near Tucson. However, these same species are strongly affected by the exotic crayfish, which eat the plants, invertebrates and vertebrates, and unfortunately control methods for crayfish have not been developed. Bullfrogs also present major threats to some native species, particularly the lowland leopard frog, and the Mexican garter snake. The Mexican garter snake, once common in Tucson, is now gone largely because of predation by the bullfrog.

Several approaches might be taken to protect native species and habitat. When removal of exotic species from existing habitat is pursued, the entire system needs to be addressed at the same time so that areas aren't recontaminated with exotics. If created habitats closely mimic historically natural systems, they would favor native species and be less favorable for exotic species. Natural systems tend to be small streams and springs, with small ephemeral ponds. Scouring associated with floods is characteristic of these natural ecosystem. Native fish and Leopard Frogs are adept at living in flow and are able to handle scouring flood conditions as well as drought conditions. Large ponds, lakes, deep-water washes, slow water ditches, and big rivers with deep pools should be avoided because these systems promote exotic species. A network of smaller sites would be more appropriate for restoration of native species.

Arizona Game and Fish and their role in managing exotic aquatics

Presenter: Larry Riley
Chief of Fisheries, Arizona Game and Fish

The Arizona Game and Fish Department (AGFD) is governed by a Commission that is dedicated to recreational opportunities, and is also committed to preserving the natural resources of the state. The principle roles of the agency include managing resident wildlife, sport fishing, native fish, and aquatic habitats. The AGFD does extensive inter-organization coordination as part of their management program. This includes providing guidance, assistance, or mutual support for other programs. Part of AGFD's role is to work through a collaborative process to resolve conflicts arising by balancing sport fishing enhancement with native species restoration.

The broad arena of resident wildlife management includes sport fish management. This focuses largely on resident non-native species, although some native species are managed as sport fishes. Much of this effort is directed toward enhancing recreational opportunities, which include the urban fishing program. Management rules and regulations can help assist conservation of indigenous wildlife. For example, water bodies may be closed to fishing to discourage recreational anglers from visiting the site. Other rules govern limits for fishing, methods of take, and the use of bait items. For example, the use of live bait has been greatly restricted in Pima County. AGFD also reviews applications for aquatic wildlife stocking, and works closely with the Arizona Department of Agriculture on aqua-culture issues.

AGFD is very committed to public outreach as a means of educating people about conservation strategies. The public puts value in native wildlife, but they also put value in resident non-native wildlife that they utilize for other purposes. This must be looked at with a balanced perspective. One opportunity for public education is the Sonoran Sea Aquarium, which may be built near downtown Tucson.

Over the last several years, AGFD has become more involved with the general issue of invasive species. Anticipating which new species might become problem invasives is a priority. For example, the invasion of giant salvinia potentially presents a huge threat to native habitats. Management strategies must include prevention, detection, and building the capacity and capability to address threats from exotic species when they come.

SESSION II

CONTROL OF EXOTIC AQUATIC SPECIES IN EXISTING RESERVES

Saguaro National Park

Presenter: Don Swann
Biological Technician, National Park Service

Saguaro National Park does not face the same threat from exotics as some other areas, because it does not have large, permanent water bodies. The western part of the monument contains very little water, but the eastern part of the park, the Rincon Mountain District, which is surrounded by Coronado National Forest, does have aquatic habitat. The elevation of Rincon Mountain District ranges from 2,700 to 8,700 feet above sea level. Aquatic habitats in this area have been inventoried since 1996. Many of the aquatic habitats are ephemeral, but some are perennial, such as tinajas; rocky pools along ephemeral drainages. Species associated with these environments include the canyon tree frog, Sonoran mud turtle, lowland leopard frog, and black-necked garter snake. Typically pools will contain water during the winter and summer rainy seasons, but will go completely dry during May and June.

Canyon tree frogs and Sonoran mud turtles survive well in ephemeral drainages. Three core populations of lowland leopard frogs have been identified in Saguaro National Park since 1996. They require semi perennial water to survive in a particular drainage because their tadpoles need several months to mature into frogs. Along a single drainage, lowland leopard frog populations may grow during wet years and diminish during drought years. For example, in 1996, only a few adult frogs were found in one of the surveyed drainages. In 1997 and 1998 the populations grew until there were relatively large numbers of frogs in 1999. Subsequent drought caused the population to drastically decrease.

Reproducing populations of bullfrogs are not located in the Park, however, bullfrogs are found in areas neighboring Park lands. A few isolated bullfrogs have been found in drainages inhabited by lowland leopard frogs, but they bullfrogs have only been found in the downstream parts of the drainages and they have not been surviving. No native fish have been found in Saguaro National Park. Exotics include goldfish that have been released by the public into several of the streams.

Other exotic species of concern include fountain grass, red brome, buffelgrass. During fires, these grasses burn hotter than the native grasses. Also, there has been a recent increase in fire frequencies in Saguaro National Park. One consequence of fires is increased ash deposition and sediment load in aquatic habitats. This can jeopardize tadpole populations.

Cienega Creek

Presenter: Jeff Simms
Fishery Biologist, Bureau of Land Management

In 1875, carp were introduced to the State of Arizona fisheries. Over time, native fish communities have been largely replaced by introduced species. This is true for most of the fisheries in the state. The collapse in fauna is illustrated by the fact that about 74% of native fish species are listed by the Arizona Game and Fish Department, and 56% of Arizona's native fish are listed by the federal government (Appendix D).

Cienega Creek was obtained by the Bureau of Land Management (BLM) through a land exchange in 1988. At that time Cienega creek was a pure native fish community with no invasive fish, frogs, or crustaceans. In 1988, the BLM conducted a threat assessment and response strategy to determine the degree of risk to Cienega Creek from nearby waters. The BLM, in conjunction with the AZ Game and Fish Department, conducted the Cienega Creek Basin Water Sources Inventory in 1991. Aerial photographs and topographic maps were studied to find all the waters in the basin resulting in 246 identified water bodies: 128 urban stock ponds, 32 springs, six larger ponds, and 80 wells with troughs. Of the 246 waters, 86 were visited in the field and only two of the 57 urban stock ponds visited had fish. Several fish species, two species of introduced snails and fresh water clams were found at one of these private stock ponds.

A management decision was made to close Cienega Creek to fishing so that anglers would not visit the creek and possibly introduce exotic species to the system. It is very hard to detect covert transfers. However, if the creek is off limits to fishing, the public is much less likely to stock it with sport fish. Another key element to managing the creek was detection of invasive species through annual fish monitoring at five or more locations. After 11 years, no introduced fish have been detected. Also, attractive stocking locations, such as large ponds along the creek, have been eliminated, and stock ponds have been redesigned to be small and self-cleansing; they are allowed to dry out on a regular basis. Vehicle access limits will be included in the newest management plan, and efforts are being made to close several stream crossings. There is one primary crossing on the creek, which happens to be in an area where pool development is not very common.

Bullfrogs showed up as a breeding population in Cienega Creek in 1999. Previously, only individuals had been collected in the creek. The most likely source of contamination was the Northwest Reservoir, which is a private pond at the foot of the Whetstone Mountains. In 1999, when the BLM was alerted that bullfrogs had been found, a bullfrog roundup was organized and attempts were made to dry the upstream ponds (Appendix E).

Risk factors for Cienega Creek include the following:

1) proximity of waters that are contaminated with exotic species 2) attractiveness to local anglers 3) attractiveness for aquatic pet-release 4) ease of public access	5) lack of management presence 6) proximity of human population centers 7) once contaminated, difficult to renovate 8) government commitment to native species that have no sport value

Sabino Canyons

Presenters: Dr. William Matter
Associate Professor, Wildlife and Fishery Science, University of Arizona
Steve Romero
Wildlife Staff Officer, Santa Catalina Ranger District, National Forest
Heidi Blasius
Fishery Biologist, Arizona Game and Fish

Sabino Creek contains populations of the exotic green sunfish and the Gila chub. Other exotics include crayfish and bullfrogs. Bridges along Sabino Creek act as a series of fish barriers within the creek. In the late 1990's, fish distribution was as follows: no Gila chubs were found below bridge 1, Gila chubs and green sunfish coexisted between bridges 1 and 9, and only Gila chubs were found above bridge 9. Where green sunfish and Gila chubs co-occurred, the Gila chub were far less abundant and the chub populations lacked small fish as compared to areas without sunfish. In one experiment, approximately 90% of the sunfish were removed from several isolated pools, leaving only small sunfish and Gila chub. Still, the Gila chub did not successfully reproduce in these pools, indicating that small sunfish might be eating the small chubs.

The Sabino Canyon Gila chub renovation project was an attempt to restore a healthy population of Gila chubs to Sabino Canyon. This two-phase project included a planning phase and a renovation/treatment phase. The planning phase involved reaching compliance with the National Environmental Policy Act (NEPA), the National Preservation Act, which requires an impact analysis on cultural resources, the Endangered Species Act, and U. S. Forest Service policy. Key partners included Arizona Game and Fish, U.S. Forest Service, University of Arizona, and local homeowners. Potential pit falls were identified and dealt with in the planning phase of the project.

The target species was the green sunfish with a goal of 100% removal. The treatment area was from bridge 9 down to Sabino Lake Dam. The implementation plan had an extensive public relations strategy. In preparation for eliminating the sunfish, the University of Arizona trapped and removed turtles from the creek and either took them to the U. of A. for experiments, or kept them in coolers and returned them to the creek after the treatment. A 10-person crew removed as many Gila chub as possible from the treatment area, and moved them upstream above bridge 9. The fish toxin was applied to the three-mile treatment area, causing sunfish to die within a few hours of application. The full process took approximately 3 days to complete, and it was done once in June and again in October. The treatment chemical had almost no affect on any other wildlife using the creek.

After the green sunfish were removed, Sabino Creek was repeatedly monitored to determine the success of the treatment process. Immediately after the first treatment, a cursory inspection of the creek revealed no sunfish. A more rigorous survey in August 1999, and again after the October 1999 treatment, showed that there were still no fish in the creek. In June of 2000, a lowland leopard frog was found along the creek. This was the first lowland leopard frog found in Sabino Creek for almost 30 years, suggesting that the highly predacious green sunfish was wiping out the eggs or tadpoles of the leopard frog. The treatment of Sabino Canyon is considered to be a 100% success.

A thriving population of green sunfish remains within the creek directly below Sabino Canyon Dam. Also, green sunfish are located in Rose Canyon Lake, which drains directly into Bear Canyon Lake, which meets up with Sabino Creek. With the U.S. Forest Service in the lead, Rose Canyon Lake is scheduled to be renovated during October 2001. A fix toxin will be applied to the lake and only the Rainbow trout will be re-stocked. Eventually, a similar process will be conducted at Bear Canyon. There are also future plans to remove green sunfish from a ½ mile reach of the creek located below Sabino Canyon Dam, and plans to treat the area on a long-term basis.

The Forest Service and AZ Game and Fish would like to place interpretive signs within Sabino Canyon, so that the public can become better informed and can help protect the creek. The Tucson region of AZ Game and Fish has partnered with Maxwell Elementary School and the International Wildlife Museum to provide information about native fishes and the threat of exotic species to 7th graders.

Crayfish are still very widespread in Sabino Canyon. Treatment of the creek with fish toxins had almost no affect on the adult crayfish population. AZ Game and Fish would like to eventually reintroduce the longfin dace and the Gila topminnow to Sabino Creek. These two species would probably do very well in this habitat.

Bullfrog Control in Arivaca Canyon and the Upper Altar Valley

Presenter: Cecil Schwalbe, Research Ecologist
USGS Sonoran Desert Field Station, University of Arizona

Exotic aquatic predators have played a significant role in declines of Arizona's native leopard frogs. Major culprits in southern Arizona are the green sunfish, the northern crayfish, and the bullfrog. In the Altar Valley, Arizona, the Chiricahua leopard frog is barely hanging on and the lowland leopard frog has not been confirmed there, although some believe it likely occurred there historically. Natural habitats of both of these frogs included springs, cienegas and streams in Arizona, New Mexico, and northern Mexico. Most existing populations of Chiricahua leopard frogs are now in earthen cattle tanks. In the past, source populations occurred in perennial valley bottom wetlands such as San Bernardino Valley in extreme southeastern Arizona and Arivaca Creek and Cienega in the Altar Valley, areas now occupied by many bullfrogs – and no leopard frogs.

Crayfish and bullfrogs threaten both leopard frogs and other species. Because bullfrogs eat other bullfrogs, they achieve very high adult population densities in Arizona without relying on additional types of prey. This creates such predation pressure on native species that leopard frogs, Mexican garter snakes, and juvenile Sonoran mud turtles cannot survive in simple wetlands with bullfrogs. At San Bernardino National Wildlife Refuge (SBNWR) east of Douglas, Arizona, Phil Rosen and I found the Mexican garter snake population there consists almost entirely of large adult females with bullfrog-chewed tails. Adult female Mexican garter snakes grow to more than three-feet in length; bullfrogs regularly consume the male snakes, which are slightly smaller. We saw few mud turtle hatchlings there until we implemented bullfrog removal.

Ponds in desert environments favor exotic species over natives. Elimination of bullfrogs from even simple wetlands is often very difficult. Methods include gigging (spearing), trapping, hand capture, removing egg masses, poisons, and drying out the water sources (with and without fencing). A combination of these methods is almost always necessary to completely remove bullfrogs from an area. The most effective method has been erecting a fence around a pond so the frogs cannot escape, then drying the pond by natural evaporation or pumping. In combating bullfrogs, it is important to take advantage of dry years and dry seasons. We removed a major source population of bullfrogs (799 total frogs) from Rock Tank at Buenos Aires National Wildlife Refuge in 1999 by first fencing the pond, then pumping the water over the tank dam into the adjacent sediment trap, and capturing the stranded frogs. When the pond was almost dry, we added swimming pool chlorine (which dissipates from the system in a few days) to the muddy water to kill any remaining tadpoles and to cause the few frogs to leave their hiding places in the mud.

Bullfrog populations re-establish very quickly, in part because a single egg mass may contain up to 20,000 eggs and the eggs and tadpoles are distasteful to potential predators. Successful removal of bullfrogs requires complete eradication throughout the system. Bullfrogs can travel overland surprising distances, greatly complicating control measures. In a single summer rainy season UA Graduate Student Dennis Suhre recaptured marked bullfrogs1.7 to 3.1 miles from source ponds after they had traveled overland across and within drainages.

Arivaca Canyon and the Upper Altar Valley

Presenter: Will Hayes, Fisheries Program Manager
Arizona Game and Fish

Arizona Game and Fish has a mission to manage and take care of the state's wildlife resources and fisheries resources. The Arizona Fish Commission, started in the late 1800's, first introduced the non-native fish to Arizona. Early in the agency's history, many of the management decisions were made to support fisheries without regard to native species. However, in the last 25 years there have been many changes, so that the program is more sensitive and shows more responsibility toward the native fisheries and wildlife. There are numerous invasive species that pose a threat to native aquatic wildlife in Pima County and throughout Arizona. The Arizona Game and Fish faces the challenge of balancing the needs of the sport fisheries against the needs of the native species. Because Arizona's native species have never been perceived as sport fish species, all the sport fish species are exotics imported from the Mississippi drainage.

The Heritage fund was established to use lottery revenues to support the native wildlife work. This fund supports 100% of Arizona Game and Fish's native wildlife and habitat program. Attempts are made every year to use the Heritage fund moneys for other programs. Revenue generation is down because of decreased sales in lottery tickets.

Because of flood damage in July 1999, the Forest Service has insurance money that can be used to dredge Rose Canyon Lake. This would be the first step in the renovation effort for Sycamore Canyon and Bear Canyon and the stabilization of the Gila chub population in Sabino Canyon. After renovation, Rose Canyon would be restocked with Rainbow Trout. Rainbows have not posed a significant threat to native minnows, and if they disperse downstream with flood events, they do not survive in low elevation streams due to warm temperatures. It is unclear if the Rainbow Trout effects leopard frog populations.

Arivaca Lake has a significant sport fishery, and will pose more renovation challenges than Rose Canyon. The Arivaca watershed has not been a point of concern for Arizona Game and

Fish until recently. In other similar environments in the state, such as Patagonia Lake, warm water fish species don't seem to impact native species up and down stream. The long-range goal in these areas would be to optimize the survival and stabilization of the upstream populations of native species and yet understanding that there will be chronic introduction of exotics in downstream areas. Arivaca is a different environment because there is nothing upstream, and there are no native fish species in the cienega. The abundance of bullfrogs may be a significant problem for the Arivaca Lake area. This may need to be tackled through partnerships with other agencies. Eradication of the bullfrogs would require treating the entire area including all neighboring stock ponds. As an agency, the Game and Fish Department will be a key player in future renovations as is fitting with their role as a management agency for native aquatic wildlife.

SESSION III

CONTROL OF EXOTIC AQUATIC SPECIES OUTSIDE OF EXISTING RESERVES

Urban Water Bodies and Future Design Guidelines

Presenter: *Julia Fonseca*
Program Manager, Pima County Flood Control District

Development in urban areas generally includes construction of numerous water bodies. This has happened in Pima County and is expected to continue as urbanization of the region continues. Constructed water bodies may consist of either pond-type or flowing-water type environments. Ponds include features such as Central Arizona Project recharge basins, backyard ponds, and constructed wetlands for wastewater treatment. Flowing-water systems such as discharge areas for treated wastewater are also prevalent. Gravel washing operations often create both ponds and flowing water aquatic habitats.

Pima County needs to make management decisions for several existing aquatic habitats. For example, one unplanned wetland on Pima County property is a remnant pond that persisted after gravel-mining operations were completed. Because the base of the excavation intersects the shallow groundwater table, it has become a perennial pond, which also happens to be a significant bullfrog habitat. Alternative strategies for this pond include: filling it in, breaching the perimeter dike to allow the basin to naturally fill the next time Pantano Wash floods the area, or allowing the pond to continue as a wetlands.

Discussion followed about various management strategies for the site. Some types of management would be easily pursued by the County. For example, the County has access to construction crews and could easily fill in the pond, whereas the County does not have a bullfrog eradication program, so pursuing bullfrog management would be logistically difficult. Also, any attempt to remove all the bullfrogs might be futile because populations could reestablish at the site due to dispersion of bullfrogs from neighboring water bodies. These small ponds are stepping stones for bullfrogs as they move across the landscape. If the pond becomes a popular recreational site, it could be much more difficult to get public support for filling the pond.

Another site, the Ajo Detention Basin, was a Corp of Engineers detention basin constructed in the 1960's. At one time, the site contained a retention area that included wetlands, which presented a significant mosquito problem for the area. Because of the mosquito problem the retention area was graded so that the retention feature holds much less water. Currently, reclaimed water is delivered to the site for irrigation of sports fields, and stormwater can be harvested for additional irrigation. At the Ajo Detention Basin, the Corp of Engineers has developed an environmental restoration project that will include 50 acres of wetlands and riparian vegetation. During the design phase, little consideration was given to native aquatic species because it was largely designed as a shore bird habitat. It is unlikely that any exotic aquatic species would show up at the site unless they were released by a management agency or the public.

Discussion was held about the appropriate management strategy for the site. If the site were designed to support native fish, it would still be a single refugia for the native species because it does not connect to other wetlands areas. Efforts might be better spent to maintain native populations through natural resource recovery plans for native habitats rather than attempting to preserved native species within artificially constructed refugium. The detention basin could be dried out, as a management tool for exotic species control. Once the wetlands are created, there must be a long-term commitment to monitoring, management and maintenance of the site. Any type of ecosystem that is functioning outside its natural environment will need artificial maintenance. This area presents an excellent opportunity for information provision and education about native species and desert aquatic habitats. It is not premature to develop design guidelines and best management practices for different types of constructed water bodies in an urban situation.

Sweetwater Wetlands

Presenter: Bruce Prior
Hydrologist, Tucson Water

The City of Tucson designed the Sweetwater Wetlands to handle backwash water from the City's reclaimed water filter plant. The reclaimed plant produces on average 8 million gallons per day (mgd) of reclaimed water, but during summer peak months over 20 mgd can be produced. The backwash water is pumped to the settling basins at the wetlands where the water is split into two treatment streams. The northern half of the wetlands consists of about 18 acres of bulrush and cattail and open water with vegetated islands. The southern part consists of about 14 acres of recharge basins where water is stored underground during low demand periods. During high demand periods the stored water is recovered through a series of recovery wells.

In early 1996, before construction of the wetlands, Scott Richardson, the Urban Wildlife Specialist for AZ Game and Fish, conducted a wildlife survey over the 50-acre parcel. He documented about 15 bird species, most of which were raptors. Recently, the Tucson Audubon Society documented over 120 bird species at the Sweetwater Wetlands alone.

Mosquitoes have been a problem at the site since 1998. The Arizona Department of Health Services (ADHS) compiles mosquito trap counts from every vector control office throughout the state of Arizona. Their analysis of the mosquitoes species composition and virus data showed that the threat from mosquitoes has increased statewide. Since the summer of 1998, active abatement procedures have reduced mosquito populations at Sweetwater wetlands. In May of 1998, the City began using BTI, a biological larvicide, but application of the larvicide was done by hand. In July 1998, the City began applying the larvicide using a remote controlled helicopter so that 18 acres could be treated in approximately 3 hours. This application method continues to be used at the site. Additionally, the City destroyed significant amounts of bulrush and cattail habitat at the site so that insecticide could successfully reach the open water. Some vegetation was retained to ensure the wastewater treatment capacity of the wetlands.

Each year, mosquito numbers peak in May and June, but they do not generally bear diseases until July when migratory birds come to the region. Therefore, the health hazard is greatest during September and October. In fall 1999, several mosquitoes carrying the encephalitis virus were detected at Sweetwater wetlands. In response, the City began augmenting their mosquito abatement program using insecticides that specifically target adult mosquito. Although, mosquitoes can be managed by using insecticides, it is unrealistic to expect to eliminate mosquitoes from a wetlands environment.

There are currently no fish in the wetlands. The Citizens Advisory Committee that helped to design the wetlands had a strong ethic about keeping the wetlands as native as possible. No non-native vegetation has been planted at the site and non-native vegetation has been aggressively removed. If the City decides to introduce a fish to the wetlands, it would be for the purpose of eating mosquitoes. High ammonia levels and low dissolved oxygen levels restrict the type of fish that can be introduced to the system.

A large bullfrog population is supported by the Sweetwater wetlands. A University of Arizona student conducted a two-year wildlife study of the site, starting in 1996. Early surveys showed a wide range of amphibians and reptiles at the site, but by the end of two years bullfrogs had wiped out the other species.

The Central Arizona Project (CAP) canal

Presenter: Sally Stefferud
Fish and Wildlife Biologist, U.S. Fish and Wildlife Service

Before human intervention, many Gila River basin tributaries were connected to the Gila River for much of the year, but the Santa Cruz River never did. The Santa Cruz River only had, and still has, water connection with the Gila River during really big flood events. This disconnection seems to be very old, because there are 18 fish species native to the Gila River basin, but only eight of them are also native to the Santa Cruz basin. The disconnection has also protected the Santa Cruz River and its tributaries from invasive exotic species. There are only about 25 exotic aquatic species known in the Santa Cruz basin, whereas there are 2 or 3 times that number in the Gila River basin. For example, the Gila basin has both small mouth bass and Asian clam, neither of which have reached the Santa Cruz basin.

The biggest risk of exotic species introduction to the Santa Cruz basin is through human introduction of species. Comparatively, the risk from fish swimming upstream into the basin is fairly low. The second biggest risk is interbasin water transfers, which in Arizona consists of the Central Arizona Project (CAP). The CAP provides a direct connection between the Colorado River, Gila River basin, and Santa Cruz River basin. Currently, 21 exotic species are known to inhabit the CAP aqueduct. Only three of these are absent from the Santa Cruz basin: two fish and one invertebrate (Asian clam). There is a very high likelihood that the CAP has already introduced the Asian clam into the basin. It is also very likely that many more species will come through the system during the 100-year live span of the CAP. Two species that are poised to come through are pacú and giant salvinia.

Because CAP is a federal project and because it has such a high potential as a dispersal route for exotic aquatic species, and because that dispersal threatens listed fish, the whole issue is regulated under the federal Endangered Species Act. Mitigation measures have been set up through the Bureau of Reclamation. Unfortunately, the mitigation efforts are primarily focussed on exotic fish, and no good methods have been developed to control the introduction of non-fish species, which are much more difficult to control because many of them can move independently from the water. Consideration has even been given to sterilizing everything in the CAP canal. However, this is infeasible because it would be a massive undertaking and would cost a great amount of money. Three other methods have been considered: chlorination, ozonation, and a massive gravel filter at the Havasu intake.

Physical barriers, preventing upstream exotic fish movement, need to be a keystone of the CAP program. The idea of physical barriers has been met with resistance from some members of the biological community. Still, this is the best method available, and the expectation is that fish barriers will be installed at the bottom of most of the native fish habitats and on selected streams targeted for repatriation by native fish. Other parts of the program will be an extensive monitoring program and a system of management to do something about the exotic fish when they get over the barriers. The ideal solution would include a paired set of physical barriers, with intensive monitoring between the barriers and a management scheme to remove any fish that got over the first barrier before they get over the second barrier. Unfortunately, this solution is very expensive and time consuming, and it can't be done everywhere. Many streams will receive a single barrier, annual monitoring, and a contingency plan for exotic fish that get over the barrier.

Part of the CAP program money is being used to develop new control methodologies to target certain fish species for removal without killing all the fish in the stream. A USGS lab in Wisconsin will soon be under contract with the Bureau of Reclamation to help develop a way to target certain species or species groups so that selective removal can be done. Selective removal of catfish will be explored because there are no native catfish in the Gila River basin.

Bioengineering is also being considered as a control methodology. It might be possible to bioengineer individual fish so that when they are released into the population, they will eventually be fatal to the entire population. This may work particularly well in small closed system such as stock ponds. The sterile male technique is also being considered. A combination of these new techniques should help in overall management of the problem. Also, part of the CAP program funds outreach and education efforts.

The CAP recharge basins in Pima County present significant problems for the Santa Cruz basin. Untreated CAP water is going into the basins and the canal is attractive for pet fish release by the public. While the CAP canal is fenced to keep people from fishing in it, lateral canals transporting water in irrigation districts are not fenced and may be subject to fishing and pet release.

Backyard Ponds

Presenter: Dennis Caldwell
Chairman of the Conservation Committee, Tucson Herpetological Society

The popularity of backyard ponds has skyrocketed in recent years. The relatively low cost of water along with the availability of supplies, pumps, liners, filters, plants, and fish is contributing to the problem. In most cases, aquatic fauna and flora available from retailers have been raised in the southeastern United States. These plants and animals are commonly shipped across the country with enough soil and water to keep them alive. The soil and water may also contain a variety of other organisms. For example, numerous exotic snails and bullfrog tadpoles have come into the region in this way, but it is unclear what kinds of micro fauna might also have been transported. There is concern that parasites and diseases transported with plants and animals might infect native species, which have no natural defense mechanisms. As more homes are being built along the boundaries of riparian preserves, often up hill from flood prone wetlands, exotics are continually washing down with runoff into preserves where they are reaping havoc.

Steps need to be taken to reduce this threat to native aquatic systems. Legislative solutions are needed to stop the importation of invasive species. Water gardeners and retailers need to be educated about the risks posed by exotic species. The Tucson Herpetological Society, in cooperation with Pima County flood Control District and the Department of Ecology and Evolutionary Biology, Wildlife and Fisheries Resources in the School of Renewable Natural Resources, University of Arizona, has developed information to be distributed to home owners near riparian areas, local water gardeners, and retailers. Assistance needs to be provided to pond owners who want to eradicate exotics on their property. Also, large ponds can be difficult to drain and many people may need a lot of encouragement to destroy plants and animals they might consider pets.

Native aquatic plants and animals need to be made available for retailers and water gardeners. Currently, water gardeners cannot avoid using exotics since most native aquatic species are protected. It is especially important for native fish to be made available for mosquito control. With native fish unavailable, the problematic mosquito fish, Gambusia affinis, is being widely distributed amongst water gardeners as their only viable method of mosquito control.

Backyard ponds, golf course ponds, cattle tanks and storm basins are significant vectors for invasive aquatic plants, animals and disease. Exotic species in these areas need to be addressed in order to protect the native fauna of our region's wetlands.

Agua Caliente Park

Presenter: Amy Loughner
Natural Resource Specialist, Pima County Parks and Recreation

Agua Caliente Park is a 101-acre facility located in the northeastern part of the Tucson basin. Pima County acquired the property in 1984. Agua Caliente spring supports three ponds and it has attracted human activity for several thousand years. Fish including bluegill, large mouthed bass, mosquito fish and grass carp have been introduced to the ponds at the park. The grass carp has been stocked for the past 5 years to control the aquatic weed infestation problem.

Fish release by the public is a significant problem at Agua Caliente Park. The public release Oscars, Poi, tropical fish, pacú, and even their ducks into the aquatic environment. Another management issue is the proliferation of bulrush and cattails.

The first pond is 2.5 acres in extent, and it empties into a 750-foot long stream, which flows into a 1.8-acre pond, which subsequently empties into a 1.4-acre pond. The connecting stream is filled with cattails and bulrush that restricts the flow between the ponds. This area also has problems with citizens building dams within the stream to redirect the flow. There are rodent problems and recently high flows from the spring have cause overland flow. Wildlife using Caliente Park includes javalina, migratory ducks, mule deer, and turtles.

Agua Caliente Park is considered both a natural resource park and an urban park because of its design and its use. Picnickers, walkers, birders, educational groups, and people getting married all use this park. A ranch house, dating from the 1870's is located on site and plans include converting the house into an educational visitors' center for the park.

As part of the Sonoran Desert Conservation Plan, there is a proposal to reintroduce native fish, snakes and frogs to the Park.

APPENDIX A

Contact Information for Symposium Speakers

Contact Information for Exotic Aquatics Symposium Speakers, February 27, 2001

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APPENDIX B

Written Responses from Comment Cards
Collected at Exotic Aquatics Symposium, February 27, 2001

During Session III of the symposium, a comment card was distributed to the attendees. It contained a request for comment on the following topics:

1) **Exotic aquatic species – greatest concerns**
2) **Native species preservation – greatest concerns**
3) **Habitat enhancement needs**
4) **Agency program development needs**
5) **Outreach and education needs**
6) **Other**

The following is a summary of the comments received.

Exotic aquatic species - greatest concerns:

Further (continued) spread. Mitigate with more exotic/native species biology/ecology.

Let's avoid creating and proliferating non-native species in the city–before it's too late and they get entrenched.

Lack of public education

Continued creation of suitable habitat for exotics often by government entities with public funds.

The things we don't yet recognize as threats are yet to emerge.

Cooperation needs to happen between all stakeholders. Cost benefit analysis should be done to prove the need to combat exotics quickly and decisively.

Several - bullfrog, salvinia, zebra mussel, salt cedar, aquatic weeds.

I am more concerned about the amphibians exotics (bullfrogs & crayfish) than the exotic fishes or turtles because bullfrogs and crayfish are so much harder to eradicate than invasive fish or turtles.

Native species preservation - greatest concerns:

Lack of basic ecological information on native species (e.g. leopard frogs) dispersal ability, meta-population structure, population dynamics, etc. Absolutely necessary for addressing many of the issues brought up today!

No good way to get native fish/frogs onto the landscape broadly, or to people for their own waters.

Maintenance, protection, and enhancement of natural populations. But all options need to be pushed - such as potential natural habitats and created aquatic habitats.

Conserve and restore existing habitat and native range. Natural ecosystem function.

This is achievable, and needs to focus on opportunities that are feasible. Feasibility will rely in part on consensus of partners and the public. These sites will require commitment to intensive management.

Balance of sport fish and natives.

Native fish, leopard frogs.

Native fish, leopard frogs. We must act now. These animals are declining at alarming rates or are already gone or almost gone.

Making native aquatic plants available.

Habitat enhancement needs:

Exotic species renovations from good remaining perennial stream habitats in Catalinas and Rincons. Sabino Canyon good example although only did removals on USFS - Ultimately not a success until entire system "cleansed."

Need to have a broad landscape vision and ecosystem understanding to keep our thinking as tied together as the natural/man-made ecology is in of itself.

Education on ecosystem functions - what is functional system?

Focus on approaches that restore headwaters, then utilize natural processes to assist in restoration. Once we commit to restore, there needs to be a commitment to monitor, maintain, and manage.

Make natives more available for the public and for education purposes.

Habitat preservation first and foremost, public information a close second.

Need to be extremely cautious in creating artificial permanent ponds, which will eventually be invaded by bullfrogs and will serve as a source population and/or stepping stones across arid areas.

Agency program development needs:

Control of exotics (commercially and legally) support of native species research.

Funding, personnel, coordination. Agencies without resource personnel could use them.

Cooperation and drainage area scale vision (appropriate) ecological scale.

Collegial exchange, collaborative process, and consensus conservation strategies.

Coordination of agencies activities.

Both the Forest Service and Game and Fish need to develop or augment program to deal with this problem. It's a big problem that will require commitment.

Outreach and educational needs:

Bait-bucket fisherman, parents/children bringing exotics (esp. bullfrogs/crayfish) from exotic polluted areas to home to be (re released) in exotic free areas, backyard pond, and commercial areas.

Multi-level, multi-faceted, multi-agency.

Convey and interpret to the public the values associated with native aquatic resources. We need to help the public with information so that they can formulate their values.

General public definitely needs to be made aware of this multifaceted problem.

1) agency personnel 2) general public

The suggestions today were excellent. We need to take advantage of every opportunity to increase public awareness of this problem.

Other:

Design management guidelines for created aquatic/riparian habitat should be done as part of the SDCP process, and maybe as a SDCP report.

To get the public on our side, we need to find a way to be non-threatening. Recognize and meet their wants and desires as well as appeal to their "values" in Aquatic System restoration. We need to make restoration (T&E species/candidate species restriction) non-threatening.

I think it would have been good to have a interactive "workshop." The second half tended to lose the exotic aquatics focus.

Thanks for putting on the workshop. It brought a great cross-section of people to bear on a ubiquitous problem.

APPENDIX C

EXOTIC AQUATIC SPECIES KNOWN FROM ARIZONA

Compiled from USGS Website http://nas.er.usgs.gov/

by Dr. Kenneth Kingsley, SWCA, Inc.

The USGS defines "nonindigenous aquatic species as a member(s) (i.e. individual, group, or population) of a species that enters a body of water or aquatic ecosystem outside of its historic or native range. Most of the nonindigenous introductions are a result of human activities since the European colonization of North America. This includes not only species that arrived from outside of North America, which are commonly referred to as exotics, but also species native to North America that have been introduced to drainages outside their native ranges within the country. An example of the former would be the Brown Trout, *Salmo trutta*, a native of Europe first imported to the United States in 1883 from Germany. An example of the latter would be the Coho Salmon, *Oncorhynchus kisutch*, a native to the Pacific coast from northern California to Alaska, which was introduced into the Great Lakes as early as the 1920's."

This list was compiled from the taxonomic group listings available by searching the USGS website cited above. This, therefore, is the list of species currently recognized by USGS as exotic aquatics in Arizona, and it may not include all of the species that are actually present. It does not include insects, because insects are not included on the USGS website. Note that some species on this list are native Arizona species, including some currently listed as endangered or threatened (e.g. *Poeciliopsis occidentalis occidentalis* Gila topminnow). That is because they have been moved to "a body of water or aquatic ecosystem outside of its historic or native range."

PLANTS

Family: Brassicaceae
Nasturtium officinale water-cress

Family: Haloragaceae
Myriophyllum aquaticum parrot-feather
Myriophyllum spicatum Eurasian water-milfoil

Family: Hydrocharitaceae
Egeria densa Brazilian waterweed
Hydrilla verticillata hydrilla

Family: Lemnaceae
Landoltia (Spirodela) punctata dotted duckweed

Family: Menyanthaceae
Nymphoides peltata yellow floating-heart

Family: Pontederiaceae
Eichhornia crassipes (not persisting yet) water-hyacinth

Family: Potamogetonaceae
Potamogeton crispus curly pondweed

Family: Salviniaceae
Salvinia molesta giant salvinia

ANIMALS

Mollusks

Family: Corbiculidae
Corbicula fluminea Asian clam

Family: Lymnaeidae
Radix auricularia big-ear radix

Family: Thiaridae
Melanoides tuberculatus red-rim melania

Family: Viviparidae
Cipangopaludina chinensis malleata Chinese mysterysnail

Crustaceans

Family: Cambaridae
Orconectes causeyi crayfish
Orconectes virilis virile crayfish
Procambarus clarkii red swamp crayfish

Family: Palaemonidae
Palaemonetes plaudosus riverine grass shrimp

ANIMALS (continued)

Amphibians

Family: Ambystomatidae
Ambystoma tigrinum tiger salamander

Family: Hylidae
Hyla eximia Mountian treefrog
Pseudacris regilla Pacific chorus frog

Family: Pipidae
Xenopus laevis African clawed frog

Family: Ranidae
Rana berlandieri Rio Grande leopard frog
Rana catesbeiana bullfrog
Rana clamitans green frog

Reptiles

Family: Alligatoridae
Alligator mississippiensis American alligator
Caiman crocodilus spectacled caiman

Family: Chelydridae
Chelydra serpentina serpentina common snapping turtle
Chelydra serpentina snapping turtle
Macroclemys temminckii alligator snapping turtle

Family: Emydidae
Chrysemys picta bellii western painted turtle
Chrysemys picta dorsalis southern painted turtle
Graptemys pseudogeographica false map turtle
Trachemys scripta elegans red-eared slider
Trachemys scripta scripta yellowbelly slider
Trachemys scripta slider

Family: Kinosternidae
Kinosternon flavescens flavescens yellow mud turtle
Family: Trionychidae
Apalone spinifera emoryi Texas spiny softshell
Apalone spinifera spiny softshell

Family: Varanidae
Varanus salvator water monitor

Fish

Family: Acipenseridae
Acipenser transmontanus white sturgeon

Family: Anguillidae
Anguilla rostrata American eel

Family: Auchenipteridae
Parauchenipterus galeatus driftwood catfish

Family: Catostomidae
Catostomus platyrhynchus mountain sucker
Catostomus plebeius Rio Grande sucker
Catostomus undescribed sp. Little Colorado River sucker
Ictiobus bubalus smallmouth buffalo
Ictiobus cyprinellus bigmouth buffalo
Ictiobus niger black buffalo

Family: Centrarchidae
Ambloplites rupestris rock bass
Archoplites interruptus Sacramento perch
Chaenobryttus gulosus warmouth
Lepomis cyanellus green sunfish
Lepomis gibbosus pumpkinseed
Lepomis macrochirus bluegill
Lepomis microlophus redear sunfish
Micropterus dolomieu smallmouth bass
Micropterus punctulatus spotted bass
Micropterus salmoides floridanus Florida largemouth bass
Micropterus salmoides northern largemouth bass
Pomoxis annularis white crappie
Pomoxis nigromaculatus black crappie

Family: Characidae
Astyanax mexicanus Mexican tetra

Colossoma or *Piaractus* sp. unidentified pacu

Fish (continued)

Family: Cichlidae
Cichlasoma cyanoguttatum Rio Grande cichlid
Cichlasoma meeki firemouth cichlid
Cichlasoma nigrofasciatum convict cichlid
Oreochromis aureus blue tilapia
Oreochromis mossambicus Mozambique tilapia
Oreochromis niloticus Nile tilapia
Oreochromis urolepis Wami tilapia
Tilapia mariae spotted tilapia
Tilapia zillii redbelly tilapia

Family: Clupeidae
Alosa sapidissima American shad
Dorosoma petenense atchafalayae Mississippi threadfin shad
Dorosoma petenense threadfin shad

Family: Cottidae
Cottus bairdi mottled sculpin

Family: Cyprinidae
Carassius auratus goldfish
Ctenopharyngodon idella grass carp
Cyprinella lutrensis red shiner
Cyprinus carpio common carp
Hypophthalmichthys molitrix silver carp
Hypophthalmichthys nobilis bighead carp
Meda fulgida spikedace
Notemigonus crysoleucas golden shiner
Notropis ludibundus sand shiner
Pimephales promelas fathead minnow
Plagopterus argentissimus woundfin
Rhinichthys chrysogaster longfin dace
Richardsonius balteatus redside shiner
Tinca tinca tench

Family: Cyprinodontidae
Cyprinodon macularius eremus Quitobaquito pupfish
Cyprinodon macularius macularius desert pupfish

Family: Esocidae
Esox lucius northern pike
Esox masquinongy muskellunge

Family: Fundulidae
Fundulus zebrinus kansae plains killifish
Fundulus zebrinus plains killifish

Family: Gobiidae
Gillichthys mirabilis longjaw mudsucker

Family: Ictaluridae
Ameiurus melas black bullhead
Ameiurus natalis yellow bullhead
Ameiurus nebulosus brown bullhead
Ictalurus furcatus blue catfish
Ictalurus pricei Yaqui catfish
Ictalurus punctatus channel catfish
Pylodictis olivaris flathead catfish

Family: Loricariidae
Hypostomus sp.suckermouth catfish

Family: Moronidae
Morone chrysops white bass
Morone mississippiensis yellow bass
Morone saxatilis striped bass

Family: Percidae
Perca flavescens yellow perch
Stizostedion vitreum walleye

Family: Poeciliidae
Gambusia affinis mosquitofish
Poecilia latipinna sailfin molly
Poecilia mexicana shortfin molly
Poecilia reticulata guppy
Poecilia sphenops Mexican molly
Poeciliopsis occidentalis occidentalis Gila topminnow
Xiphophorus helleri green swordtail
Xiphophorus variatus variable platyfish

Family: Salmonidae
Oncorhynchus aguabonita golden trout
Oncorhynchus clarki cutthroat trout
Oncorhynchus clarki x mykiss cutbow
Oncorhynchus kisutch coho salmon
Oncorhynchus mykiss rainbow trout
Oncorhynchus nerka kennerlyi kokanee
Oncorhynchus nerka nerka sockeye salmon
Salmo trutta brown trout
Salvelinus fontinalis brook trout
Thymallus arcticus Arctic grayling

APPENDIX D

Water Body Inventory for Wetland Vertebrate Conservation in Pima County

Jeff Simms

Fishery Biologist, U. S. Bureau of Land Management

Pima County has hundreds of surface waters inside and outside of urban areas. These habitats range from artificial fishing ponds to healthy, functioning springs and streams. The first task is to inventory surface waters and categorize them by their potential as suitable habitat for wetland vertebrates and management related to present human uses (suitability and compatibility).

Proposed Categories

Category A. Largely, unmodified natural water sources where human uses are light and do not conflict with supporting most forms of aquatic wildlife.

A1. Natural water body is the sole product of geologic, hydrologic and biologic processes. Habitat quality is high, at or near it natural potential. Human uses are light and do not conflict with supporting aquatic wildlife (e.g. wildland springs and streams).

A2. The water body has some features that make it suitable for native wetland vertebrates but it is in need of restoration (active or passive) to improve habitat quality to meet its potential. Human uses are light and do not conflict with supporting aquatic wildlife (e.g. springs and streams with poor riparian development from overgrazing).

A3. The water body has some features that make it suitable for native wetland vertebrates but it is in need of enhancement beyond its natural potential to improve habitat quality. Human uses are light and do not conflict with supporting aquatic wildlife (e.g. springs and seeps where pools do not naturally form from current geomorphic processes).

A4. The water body may have features that make it suitable for occupation by aquatic wildlife but constraints of its current use and management are not compatible with supporting aquatic wildlife (e.g. spring or seep completely diverted seasonally for agriculture).

Category B. Water body created by engineering but water source is a product of favorable local hydrology. Infrequent, periodic maintenance to maintain the integrity and habitat quality of the water body may be necessary.

B1. Habitat quality is high, at or near it natural potential. Maintenance is light or largely unnecessary. Human uses are light and do not conflict with supporting aquatic wildlife (e.g. springs and seeps impounded to water livestock).

B2. The water body has some features that make it suitable for native wetland vertebrates but it is in need of enhancement beyond its current potential. Human uses are light and do not conflict with supporting aquatic wildlife (e.g. springs and seeps impounded to water livestock but turbid and lacking riparian vegetation).

B3. The water body may have features that make it suitable for occupation by aquatic wildlife but constraints of its current use and management are not compatible with supporting aquatic wildlife (e.g. springs and seeps impounded to water livestock that are dredged frequently).

Category C. Water body created by human engineering including the source of surface water. Frequent maintenance to maintain the integrity and habitat quality of the water body is required.

C1. Habitat quality for aquatic vertebrates is high. Human uses are light and do not conflict with supporting aquatic wildlife. There is a commitment to maintain water and other habitat features in place for long periods of time (years) (e.g. Windmill water source impounded to water livestock or wildlife).

C2. The water body has some features that make it suitable for native wetland vertebrates but it is in need of enhancement beyond its current condition. Human uses are light and do not conflict with supporting aquatic wildlife. There is a commitment to maintain water and other habitat features in place for long periods of time (years). The owner/manager of the water body supports modifications necessary to enhance habitat quality (e.g. windmill water source impounded to water livestock but confined to a metal tank).

C3. The water body may have features that make it suitable for occupation by aquatic wildlife but constraints of its current use and management are not compatible with supporting aquatic wildlife and/or there is not a commitment to maintain water and other habitat features in place for long periods of time (years), (e.g. windmill water source impounded to water livestock seasonally but and then shut off).

Category D. Artificial or natural habitats that are not compatible for management of native aquatic wildlife but harbor non-natives in close proximity to sites with a high potential for re-establishment of wetland vertebrates.

D1. Water body harboring non-natives in a relatively remote location. Low potential for contamination of other water bodies in the general area (e.g. an artificial pond used for sport fishing).

D2. Water body harboring non-natives in a location near other waters where there is a distinct possibility of contamination with non-native species. Owner/manager of water body cooperative with removal of species that have a potential to contaminate nearby water bodies (e.g., an artificial pond on private land used for sport fishing with an owner/manager willing to consider conversion to native fishes and frogs).

D3. Water body harboring non-natives in a location near other waters where there is a distinct possibility of contamination through migration or illegal/wildcat transfer. Owner/manager of water body resistant to the idea of removal of species that have a potential to contaminate nearby water bodies, (e.g., an artificial pond on private land used for sport fishing with an owner/manager that is opposed to any government activities).

A difficulty with the use of urban and rural water bodies frequented by people is that they often already harbor introduced fish or frogs that preclude a successful re-establishment of native species without renovation. This will require some level of renovation (removal of problematic species) before the habitat will support native aquatic species. In addition, future renovation and education of the public may be required to quell the local practice of stocking sport or aquarium species.

Water supplies that can be turned on and off, or re-routed to allow drying up of habitat, are ideal for elimination of various exotic fish species and bullfrog tadpoles that may invade (or be wildcat-introduced into) re-establishment sites. Thus category II and III waters including effluents, reclaimed water, and highly managed waters in general offer an opportunity for multi-species recovery of the native wetland fauna. Where this is not possible a piscecide and treatments to kill tadpole and adult bullfrogs (renovation) will have to be conducted; these treatments are labor intensive with the level of success depending on factors such as habitat complexity and size.

The use of remote canyons as conservation refuges for native fish and frogs has several considerations:(1) they are often unpredictable and varying (drying, flash-flooding) for some species, 3) lack habitat diversity, and (2) they are so isolated that they are vulnerable to random extinction processes. This will limit their suitability for some species and may require periodic augmentation in order for populations to remain viable. The approach should be to treat the Santa Cruz Basin as a meta-population. All reintroduced populations of native aquatic wildlife will require periodic augmentation and from adjacent sources to allow for genetic variability and flow that is no longer possible in isolated and fragmented aquatic habitats available in the basin. Such protocols can be found in recovery plans for the Gila topminnow and desert pupfish (USFWS 1992?, USFWS 1999 - draft Gila topminnow plan).

I propose a multi-faceted approach to wetland faunal restoration in the core of the Tucson Basin. First, category A1 waters should be preserved or enhanced where an intact native fauna exists. Where non-native forms predominate, category A1 habitats should be pursued for renovation and the fauna replaced with the appropriate native wetland species. Second, Category B1 and B2 waters (dammed-up, still (lentic) systems) with sufficient surface flow should be restored to in-channel streams with native components of Sonoran Desert fauna including fishes and leopard frogs. The natural flooding cycle should succeed in restoring natural self-maintaining ecosystem processes, as well as, provide an opportunity for native species to maintain at an advantage over non-native predators and competitors (Meffe and Minckley 1987, Minckley and Deacon 1991).

Category C1 and C2 waters that are part of local recreation facilities or wastewater treatment facilities should be considered for conversion to a native wetland fauna. Those with suitable habitat should be considered a high priority for repatriation (C1). Those waters in which habitat improvement is required should be considered as funding becomes available (category C2). These can be brought on line as grants are secured for this type of restoration work. Several types of grants for this type of habitat work are available.

Where feasible, ponded sites categories B, C, and D should be designed or reconfigured to permit drying to kill introduced species, especially non-native introduced fishes. These sites would then support leopard frogs and endemic fish species where habitat is suitable and management of the water body for its primary use is compatible.

Problematic wetland habitats included in categories A3, B3, C3, and D3 need to be considered in management of waters with native wetland fauna or considered to receive new populations. These waters may harbor non-native species on a periodic or perennial basis leading to a potential biological contamination problems requiring costly and disruptive habitat renovations.

APPENDIX E

Bullfrog Management in Las Cienegas National Conservation Area

Jeff Simms

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A single large bullfrog was collected in the Cienega adjacent to the Cienega Ranch in 1989. Dr. Phil Rosen at UA collected a big bullfrog that had a Mexican garter snake and a mud turtle in its belly in June of 1996. In the summer of 1999, Dennis Caldwell (Tucson Herpetological Society) had discovered a small breeding population of bull frogs at the confluence of Cienega Creek and Spring water canyon as well as a population in the twin tanks at Road Canyon. This information created an urgent situation that needed to be addressed before this highly invasive non-native frog became well established.

Three eradication efforts were conducted in April and May 2000 on Cienega Creek and its tributaries. Of particular concern in the stock tank in Road Canyon, which has been reported to support a bull frog population. This is likely an intermediate habitat used by migrating bullfrogs to get to Cienega Creek. Management of the tank needs to be altered to prevent a pathway for migrating bullfrogs.

Bullfrogs in twin tanks at Road Canyon were collected on April 28th with good results. None appeared to be in spawning condition. In addition, the headwaters of Cienega Creek were surveyed for bullfrogs. Only one was observed. Pools locate downstream from the headwaters were surveyed. Unexpectedly, no frogs of any kind were observed where Dennis Caldwell has seen bull frogs before. The Road Canyon ponds were visited again on May 2nd. Seven bullfrogs were collected. None appeared to be in spawning condition. The headwaters were surveyed for bullfrogs again as well. Three other bullfrogs were encountered but only one was collected. Only one large breeding size male was observed but the rest were sub-adults.

On May 20th, the twin tanks at Road Canyon produced two bullfrogs of which only one was collected. At Spring Water Canyon one bullfrog was observed but escaped collection. One bullfrog was collected from the headwaters. Following this effort the windmill at Road Canyon was turned off and plans made for chlorination of the ponds once they were nearly dry. This attempt was confounded by early, heavy summer rains that filled the tanks. Rain persisted throughout the summer, which maintained filled stock ponds.

The spring of 2001 will provide another opportunity to eradicate a small population that was partially eradicated before the spawning season in 2000. A survey of frogs from Oak Tree Canyon to the head waters will provide a perspective of the extent of the problem. The twin tanks in Road Canyon will be dried and treated. It is anticipated that these tanks can be used for native fish and frog conservation.

Ultimately, the key to bullfrog management is to plan the management of stock tanks basin wide. This cannot be accomplished without bringing the private landowners into the fold. BLM/AGFD conducted a stock pond inventory and aquatic wildlife survey in 1991. It is a good foundation for a basin-wide bullfrog management plan. Additional information from the forest service and private landowners will be necessary to manage aquatic habitats to limit bullfrog populations. Private land issues can be coordinated through the Cross-Roads group working on land planning issues in the Sonoita Valley.