



# Arizona Riparian Council

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## THE COCOPAH TRIBE, THE COLORADO RIVER, AND CONSERVATION: HOW COLLABORATION IS RESTORING A CULTURAL AND RIPARIAN ECOSYSTEM

by Garrit Voggeser, Ph.D., National Wildlife Federation, Tribal Lands Conservation Program

*Editor's Note: This is the second of a two-part article on the Cocopah Tribe's efforts along the Lower Colorado River. The Cocopah Indian Tribe Reservation is located 13 mi south of Yuma and 15 mi north of San Luis, Mexico in Yuma County along the river.*

The Colorado River has changed dramatically in the last 150 years. Diversion of the river to meet the agricultural, hydropower, industrial and urban demands of seven western states (Arizona, California, Colorado, New Mexico, Nevada, Utah, and Wyoming) and Mexico has had significant impacts on wildlife and habitat. Moreover, Native American tribes that utilize and have rights to Colorado River water have had to adapt to changes in river management and allocation. For many tribes, this has translated to increased development of irrigated agriculture on their reservations. The rising demand for water has made it increasingly valuable. Consequently, a number of tribes have also capitalized on a new market by leasing

their water to major metropolitan areas. Yet many tribes continue to believe that Colorado River water has significant environmental and cultural value.

As a result of the many demands placed on the Colorado, the river on the Cocopah Indian Reservation has nearly run dry, invasive plants took root, and a vital ecosystem became endangered. However, the Cocopah, or "River People," have taken the challenge head-on. Today, the Cocopah Indian Tribe is cooperating with diverse partners from both sides of the U.S.-Mexico border to protect the biological and cultural resources of the lower Colorado River. With collaboration, the Cocopah hope to restore and protect their cultural and riparian ecosystem.

In 2002, the Cocopah Tribal Council passed a resolution supporting efforts for the protection of river habitat and wildlife, and the creation of an international wildlife refuge (Cocopah 2002). The resolution was an expression of tribal sovereignty and the Cocopah's cultural and historical connections to the Colo-

rado River ecosystem. The Cocopah seek to preserve the cultural and environmental integrity of reservation riparian habitat and public lands in the Lower Colorado Limitrophe, the final 23 miles of the river in the U.S., including approximately 12 miles on the Cocopah Reservation. To achieve their goals, the Cocopah united over 20 local organizations, NGOs, and government agencies from the U.S. and Mexico to restore and protect the Colorado River Limitrophe and Delta in both countries. The Cocopah believe that uniting a diverse group of bi-national stakeholders will improve the possibility of successfully protecting the Colorado River for the benefit of wildlife, habitat, and people for future generations.

*(Cont. pg. 3 . . . . . Cocopah)*

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## PRESIDENT'S MESSAGE

**H**ello again to all our members. It's midwinter, a time when everyone seems to be at their busiest, with the holidays and all the demands of work and school in full swing. Your ARC Executive Board remains hard at work also, after a successful fall meeting at the Nature Conservancy Preserve on the San Pedro River, moving immediately into preparing for a special spring meeting (see the announcement in this newsletter). We are also developing some activities for members to learn and practice more about riparian assessments and management, continuing to be a resource to the community through educational activities and continuing to serve as a reviewing resource to agencies.

Recently we have cosponsored (with the SW River Management and Restoration committee of the Arizona

Floodplain Management Association) a series of field trips/workshops to various riparian and floodplain areas to review projects or situations. Please join us for one or more of these field trips! About 20 of us visited the Rio Salado Oeste project area in early December to help visualize the proposed project and continue the relationship we have developed with respect to this project and the project proponents. We will continue to be available to the Army Corps of Engineers and the City of Phoenix as stakeholder resources as the development of this project goes forward.

I will again take the opportunity to encourage any of you with a desire to get more involved. Please try to either attend one of our Board meetings (typically the 3rd Wed. of each month), or contact one of us to help keep the Council's

momentum moving forward. We're doing some good work and need your help to continue our success!

We likely will have a vacancy or two on our Board at the time of our elections in the spring, so please consider offering yourself for that service. We also are planning some ongoing field assessments of riparian areas on the Aqua Fria National Monument (more later) and will be establishing small teams of volunteers to periodically assess stream reaches there. Our educational efforts at events and schools always can use an extra hand and don't require a great deal of commitment, just let us know you're available and show up at the event to help. We'd like to upgrade our educational materials as well, and can use the services of an artist to develop illustrations of specific concepts and anyone who might contribute to the enhancement of the professionalism of our educational products. Please pitch in! Give us a call! Thanks in advance...

*Tom Hildebrandt, President*



*Scott Jones, Tom Hildebrandt, Tice Supplee, and Roger Joos assess the riparian functions and values along the Agua Fria River.*

*(Cocopah . . . cont. from pg. 1)*

The Limitrophe provides vital wetland and riparian habitat for the survival of migratory neotropical songbirds, waterfowl, and other wetland species, including threatened and endangered species such as the Southwestern Willow Flycatcher (*Empidonax traillii extimus*), Yuma Clapper Rail (*Rallus longirostris yumanensis*), and Yellow-Billed Cuckoo (*Coccyzus americanus*). Birds migrate across the Mojave and Sonoran Deserts between western U.S. and Canadian breeding areas to their winter habitats in Mexico and Central America. Restoration of native cottonwood (*Populus fremontii*), willow (*Salix gooddingii*), and mesquite (*Prosopis glandulosa* and *P. pubescens*) habitat is critical to providing safe feeding and resting haven for birds. Protection of the Limitrophe will help complete a link among national wildlife refuges along the lower Colorado, treating the river as a complete ecosystem rather than as fragmented areas. Despite increased awareness and science supporting their importance, fish and wildlife habitat along the lower Colorado continue to be destroyed and degraded. The Cocopah Tribe feels a sense of urgency to protect the remaining high-quality habitat before it is lost to development and other threats. One of the most serious threats comes from invasive plant species. Much of the Cocopah Reservation and adjacent land along the lower Colorado is overrun by non-native saltcedar (*Tamarix ramosissima*). However, the Limitrophe is one of the few

areas along the Colorado River that continues to support significant stands of native riparian trees.

Restoring native cottonwood, willow, and mesquite is the keystone to the Tribe's larger conservation efforts. In the last two years, the Cocopah Environmental Protection Office (EPO) conducted riparian restoration on the reservation. With funding from the Bureau of Indian Affairs, Department of Homeland Security, and other agencies, the EPO selectively cleared invasive saltcedar on approximately 265 acres at four different sites along the Limitrophe. The thinning of saltcedar has allowed native species of cottonwood, willow, and mesquite the room and water to begin spreading and flourishing. The restoration is dramatic, opening up the river channel for more water flow and beginning to return riparian areas to their native state. These projects proved that native restoration can significantly enhance the environmental quality of reservation riparian areas. The Cocopah Tribe is also developing a comprehensive riparian restoration plan for the Reservation that will prioritize restoration sites and the protocol for saltcedar removal and cottonwood, willow, mesquite, and other native plant revegetation. Currently, the Cocopah Tribe is working on plans to restore another 50-100 acres, including the use of irrigation to augment the survival of replanted native species. The Tribe's efforts have attracted attention from a wide variety of U.S. and Mexican environmental organizations, state and

federal agencies, and the local community. Riparian restoration is reestablishing native habitat and providing security for wildlife. Moreover, the Tribe's conservation efforts are creating unique partnerships with government agencies and the local community because riparian restoration has the added benefit of increasing security in one of the most dangerous areas along the U.S.-Mexico border. Equally, if not more, important, restoration is bringing back the traditional plants and animals that are vital to Cocopah culture.

The Cocopah recognize that collaboration and cultural values play an important role in conservation. The Tribe is working with the National Wildlife Federation and other partners to conduct public outreach to foster knowledge of the cultural and environmental importance of the river and build the investment of Cocopah tribal members, the local community, and other stakeholders in the restoration and protection of the Limitrophe. The Bureau of Land Management (BLM) is preparing an environmental impact statement (EIS) for managing the Yuma Region surrounding Cocopah lands. To preserve the biological and cultural resources of the Limitrophe, the Cocopah submitted a proposal to the BLM requesting formal environmental protection for the area. The EIS's preferred alternative proposes coordinated management of the Limitrophe among the BLM, the Cocopah Tribe, and other entities, with the goal of both protecting habitat and wildlife as well as cultural resources and

sites (U.S. Department of the Interior 2006). Coordinate management respects the importance of government-to-government consultation with the Cocopah Tribe and could be an integral step to reaching the Tribe's goal of permanent protection for the area.

In 2004, the Secretary of the Interior directed the seven Colorado River Basin States to develop proactive approaches to river management. In February 2006, the Basin States reached an unprecedented agreement for managing the river. The accord called for increasing water delivery efficiency, the creation of credits for water conservation, and water-wheeling between states, recommendations that may increase the equity between water users and help deal with drought shortages. These extremely significant changes to the "Law of the River," if implemented, may have significant benefits to water users as well as secure instream flow for the environment (Defenders of Wildlife et al. 2006, The States 2006, Seven Basin States 2006, *Arizona Republic* 2006, Brean 2006, Jenkins 2006, Culp 2006).

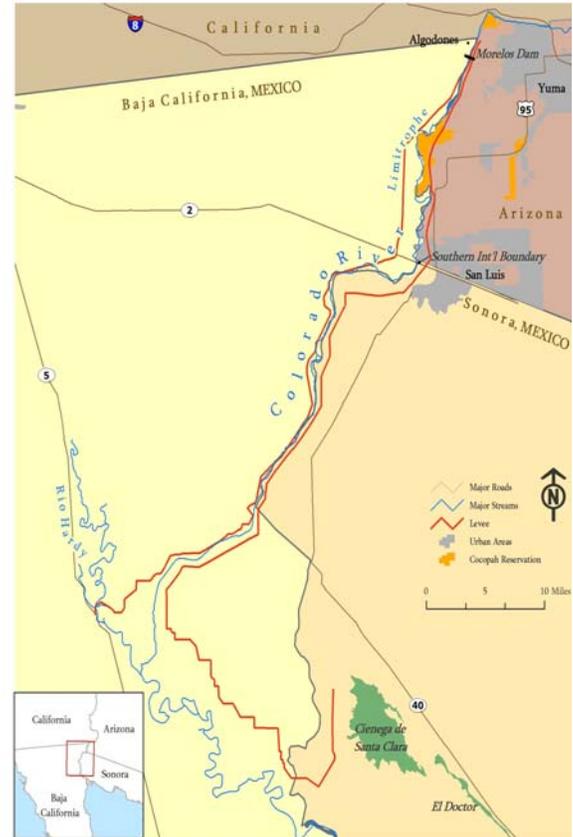
The Colorado River shapes the geography of the Southwest and it shapes the people who live there. Simultaneously, we have shaped the river, attempting to make the Colorado what we want and expect it to be. In the process, we have created a much different river. Thinking back on his visit to the Colorado River Delta, Aldo Leopold reminisced, "It is the part of wisdom never to revisit a wilderness, for the more golden the lily, the more certain that someone has gilded it" (Leopold 1949).

The Colorado River has significant environmental and cultural importance for the Cocopah. "We think of the river as a gift to us," Tribal Member Colin Soto says. "When you take the river, the trees and the woods away, I have no identity. If the river stops flowing, we will no longer exist" (Morrison 2006). Don Onesimo, a Cucapah Tribal Elder living in Mexico, is equally blunt: "What is done to the river is done to us" (Bergman 2002).

Despite the changes caused by white settlement, development, and federal policy, the integrity of Cocopah culture has remained.

Today, the Cocopah hope to secure permanent protection for the vital Limitrophe riparian ecosystem, while honoring the Tribe's cultural and ecological relationships with the Lower Colorado River landscape.

We cannot recreate the historic Colorado River landscape. But, as the Basin States' agreement and restoration efforts of the Cocopah reveal, we can expect the unprecedented and unexpected. For the Cocopah, "each piece of restored river is another piece of the tribe's legacy preserved." For Colin Soto, the importance of protecting the Colorado River is clear. "The thing that ties me back to history is the river," Soto explains. "Some of it's coming back. It looks beautiful. If we restore it, we will be able to not only have some rejuvena-



Map showing the Limitrophe Division of the lower Colorado River.

tion of our culture but be able to take people [to the river] and say, 'This is who I am. This is Cocopah'" (Morrison 2006). While the lower Colorado River landscape has experienced dramatic change in the last century and a half, the past continues to provide the foundation for the future of the River People.

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## PROPOSED BYLAWS CHANGES

One of the responsibilities I have taken on after almost five years of leadership as Vice President and President is to recommend changes to our Bylaws to improve our functional capability and add clarity where necessary. I have worked with other members of our Board, and we are now prepared to present to the membership our recommendations for changes to the Bylaws.

Please go to the Council website <<http://azriparian.asu.edu/2007/bylaws.htm>> for all the details, including a summary document, the revised bylaws in strikethrough and underline format, and a clean copy of the newly proposed bylaws. In short, we are proposing some editorial changes and these more significant changes:

- Create a new option to fill Officer/Board Member vacancies by election at the next annual meeting;
- Add the criteria of at least one year as a member in

good standing to qualify for office;

- Stagger terms of At-Large Board Members so not all are elected the same year;
- Create a ratifying process for Chairs of Standing Committees to earn voting privileges on the Board; and
- Significantly revise the number and responsibilities of the Standing Committees.

The last two of these have the potential for questions to be raised, so a brief explanation of our rationale is warranted.

1. Chairs of Standing Committees are conferred voting privileges on the Board of Directors by the existing Bylaws. These chairs are appointed by the President, however, making them the only voting Board members not elected by the membership. The new language would require ratification by vote of the membership before the committee chair would be authorized to a vote on the Board.

2. We are recommending some significant changes to the Standing Committees of the Council: deleting the Classification and Inventory Committee; changing the charter of the Policy Committee; adding an Activities Committee; and rolling the responsibilities of the Land Use Committee, Protection and Enhancement Committee, and the Water Resources Committee into a single Conservation Committee. We would end up with a total of five committees where previously we had six. We expect that these changes will reduce confusion about the roles of various committees and address some issues that were going unattended.

Please review our proposed changes and come to our Annual Meeting in April prepared to cast your vote to ratify them or not.

**Tom Hildebrandt, President**



## 21<sup>ST</sup> MEETING OF THE ARIZONA RIPARIAN COUNCIL, APRIL 11-13, 2007

This year's meeting is being held in conjunction with the University of Arizona's CLIMAS and the Cooperative Extension Service. We will be meeting at the Hotel Casa Grande (Holiday Inn), 777 N. Pinal Ave, Casa Grande. The theme of the meeting is: *Connecting the Dots – Climate Change/Variability and Ecosystem Impacts in Southwestern Riparian Areas*. Join leading scientists and educators to learn more about emerging climate and riparian area ecology research. The workshop and meeting offer an opportunity to interact with scientists to discuss and help create practical tools for land managers and decisionmakers to link climate and natural resources.

Wednesday, April 11, will be a workshop with speakers including:

**Jonathan Overpeck**, Institute for Study of Planet Earth, University of Arizona – *Welcome – Climate Change and Variability Global View: Past, Present and Future*

**Katie Hirschboeck**, Laboratory of Tree-ring Research, University of Arizona – *Climate Change and Southwest Riparian Areas: Science and Study of Climatology and Riparian Areas*

**James Hogan**, Center for Sustainability of Semi-Arid Hydrology and Riparian Areas, University of Arizona – *Climate Impacts and Water in the Riparian Zone*

**Mark Dixon**, Department of Biology, University of

South Dakota – *Climate and Riparian Ecosystem Dynamics in the Southwest*

**Dave Breshears**, School of Natural Resources, University of Arizona – *Watershed and Upland Disturbance Factors and Riparian Area Impacts*

**Duncan Patten**, Land Resources and Environmental Sciences, Montana State University – *Synthesis Discussion: Implications for Management of Riparian Areas*

**Gregg Garfin**, Institute for Study of Planet Earth, University of Arizona – *WorldCafe – Interactive Discussion Session*

**Arizona Riparian Council** – *General Membership Meeting*.

This will be followed by a dinner that evening.

Thursday morning, April 12, will be the technical session of the Arizona Riparian Council followed by a panel presentation and discussion session of Melanie Lenart, Institute for Study of Planet Earth, University of Arizona; Charles Paradzick, Salt River Project; JeanMarie Haney, The Nature Conservancy; and Holly Richter, The Nature Conservancy. This will be followed by a breakout session led by George Zaines, School of Natural Resources, University of Arizona, on riparian area photo series exercises.

Friday, April 13, will be the Arizona Riparian Council field trip to a Tucson Audubon restoration site along the Santa Cruz. The land is owned by



City of Tucson and managed by Tucson Water. About 1.2 miles of the river runs through the site. Water is normally effluent, except when storm waters enhance the flow. Restoration focuses on planting and seeding native plants appropriate for floodplain and riparian plant communities in this region; heavy use is made of rainwater harvesting earthworks (micro-basins, swales) to increase soil moisture around plantings. A water use agreement with Tucson Water allows the use of 10 acre-feet/year for irrigation of plantings (either groundwater or river water). Restoration work has been funded by in-lieu mitigation funds, the Arizona Water Protection Fund Commission, and a U.S. Fish and Wildlife Partners grant.

A special rate of \$60 per night (single or double), at Hotel Casa Grande is good through March 11, 2007. Call (520) 426-3500 to make your reservation. Registration information may be found at <http://azriparian.asu.edu/2007/registration.htm> and meeting information at <http://cals.arizona.edu/climate/index.htm>

Please join us, it's going to be an exciting meeting!



## THE RIO SALADO OESTE PROJECT: TWO PERSPECTIVES

*Tom Hildebrandt and Tim Flood*

As most members know by now, the Arizona Riparian Council has recently reviewed and commented on the City of Phoenix (City)/U.S. Army Corps of Engineers (ACOE) Rio Salado Oeste Project. We provided a comment letter (ARC Web Site under "Issues"). We followed that up by meeting with the City and ACOE staff and also a recent field trip to the project location to better understand the relationships on the ground and contrast between current and proposed conditions. Tim Flood and I were the primary authors of our letter to the ACOE, with input from a number of others.

As a result of this effort, it became apparent that we have a range of opinions and expectations for this project within the active leadership of the Council itself that probably should be acknowledged and explored a bit further. We see the same thing through different eyes.

I have basically reconciled myself to this project as an example of pretty good planning to accomplish the enhancement of what has been a wasteland for many years. I approach many situations from a manager's perspective, believing that with Arizona approaching six million people, we are long past the point where we can leave nature alone to take care of itself. The Rio Salado Oeste Project obviously does not satisfy our desire to see the restoration of a river and its riparian habitats in a complete and interconnected fashion. The project is artificial in its

construction and layout, and will require continued inputs of active management to remain in place. It is not self-sustaining. Can the millions of dollars to be expended be put to better use in riparian restoration? Of course, but that isn't going to happen.

On the other hand, the City's binding promise of 8 million gallons per day (mgd) of effluent discharge and continued operations and management is a substantial commitment to the future for this project. We have already seen what can be done in the Rio Salado Project area upstream. The plantings on the terrace levels and the naturally establishing marshland vegetation in the low flow channel are already offering significant habitat for wildlife. These habitat areas have a large and increasing clientele of recreational users, and are offering opportunities to school children and others to learn about nature in a replica of our most productive native habitats.

To be sure, this is and the Oeste project will be a replica, not the real thing. We pointed out in our letter that we would like to have seen a complete restoration of not only the habitats, appropriately sited in the floodplain, but also the connections to floodplain, groundwater, flooding regimes and upper watersheds. This is frankly not possible in this situation. This river was severed when the series of dams were closed upstream, beginning with Granite Reef in 1908 and Roosevelt in 1911. Since then the Salt River through Phoenix

has not had a natural connection with the upper watersheds.

I believe that what the Rio Salado Oeste project offers is significantly better than what we have now. With appropriate oversight this project can be an enormous benefit to people's appreciation of nature and understanding of riparian habitats and their qualities. I am not confident this oversight will occur without entities like the Arizona Riparian Council remaining involved in the interpretation of the project and offering their various alternative perspectives and knowledge. We do need to guard against people thinking this is the real thing!

### THE OTHER PERSPECTIVE

If promoted as river restoration, the proposed Rio Salado Oeste project would be a bitter-sweet improvement. While I applaud the City's intention to dedicate 8 mgd to the project, this commitment will effectively remove the last remaining, current hydrological connection between the surface flow and natural riparian habitat. Instead of leaving the water in the low point of the channel, the project would capture that water and move it up into a linear, to-be-shaped terrace near the 10-year floodplain.

The details of the landscaping and engineering to create this terrace and deliver the water are yet to be worked out. Keeping the water up on the terrace will pose challenges both in terms of the initial construction and in long-term maintenance. It will be quite an expensive project.

To me, the disconcerting aspect of the project is the major policy decision that the Salt River will no longer be allowed to function as a natural river. This project would likely be the definitive action to extinguish what little remains of the natural river through Phoenix. I liken it to a fatal exsanguination.

In its favor the project will create an irrigated ribbon of green, surely increasing biodiversity and providing a much desired opportunity for recreation along a river. However, the artificial nature of the project will not stabilize the water supply in the river, nor reduce soil erosion, nor improve water quality. The project severs the opportunity for the river to perform its natural functions: trapping sediment and nutrients, dissipating energy through meanderings within its flood-

plain, and recharging base flow. I would feel better about the project if the ACOE and its partners could find a reach within the project area where they will also allow some *in-situ* restoration of these river functions to occur. I would argue for a wider channel within which to let nature take its course, literally. Some components of the newly opened, upstream Rio Salado project appear to function well; the successful ones could be replicated in the Oeste area.

There are lessons here. It never should have come to this point. It is unlikely that the decisionmakers of the past understood the consequences to riparian habitat of removing the surface flow from the river. No one previously spoke up for preserving a lessened, but still functioning, river. Arizona's land and water laws are seri-

ously stacked against preserving riparian areas. Our lawmakers favor the needs of urban development over having a functioning river, but the impact of imposing a dysfunctional river also has been great, as evidenced by the need to propose this and other costly projects. The challenge to our organization is to effectively demonstrate the value and benefit of a functional urban river. We could benefit by discussing the steps that lead us to this point.

Economically, there well may be a favorable short-term cost-benefit ratio now for proceeding with the Rio Salado Oeste project. That is to say, the greenbelt improvements may favor economic development of this now-blighted area. However, I would not label this project as a "river restoration."



## LACK OF IMPLEMENTATION OF EXISTING RECOVERY PLANS MAY DOOM NATIVE FISH IN SOUTHWEST

*An Analysis of Recovery Plan Implementation for Threatened and Endangered Warm Water Fishes of the Gila River Basin. Report Number 3. Desert Fishes Team. December 2006*

A report released in December by the Desert Fishes Team concludes that federal and state agencies charged with protecting and recovering endangered and threatened species are failing to implement existing recovery plans for eight endangered and threatened fish of the Gila River basin in Arizona and New Mexico. Recovery plans are basic provisions of the Endangered Species Act setting out steps for protection and species enhancement. According to the report, all eight species are declining and without effective and timely recovery actions face the likelihood of extinction. The

analysis found that approved recovery plans for these species, which have been in place for between 9 and 28 years, provide sound conservation programs but few of steps have been implemented. Complete or near-complete implementation has not been achieved for any of the species, and a moderate level of implementation has occurred for only one species (Gila topminnow). Progress for recovery of some of the species, such as desert pupfish, "has been virtually non-existent." In particular, the report concludes that nonnative fish and other aquatics constitute the principal

barrier to recovery of warm-water fishes in the Gila River basin and calls for greater control efforts against nonnatives, including sport fish. The Desert Fishes Team is an independent group of biologists from agencies, academia, and nongovernmental organizations interested in conservation of native fish in the desert Southwest. This, and earlier reports, by the Team can be found at <http://www.peer.org/news> or <http://www.nativefishlab.net> or by writing to Desert Fishes Team, PO Box 16815, Phoenix, AZ 85011-6815 or email to [stefferud@cox.net](mailto:stefferud@cox.net)





## NOTEWORTHY PUBLICATIONS

Elizabeth Ridgely, Tristar Engineering and Management, Inc.

**Scott, R. L., D. G. Huxman, D. G. Williams, and D. C. Goodrich. 2006. Ecohydrological Impacts of woody-plant encroachment: Seasonal patterns of water and carbon dioxide exchange within a semiarid riparian environment. *Global Change Biology* 12:311-324.**

Woody-plant encroachment has been attributed to land use changes (e.g. domestic livestock introduction, fire suppression, native herbivore elimination) acting alone or in concert with changes in atmospheric boundary conditions (e.g. air temperature, precipitation, or [CO<sub>2</sub>]). This type of encroachment in riparian ecosystems of semiarid areas likely affects biodiversity and biogeochemistry and has the potential to alter landscape hydrology. Woody-plant encroachment has been hypothesized to be an important component of the changing North American carbon cycle, although there is uncertainty as to site-specific characteristics of this vegetation change impact. Encroachment may decouple primary productivity from summer rains because deeply rooted woody plants access stable groundwater sources unavailable to grassland species. However, increased productivity by woody plants may be offset by larger respiratory fluxes from soil microbial communities that remain highly responsive to summer precipitation and are

fueled by high quality litter inputs from woody vegetation.

This study is a comparison of ecosystem water and carbon dioxide (CO<sub>2</sub>) fluxes over a grassland, a grassland-shrubland mosaic, and a fully developed woodland. It is an evaluation of the potential consequences of woody-plant encroachment on water and CO<sub>2</sub> exchange in a riparian area and a comparison of CO<sub>2</sub> and water fluxes. The goal is to predict how on-going woody-plant encroachment affects ecosystem water and carbon cycling by understanding the abiotic and biotic controls on these fluxes. The study is located in the riparian corridor of the San Pedro River in southeastern Arizona, USA.

Throughout the southwest US encroachment by mesquite (*Prosopis* spp.) in particular has been pervasive over a relatively short period (ca. 100 years). Mesquite is a nitrogen (N) fixer and produces abundant leaf litter with high N concentration in riparian habitats with potentially large impacts on soil carbon cycling.

The premise is that plants in riparian ecosystems may have access to moisture at the capillary fringe of the near-surface water table. It was found that ecosystem evapotranspiration (ET) and net ecosystem exchange of CO<sub>2</sub> (NEE) increased with increasing woody-plant dominance. Growing season ET totals were 407, 450, and 639 mm in the grassland, shrubland, and woodland, respectively,

and in excess of precipitation by 227, 265, and 473 mm. The excess came from groundwater, during the dry premonsoon period when this was the only source of moisture available to plants. Access to groundwater by the deep-rooted woody plants must decouple ecosystem ET from gross ecosystem production (GEP) with respect to precipitation.

Evapotranspiration and the NEE of CO<sub>2</sub> were measured using eddy covariance. Eddy covariance measurements were assessed using the ratio of the sum of the average sensible and latent heat fluxes over net radiation minus the ground heat flux as an indication of energy balance closure. An attempt was made to correct NEE for CO<sub>2</sub> storage in the canopy. A piezometer was installed at each site to measure water table levels.

Compared with grasses, the woody plants were better able to use the stable groundwater source. They had an increased net CO<sub>2</sub> gain during the dry periods. Enhanced plant activity resulted in substantial accumulation of leaf litter on the soil surface that, during rainy periods, may lead to high microbial respiration rates that offset these photosynthetic fluxes. The March-December primary growing season totals of NEE were -63, -212, and -233 gCm<sup>-2</sup> in the grassland, shrubland, and woodland, respectively. Therefore, there was a greater disparity between ecosystem water use and the

strength of the CO<sub>2</sub> sink as woody plants increased across the encroachment gradient. Despite a higher density of woody plants and greater plant productivity in the woodland, the woodland produced a larger respiration response to rainfall.

Precipitation totals were similar at all three sites. Closure was the lowest for the grassland (0.76), slightly better for the shrubland (0.81), and highest for the woodland (0.92). Above canopy air and dew point temperatures at the grassland and shrubland were similar to those found at the woodland. Annual mean depth to groundwater was 2.6, 6.4, and 9.8m at the grassland, shrubland and woodland, respectively. Groundwater levels generally declined from the time of new leaf production until the beginning of the monsoon. Seasonal patterns of ET of the shrubland and grassland were similar to that of the woodland

Results included the following:

1. Seasonal ET totals increased with woody-plant abundance.
2. Regular diurnal groundwater fluctuations occurred at all sites and ET exceeded precipitation; thus, dominant plants at all

ecosystems used groundwater to supplement their water use. Groundwater use increased with the amount of woody plant cover despite increasing depths to groundwater at these sites, which indicated that larger trees at the shrubland and woodland were better able to acquire groundwater.

3. All sites had high respiration losses of carbon following precipitation events during the summer monsoonal period. The response was strongest and longer lasting at the woodland, where abundant litter deposition supplied ample carbon for the soil microbial community.
4. While the grassland had a small increase in carbon gain during the rainy growing season, the woody sites had a net decrease relative to the dry part of the growing season. This decreased gain in carbon was magnified by woody-plant abundance.

The data suggests that the capacity for woody plants to exploit water resources in riparian areas results in enhanced carbon sequestration at the expense of increased groundwater use under current climate

conditions, but the potential is not specifically a function of woody-plant abundance. These results highlight the important roles of water sources and ecosystem structure on the control of water and carbon balances in dryland areas. Shifts in resource availability substantially alter the relationship between gross photosynthetic and respiratory activities. Finally, vegetation change appears to alter how precipitation drives each of these important ecosystem processes, suggesting that the interrelationships between ecosystem structure, function, and climate are fundamentally altered.



The Arizona Riparian Council (ARC) was formed in 1986 as a result of the increasing concern over the alarming rate of loss of Arizona’s riparian areas. It is estimated that <10% of Arizona’s original riparian acreage remains in its natural form. These habitats are considered Arizona’s most rare natural communities.

The purpose of the Council is to provide for the exchange of information on the status, protection, and management of riparian systems in Arizona. The term “riparian” is intended to include vegetation, habitats, or ecosystems that are associated with bodies of water (streams or lakes) or are dependent on the existence of perennial or ephemeral surface or subsurface water drainage. Any person or organization interested in the management, protection, or scientific study of riparian systems, or some related phase of riparian conservation is eligible for membership. Annual dues (January-December) are \$20. Additional contributions are gratefully accepted.

This newsletter is published three times a year to communicate current events, issues, problems, and progress involving riparian systems, to inform members about Council business, and to provide a forum for you to express your views or news about riparian topics. The next issue will be mailed in May, the deadline for submittal of articles is April 15, 2007. Please call or write with suggestions, publications for review, announcements, articles, and/or illustrations.

Cindy D. Zisner  
Arizona Riparian Council  
Global Institute of Sustainability  
Arizona State University  
PO Box 873211  
Tempe AZ 85287-3211  
(480) 965-2490; FAX (480) 965-8087  
Cindy.Zisner@asu.edu

website: <http://azriparian.asu.edu>  
moderated listserv: [riparian@asu.edu](mailto:riparian@asu.edu)

**The Arizona Riparian Council**

**Officers**

- Tom Hildebrandt, President (480) 345-6194  
(Please leave message)  
tomarc@cox.net
- Roger Joos, Vice President . . . . .  
rejoos@fs.fed.us
- Cindy Zisner, Secretary . . . (480) 965-2490  
Cindy.Zisner@asu.edu
- Cory Helton, Treasurer . . . . (928) 214-0887  
cory@jefuller.com

**At-Large Board Members**

- Diane Laush . . . . . (623) 773-6255  
dlaush@lc.usbr.gov
- Diana Stuart . . . . . (480) 491-1323  
Diana.Stuart@asu.edu
- Ron van Ommeren . . . . . (520) 884-5549  
RVanommere@aol.com

**Committee Chairs**

- Classification/Inventory . . . . . Vacant
- Education  
Cindy Zisner . . . . . (480) 965-2490
- Land Use  
Tim Flood . . . . . tjflood@att.net
- Policy . . . . . Vacant
- Protection/Enhancement  
Kris Randall . . . . . (602) 242-0210 X250  
Kris\_Randall@fws.gov
- Bill Werner . . . . . (602) 417-2400 X7264  
bwerner@adwr.state.az.us
- Water Resources  
Julia Fonseca . . . . . (520) 740-6350  
Julia.Fonseca@rfcd.pima.gov

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## CALENDAR

**Connecting the Dots – Climate Change/Variability and Ecosystem Impacts in Southwestern Riparian Areas**, Arizona Riparian Council 21<sup>st</sup> Annual Meeting April 11-13, 2007, in Casa Grande, AZ at the Hotel Casa Grande. The meeting is being held in conjunction with the University of Arizona's CLIMAS and the University Cooperative Extension Service. To register visit our website at <http://azriparian/2007/registration.htm> or for more meeting information at <http://cals.arizona.edu/climate>.

**Arizona Riparian Council Board Meetings.** The Board of Directors holds monthly meetings the third Wednesday of each month and all members are encouraged to participate. Please contact Cindy Zisner at (480) 965-2490 or [Cindy.Zisner@asu.edu](mailto:Cindy.Zisner@asu.edu) for time and location.



BT5 1005  
Arizona Riparian Council  
Global Institute of Sustainability  
Arizona State University  
PO Box 873211  
Tempe, AZ 85287-3211

