Arizona Riparian Council

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Riparian Plant Community Development on Effluent-dominated Rivers in Arizona

by Roy J. Marler, Ph.D., Cascade College, Portland, Oregon

Many rivers in the southwestern United States have been subjected to manipulation over the past century, resulting in changes in flow regime. Dams, diversions, and groundwater pumping can alter regional hydrology, often resulting in diminished or loss of surface flows. Riparian ecosystems provide valuable services, such as being a link between terrestrial and aquatic habitats, roosting and foraging habitat for migratory birds, and recreational value for people, but diminished or lost flows often degrade these services. One type of human activity, however, results in water being returned to these systems, the introduction of effluent (treated wastewater) from municipal wastewater treatment plants. As urban areas continue to develop and expand, there will be a concomitant increase in effluent generation. Water availability is a critical determinant of riparian ecosystem development and maintenance, therefore effluent may provide "new" water with the potential to restore riparian ecosystems along river systems that have experienced reduced or lost flows.

Release of effluent into river systems raises several questions, as there is the potential for effluent to alter geomorphology and riparian community structure downstream of the release point. Do effluent-dominated river systems support riparian ecosystems that are structurally and functionally similar to other, non-effluent river systems in the Southwest? Can effluent release from treatment plants provide a viable resource by which riparian ecosystems can be restored to some of their former range, or enhance existing areas? To address these questions I studied, under the guidance of Dr. Duncan Patten and Dr. Julie Stromberg, two effluent-dominated systems in Arizona, the Salt River downstream of Phoenix, and the Santa Cruz River downstream of the Nogales International Wastewater Treatment Plant (NIWWTP), which treats wastewater from the greater Nogales area. We hypothesized that 1) woody riparian vegetation would have greater density, basal area, and vegetation volume on effluent-dominated reaches due to the reliable water source; 2) growth rates of prevalent woody species would be greater on the effluent-dominated reach in response to greater nutrient availability associated with effluent; 3) species richness would be similar between reaches, but that exotic species would be more prevalent on the effluent-dominated reach in response to greater nutrient availability; and 4) there would be gradients in woody density, basal area, and vegetation volume with distance downstream from the effluent discharge point. This article addresses the primary findings of our field studies. Our ultimate goal in studying effluent-dominated systems was to provide information to resource managers regarding the potential value of effluent in restoring or maintaining riparian ecosystems in the southwestern United States.

Study Sites

Salt River System

This system is regulated by dams, altering the hydrologic regime of both control and effluent reaches. Multiple inputs and outtakes of surface and ground water occur on this system. Two rivers were used for the control

(Cont. pg. 3 ...... Effluent)

Inside This Issue

PRESIDENT'S MESSAGE

Another year has turned over and 2006 is stretching out ahead. Hopefully you all see it as a year of promise for the work we do and the things we hold dear. Your Arizona Riparian Council is moving forward with big plans for this our 20th Anniversary year!

Most prominently, we are hosting our annual s**pring meeting** by returning to our roots in many ways. We will hold the meeting in Flagstaff, at the Museum of Northern Arizona, the site of our first annual meeting! The dates are April 27-29, 2006, so mark your calendars.

We invited our founders, Duncan Patten and Chuck Hunter to join us to keynote our plenary session with the theme ***Riparian Issues: Reflections on our Past and Challenges for our Future***. Chuck and Duncan will be joined by three other speakers who can help us identify some of our successes over the years, and those challenges we know are waiting for our attention.

You may have noticed that the dates above include Thursday, Friday, and Saturday. With our success last year, we decided to again host a **workshop** in conjunction with the annual meeting. Tom Moody and his folks at Natural Channel Design will again join us for a Thursday classroom session and Saturday field exercise on fluvial geomorphology. This will be a workshop that emphasizes the basics and will be an overview of this science. I promise it will whet your appetite for more!

Of course, Friday is the annual meeting, and in addition to the plenary session, we will have a technical papers session, posters, and in the evening our **20th Anniversary Celebration Social**. We have booked a fabulous location called the Colton House. It was the home of the founders of the Museum and we will have appetizers and beverages and lots of talk Friday evening. We're hoping to land a very special guest to join us – check back later for the rest of the story!

The annual meeting necessarily involves doing some Council business as well, and this year we have a bit more to our **elections** than usual. Due to a vacancy in our Vice President's position, and the resignation of an at-large board member, we will be having an extended ballot, with Vice President, Secretary, Treasurer, and one board seat to be filled. I'd like each one of you to stop right now and consider whether you would like to step up and join us as one of the officers or board members. We always need new people to step into positions of leadership and to help our Council grow and prosper. Pick up the phone or get on your email and contact me with an offer to help in this service.

Finally, I do want to thank this year's officers and board for putting in many hours of service to the enhancement of knowledge about Arizona's riparian areas and their conservation. I push the Council leadership to always be looking to do more and better, and they unfailingly respond. They likewise offer me similar encouragement to never be satisfied with what was good enough yesteryear. They certainly get my thanks, and they deserve any thanks you all can show them. Show them the best kind of thanks by joining in to help pick up the load. **See you in Flagstaff!**

Tom Hildebrandt, President

(Effluent .... Cont. from pg. 1)

reach: the Salt River between Stewart Mountain Dam and Granite Reef Dam, and the Verde River between Bartlett Dam and Granite Reef Dam (Fig. 1). These river sections were selected because they were the nearest perennial, noneffluent surface flows upstream of the effluent reach. The effluent reach was located on the Salt River southwest of Phoenix, beginning immediately downstream of the Multi-Cities Wastewater Treatment Plant (MCWWTP) and extended 24 km downstream (Fig. 1).

Santa Cruz River System

This system is unregulated, but groundwater pumping and small inputs likely influence the hydrologic regime. The control reach began approximately 1 km from the Mexico/United States border and extended downstream approximately 18 km, ending upstream of the NIWWTP. The effluent reach was located from 13 to 26 km downstream of the NIWWTP (Fig. 1).

METHODS

Five transects spanning across the floodplain, perpendicular to the primary channel, were placed within each control and effluent reach. Along each transect 2 × 20 m quadrats were randomly placed within identified vegetation patches in which woody metrics were collected. Herbaceous data were collected from three, 1-m^2 plots that were randomly placed within each larger quadrat. Herbaceous data were only collected on the Salt River system.

To assess community structure, woody species were identified and placed into functional groups (i.e., hydric, mesic, or xeric) based on Wetland Indicator Status (WIS) values and life-history characteristics related to seed production and dispersal. Obligate and Facultative-wetland species were classified as hydric, Facultative and Facultative-upland were classified as mesic, and Upland species or species with no WIS value listed were classified as xeric. By using life-history traits we classified species as either pioneer or competitive. Pioneer species exhibit traits of high reproductive output, small seed size, and seeds adapted for wind or water dispersal. Competitive species exhibit traits of lower seed production, with larger seeds. Data were collected on stem density, basal area based on diameter at about 5 cm height, and vegetation volume. Vegetative data were scaled up from quadrat to floodplain level by weighting the patch values to the relative width of each patch across the floodplain.

Tree cores and slabs were obtained from *Populus fremontii* (Fremont cottonwood), *Salix gooddingii* (Goodding's willow), and *Tamarix ramosissima* (saltcedar) to determine age structure and growth rates. *T. ramosissima* cores were not obtained for the Santa Cruz River system due to limited presence in the study area.

Herbaceous species richness and cover were determined on two scales, overall for the reach and for m^2 plots during each seasonal sampling period (fall and spring). Unidentified species were grouped together, and were included in percent cover analysis but not richness analysis. Herbaceous species were identified as native or exotic and given WIS scores as indicated on The National PLANTS database website, *http://plants.usda.gov/*. Dominance values for herbaceous species were generated based on relative percent cover and relative frequency of occurrence in m^2 plots.

Surface and groundwater hydrology was analyzed for two transects on both the control and effluent reaches of the Salt River

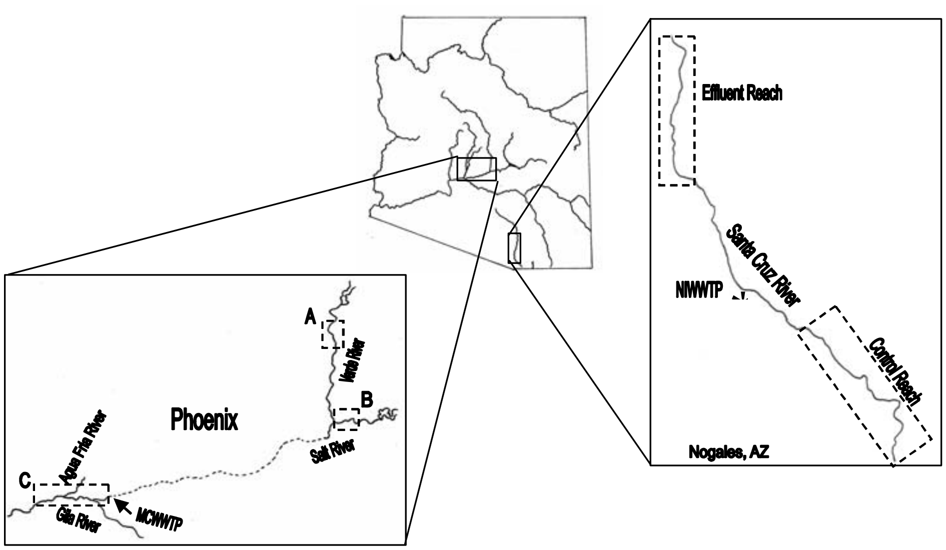

Figure 1. *Map of Salt River and Santa Cruz River systems. For the Salt River system, dashed boxes in enlargement show A) control reach on Verde River, B) control reach on Salt River, and C) effluent reach. MCWWTP is Multi-Cities Wastewater Treatment Plant. NIWWTP is Nogales International Wastewater Treatment Plant.*

system. Wells were in series of three across the floodplain to measure depth and seasonal fluctuation, and for collecting water samples for chemical analysis of nitrate-N, ammonium-N, and Soluble Reactive Phosphorus (SRP). Surface water chemistry for the Santa Cruz River downstream of the treatment plant was obtained from NIWWTP and the National Water Information System (NWIS).

Data Analysis

Woody stem density, basal area, vegetation volume, radial growth rates on the Salt River system, and herbaceous richness and cover were analyzed using Mann-Whitney and Kruskal-Wallis tests, as assumptions of normality and variance were difficult to consistently satisfy. On the Santa Cruz River system, single-factor ANOVA with Tukey HSD post-hoc multiple comparison was used to analyze radial growth rates of *P. fremontii* and *S. gooddingii*, with comparisons between reaches and based on location of the cohorts in the floodplain relative to the primary channel.

Results

Salt River System

- Total woody species richness was similar for effluent and control reaches, with 14 species identified on each reach and exotics *T. ramosissima* and *Nicotiana glauca* (tree tobacco) present on both reaches. Nine species were common between reaches.
- Mesic pioneer patch type was dominant on both reaches, occupying 34% and 30% on the control and effluent reach floodplains, respectively. This patch type is represented by *T. ramosissima*, *Hymenoclea monogyra* (singlewhorl burrobrush), and *Baccharis sarothroides* (desert broom). The hydric pioneer patch type, which includes *P. fremontii* and *S. gooddingii*, had limited presence on both reaches.
- Woody stem density and basal area was greater on the control reach, while vegetation volume was greater on the effluent reach (Table 1).
- Radial growth rates of *P. fremontii* and *S. gooddingii* were greater on the effluent reach, and when data for these species were pooled (based on similarities in growth form and ecological niche), growth rates were significantly greater on the effluent reach (1.22 cm yr^{-1}) compared to the control reach (0.97 cm yr^{-1}). *T. ramosissima* also showed significantly greater growth rate on the effluent reach relative to the control, 0.83 and 0.56 cm yr^{-1}, respectively.
- Longitudinal analysis of the effluent reach showed that differences existed between transects for woody stem density, basal area, and vegetation volume, but no overall downstream trend was discernable for any of these metrics. However, stem density of *T. ramosissima* did show an increase with distance downstream from the treatment plant.
- Herbaceous species richness at the reach level was very similar between the control and effluent reaches (46 and 45 species, respectively). Exotics comprised 39% of all species on the control reach and 33% on the effluent reach. At the 1-m plot level, species richness and percent cover were greater on the control reach during the spring season and for fall and spring seasons combined.
- Herbaceous species dominance scores (relative cover plus relative frequency of occurrence) revealed that although more native species were identified for both reaches, exotic species dominated, especially *Cynodon dactylon* (Bermuda grass).
- Both surface and groundwater chemistry showed greater concentrations of nitrate-N, ammonium-N, and SRP on the effluent reach. These nutrients showed a decline in concentration with distance downstream from the treatment plant. Control reach concentrations for these nutrients were similar to values obtained for other non-effluent streams in Arizona.

Santa Cruz River System

- Total species richness was slightly greater on the effluent reach (15) compared to the control reach (12), with eleven species common to both reaches. A slight increase in mesic and xeric species was observed on the effluent reach.
- Hydric pioneer patch type was dominant on both reaches, occupying 40% and 47% of the control and effluent reach floodplains, respectively.

Table 1. *Comparison between control and effluent reaches for woody density, basal area, and vegetation volume. Mann-Whitney test used, means ± standard error shown, alpha = 0.05. Superscript letters indicate significant differences between reaches.*

	Density (stems m^{-2})		Basal Area (cm^2 m^{-2})		Veg. Volume (m^3 m^{-2})	
	Control	Effluent	Control	Effluent	Control	Effluent
SALT RIVER SYSTEM						
All species	0.96±0.26[a]	0.35±0.06[b]	6.29±1.75	3.44±0.51	0.07±0.01[a]	0.12±0.01[b]
SANTA CRUZ RIVER SYSTEM						
Baccharis salicifolia	0.52±0.25	0.17±0.06	0.31±0.13	0.26±0.09	0.01±0.00	0.00±0.00
Populus fremontii	0.02±0.01[a]	0.12±0.04[b]	0.70±0.41[a]	4.72±1.20[b]	0.05±0.02	0.08±0.02
Salix gooddingii	0.02±0.01	0.11±0.04	2.59±1.04[a]	5.49±1.33[b]	0.06±0.03[a]	0.16±0.03[b]
All species	0.57±0.25[a]	0.48±0.10[b]	3.72±1.11[a]	10.6±1.92[b]	0.12±0.03[a]	0.26±0.04[b]

- Total woody stem density was greater on the control reach, primarily due to *Baccharis salicifolia* (Table 1). However, basal area and vegetation volume was greater on the effluent reach due primarily to *P. fremontii* and *S. gooddingii* (Table 1).
- Radial growth rate of *P. fremontii* showed no significant difference between reaches or between active channel and floodplain locations on both reaches, with growth rates ranging from 1.02 to 1.21 cm yr^{-1}. In contrast, *S. gooddingii* showed significant difference in growth rate between locations within a reach. Growth rates for control floodplain locations (0.545 cm yr^{-1}) were less than control active channel locations (0.851 cm yr^{-1}), with similar differences in growth rates found for the effluent floodplain locations (0.568 cm yr^{-1}) and effluent active channel locations (0.871 cm yr^{-1}). *P. fremontii* had significantly greater growth rate than *S. gooddingii*.
- Longitudinal analysis of the effluent reach revealed no downstream trend for woody density, basal area, or vegetation volume.
- Surface water chemistry obtained from NIWWTP and NWIS indicated that ammonia-N and ortho-phosphate concentrations on the effluent reach were greater than on the control reach, and decreased with distance downstream from the treatment plant. Control reach concentrations for these nutrients were similar to other non-effluent streams in Arizona.

CONCLUSIONS AND MANAGEMENT APPLICATION

Riparian ecosystems of the southwestern United States have been altered substantially this past century due in large part to anthropogenic influences on hydrological processes. Effluent release from wastewater treatment plants into river channels alters hydrologic conditions by creating perennial base flows and increasing nutrient availability. This research addressed how effluent released into river channels may influence riparian plant community development downstream of treatment plants, using the Salt River and Santa Cruz River as representative effluent-dominated systems. Although stream flow is large but regulated on the Salt River and small and unregulated on the Santa Cruz River, similarities existed between systems in their response to effluent. Species richness and composition was similar between control and effluent reaches on both systems. Overall woody density was greater on control reaches, while vegetation volume was greater on effluent reaches of both systems. No downstream trends for vegetation density, basal area, and volume were evident on either effluent reach, despite declining downstream nutrient availability; however, differences existed between systems. … despite declining downstream nutrient availability. Differences did exist, however, between systems. Basal area was greater on the Salt River control reach, but was greater on the Santa Cruz River effluent reach. Growth rates of *Populus*, *Salix*, and *Tamarix* were greater on the Salt River effluent reach, but *Populus* and *Salix* showed no difference between Santa Cruz River reaches. Variations in measures between river systems makes interpretation of results difficult, but several observations emerged from this study. Water quantity changes produced by effluent appears to be more important than water quality changes on community-level measures of riparian plant community development, as suggested by the lack of any downstream trend in vegetation on the effluent reach coinciding with downstream gradients in nutrient availability. Both water quantity and quality, however, may be important in population-level processes, such as seedling establishment and tree growth rate. The potential exists in the Southwest, and perhaps elsewhere, to utilize effluent to develop riparian ecosystems that exhibit structural and functional attributes similar to those found in non effluent systems which, in turn, would provide habitat critical for residential and migratory species. Recreation areas can be developed in association with these effluent-dominated systems; these areas can be used for educational purposes illustrating the importance of riparian ecosystems in the landscape. This study provides information that illustrates effluent may be a viable resource to enhance or restore riparian ecosystems on rivers in the semi-arid Southwest.

SPECIES PROFILE

LITTLE COLORADO SPINEDACE, *LEPIDOMEDA VITTATA*

By Kathleen Tucker, AZTEC Engineering

This tiny native minnow is from the family Cyprinidae and is typically less than 10 cm long. The spinedace is silvery with a darker back than belly (*http://ecos.fws.gov/species_profile/SpeciesProfile?spcode=E04M*; accessed January 8, 2006). The spinedace was first listed as threatened on March 11, 1967. On September 16, 1987, the species was listed as threatened with critical habitat (52 FR 35054). It is also listed as a wildlife of special concern by the State of Arizona and as a sensitive species with the Forest Service, Region 3.

Photo from http://www.fws.gov/arizonaes/Fish.htm; originally by Arizona Game and Fish Department.

Historically this species was endemic to the upper portions of the Little Colorado River and to its north flowing permanent tributaries on the Mogollon Rim and the northern slopes of the White Mountains in eastern Arizona. Its current range is only in portions of East Clear, Chevelon, Silver, and Nutrioso Creeks and the Little Colorado River in Coconino, Navajo and Apache Counties. Critical habitat occurs within 29 km of East Clear Creek in Coconino County, 13 km of Chevelon Creek in Navajo County and 8 km of Nutrioso Creek in Apache County.

This species inhabits small to moderate-sized streams. It is typically found in pools with water flowing over fine gravel and silt-mud substrates where it feeds on aquatic and terrestrial invertebrates. Since many these streams are intermittent this species persists in deep pools and spring areas that retain water. During times of flooding the spinedace distributes itself throughout the stream. Populations vary year to year possibly due to the cyclical periods of drought and/or increased rainfall. Their habitat ranges in elevation from 1,219 to 2,438 m. Spawning typically occurs in early summer, but some continues until early fall. Spawning in the stream occurs in slow current over cobbles or aquatic vegetation and debris. Females lay 650 to 5,000 eggs and may spawn more than once a year.

Threats that have contributed to the decline of this species include habitat alteration and loss due to modifications to streams and watersheds, grazing, road building, urban growth and other human activities. In addition, the introduction and spread of exotic predatory and competitive species (rainbow trout *[Oncorhynchus mykiss]* and green sunfish *[Lepomis cyanellus]*) as well as the use of ichthyotoxins has threatened this species existence. Predation by the rainbow trout appears to be an important factor in the success and distribution of this species *(*Arizona Game and Fish Department. 2001. *Lepidomeda vittata*. Unpubl. abstract compiled and edited by the Heritage Data Management System, Arizona Game and Fish Department, Phoenix, AZ. 5 pp.*)*. Managing this species requires delineating spinedace management areas, conserving existing populations and their watersheds, establishing refugium sites within historical habitats, and ameliorating effects of nonnative fishes in the spinedace habitats. There currently is a Recovery Plan that was finalized in January of 1998 and is available at *http://arizonaes.fws.gov/Documents/RecoveryPlans/Spinedace.pdf*.

The U.S. Fish and Wildlife Service is currently reviewing the status of this species to determine if the species classification as threatened is still appropriate. The Service is seeking any new information since the 1987 listing of the spinedace. Information regarding current distribution and evaluation of the degree of habitat protection for each population, management plans and techniques for improving and maintaining spinedace habitat is being requested. Information should be sent to the Field Supervisor, Attention 5-year Review, U.S. Fish and Wildlife Service, Arizona Ecological Services Field Office, 2321 W. Royal Palm Rd., Suite 103, Phoenix, AZ 85021, or faxed to (602) 242-2513, or e-mail to: MGRSandLCS5yr@fws.gov.

2006 Spring Meeting, April 27-29

Cindy Zisner, Secretary

Museum of Northern Arizona

Land and Peoples of the Colorado Plateau

This year our meeting is special. It is our 20th Annual Meeting. Doesn't seem that long ago – boy does time fly. As Tom mentioned in his President's Message (pg. 2), we are having the meeting this year at the Museum of Northern Arizona on April 27-29, 2006 (located 3 miles north of Flagstaff on Highway 180). We held our first meeting there in 1986 and thought it would be a great time to go back to celebrate our 20th.

Since our workshop went so well last year we've asked Tom Moody to conduct another and he has graciously agreed to do so. The format for the meeting will be as last year – full day of classroom workshop (Thursday), followed by the meeting on Friday, and Saturday will be the workshop field exercise and a field trip in the Flagstaff area for those who do not attend the workshop.

The two-day workshop (limited to 50 participants) will provide an overview of the fundamentals of stream geomorphology in the arid Southwest. The Thursday lecture session will include the nature of rivers, alluvial features, sediment transport processes, bankfull stage and its significance, channel classification, and channel adjustments to disturbance.

The Saturday field day includes examples of stream types, field identification of bankfull stage, field survey techniques, and as many interesting stream channel sites as we can fit in. Keep in mind that this is a short course and lots of material will be presented quickly.

On Friday we will have the regular meeting. We've asked Duncan Patten, our first President and cofounder to come, along with Chuck Hunter, first Secretary/Treasurer and cofounder as our keynote speakers to lead off our meeting. The theme this year is *Riparian Issues: Reflections of our Past and Challenges for our Future*. Both Duncan and Chuck will relate to us the reasons the Council was formed and what they see as challenges for us. To give us various perspectives on these topics we've also asked Tim Phillips, Flood Control District of Maricopa County; Andy Laurenzi, Sonoran Institute; and Joe Feller, College of Law, Arizona State University. There will be a panel discussion and an afternoon of technical papers. Don't forget to submit those abstracts!

The Colton House

Friday evening we have planned a reception at the Colton House. It is the former home of the founders of the Museum of Northern Arizona. We hope to have a special guest in attendance.

We hope that you will plan to join us this special year!

Biographies for ARC Officers

Vice President: Roger Joos has been a member of the Council for two years. Roger has a B.S. in Wildlife Science form the University of Arizona. He currently works with USDA Wildlife Services where he leads field operations for a beaver research project in the Phoenix Tres Rios area. His interests about riparian issues are varied, but land use and restoration of degraded streams top the list.

Secretary: Cindy D. Zisner is currently Secretary, Chair of the Education Committee, and Editor of the Newsletter for the Council, and has been a member since the Council began in 1986. She holds a B.S. in Bioagricultural Sciences and a M.S. in Botany, both from Arizona State University. Cindy is employed at the Global Institute of Sustainability (formerly the Center for Environmental Studies) at Arizona State University. She represents the Council at environmental education fairs throughout the state and also maintains the Council listserve and website.

Treasurer: Cory Helton has a B.S. in Biology and a M.S. in Environmental Engineering both from Northern Arizona University. His experiences relating to riparian issues come primarily from his involvement with JE Fuller Hydrology and Geomorphology, Inc, and the Rocky Mountain Research Station. He has been a member of the Arizona Riparian Council for two years.

NOTEWORTHY PUBLICATIONS

Elizabeth Ridgely
Gila River Indian Community, Pima-Maricopa Irrigation Project

Williams, C. A., and D. J. Cooper. 2005. Mechanisms of riparian cottonwood decline along regulated rivers. *Ecosystems* 8:382-3958.

Little is known about the physiological and structural adjustments of riparian forests subject to modified flow regimes. For this reason a paired river study was conducted for hydrology, water relations, and forest structure in cottonwood floodplains were compared between the regulated (by dams) Green River and the unregulated Yampa River in northwestern Colorado. Floodplain groundwater levels, soil water availability, cottonwood xylem pressure and leaf-level stomatal conductance were measured. A flood was simulated on a former floodplain of the regulated river. It was nearly identical to the predam mean annual peak. Canopy, root structure, leaf area, and percent live canopy and root density biomass were assessed for cottonwood.

Although there were differences in water availability, daily and seasonal trends in xylem pressure and leaf-level stomatal conductance were similar for cottonwoods at both rivers. Soil water added with the experimental flood had little effect on cottonwood water relations. The regulated Green River had lower stand leaf area, root densities, and root biomass compared with the unregulated Yampa River cottonwoods. Little cottonwood recruitment occurred during the postdam years and the riparian forests were not being replaced. Aerial photos showed that the predam forests supported a greater leaf area and a higher tree density.

The conclusions were that water relations at the leaf and stem level were similar for both rivers' trees due to structural adjustments of cottonwood forests along the regulated river. Cottonwoods sustained a reduction in above-and belowground biomass. The lower root density and fine root biomass, as well as reduced canopy area and a larger number of dead branches for regulated cottonwoods were structural and functional adjustments and adaptations that were thought to occur in response to decreased peak flows and lower saturated zone soil water availability in the form of a regulated river.

Hart, S. C. and A. C. DiSalvo. 2005. Net primary productivity of a western montane riparian forest: Potential influence of stream flow diversion. *Madroño* 52:79-90.

Riparian ecosystems are among the most heavily disturbed ecosystems in the western U.S. and they have been reduced in area by 80% since Euro-American settlement. The value of these areas is disproportionate to their areal extent. Many montane riparian ecosystems have been negatively impacted by hydroelectric plants diverting water away from natural stream channels to facilitate power generation.

The most fundamental characteristic of an ecosystem is net primary productivity (NPP) because all biological activity, including those of humans, is dependent on this process. It is one of the key attributes in assessing the integrity or health of an ecosystem.

A hypothesis was formulated that NPP would be higher at sites with higher stream flows. It would follow that these higher stream flow sites would have concomitantly higher soil carbon and nitrogen pools and rates of soil respiration than sites with lower stream flows.

Above- and belowground NPP were measured and estimated using the following components. Dataloggers recorded microclimatic figures. Daily mean soil temperatures, mean daily air temperature, relative humidity, and soil volumetric water content were measured. Forest floor mass per unit area (areal density) was estimated. Mean daily stream flows were obtained upstream of the study sites. Aboveground net primary production (ANPP) was estimated as the sum of increases in aboveground standing crop of vegetation and litterfall. A relationship between the basal area increment (BAI) per tree and stem basal diameter (DBA) was derived to estimate tree growth for individuals not measured directly. Leaf area index (LAI) was measured because it frequently correlates with NPP in many forest types and it is sensitive to structural changes that result from stream flow reduction.

Soil samples were analyzed for total carbon and nitrogen. Soil respiration was measured in terms of carbon dioxide concentrations to determine total growing season respiration. Belowground net primary productivity (BNPP) was estimated from belowground carbon allocation (BCA). The conclusion for these elements was that riparian forests exhibit greater variation in carbon allocation than has been found for upland forests.

Median air and soil temperatures were significantly higher at the high flow site. Median relative humidity was lower. Total understory productivity of herbaceous species and shrubs was 2.5 times higher at the high-flow site than at the low-flow site. Annual litterfall at the high-flow site was

(Cont. Noteworthy . . . . . pg. 10)

LEGAL ISSUES OF CONCERN

*Richard Tiburcio Campbell, U.S. Environmental Protection Agency**

THE CASE TO WATCH FOR 2006

**The viewpoints expressed in this article do not necessarily represent the viewpoints of the EPA.*

In 2001, the Supreme Court decided *Solid Waste Agency of Northern Cook County v. The U.S. Army Corps of Engineers (SWANCC)*,[1] holding that the Corps of Engineers (Corps) did not have the authority to regulate "isolated waters" (in this case, wetlands in a gravel mine) under the federal Clean Water Act (CWA) solely on the basis that they are used by migratory birds.[2] Since 2001, industry groups have initiated several lawsuits throughout the Nation in an attempt to expand the holding in *SWANCC* to remove not only isolated wetlands but also other water bodies, e.g., tributaries and adjacent wetlands, which are not themselves "navigable in fact" from Corps jurisdiction under the CWA. These lawsuits have been rejected in every jurisdiction,[3] save perhaps one (the Fifth Circuit Court of Appeals in cases out of Texas and Louisiana involving oil spills[4]). However, one case has finally made it to the Supreme Court. On February 21, 2006, the Court is scheduled to hear oral arguments in the consolidated case *Carabell, et al. v. U.S. Army Corps of Engineers, et al.*[5] and *Rapanos, et al. v. United States*[6] (hereinafter referred to together as the *Carabell* case). The legal issues in *Carabell* are twofold:

1. Whether the Corps acted reasonably in interpreting the term "waters of the United States" as it appears in the CWA, 33 U.S.C. 1362(7), to encompass a wetland area that is separated from a tributary of a traditional navigable water by a narrow manmade berm, where evidence in the record reflected the presence of at least an occasional hydrologic connection between the wet land and the adjacent tributary.
2. Whether the application of the CWA to the wet land at issue in this case is a permissible exercise of Congressional authority under the Commerce Clause.[7]

In the hopes of a broad holding in their favor by the Court, several industry groups and homebuilders, including the Home Builders Association of Central Arizona, Pulte Homes, and Centex Homes, have filed *amicus*[8] briefs with the Court, citing their experiences in Arizona, and the Corps' jurisdiction over ephemeral and intermittent washes in this State, as examples of what they characterize as "far reaching agency assertions of federal geographic jurisdiction."[9, 10] Environmentalists and groups

1 531 U.S. 159 (2001).

2 A discussion of the *SWANCC* decision may be found in the *Arizona Riparian Council Newsletter* Vol. 14, No. 2 (2001), *http://azriparian.asu.edu/newsletters/Vol14No22001.pdf*

3 *See, e.g., Headwaters v. Talent Irrigation District*, 243 F.3d 526 (9th Cir. 2001).

4 *Rice v. Harken Exploration Co.*, 250 F.3d 264 (5th Cir. 2001), and *In re Needham*, 354 F.3d 340 (2003).

5 391 F.3d 704 (6th Cir. 2004), *cert. granted*, 126 S. Ct. 415 (2005).

6 376 F.2d 629 (6th Cir. 2004), *cert. granted*, 126 S. Ct. 414 (2005).

7 Brief of Respondents (Corps and EPA) in Opposition to Petition for a Writ of Certiorari (June 2005). See *http://www.usdoj.gov/osg/briefs/2004/0responses/2004-1384.resp.html*

8 "Amicus curiae" is Latin for "friend of the court" or "one who gives information to the court on some matter of law which is in doubt." *Barron's Law Dictionary*, 3rd Ed., (1991).

9 Brief of Pulte Homes, Centex Homes, Hovnanian Enterprises, KB Home, Lennar Corporation and MDC Holdings as Amicus Curiae in Support of the Petitioners in *Rapanos v. United States*, 2005 WL 3294920 *2 (Dec. 2, 2005).

10 Brief of Amicus Curiae National Association of Home Builders in Support of the Petitioners in *Rapanos v. United States*, 2005 WL 3294920 *18 (Dec. 2, 2005).

supporting the federal government's position are scheduled to file briefs in response by January 13, 2006. How the Court decides *Carabell* could have significant ramifications in Arizona because the overwhelming majority of watercourses in Arizona that currently fall under the jurisdiction of the CWA are ephemeral and intermittent tributaries to State rivers that are not always navigable, i.e., do not float a boat, e.g., the Hassayampa, and reaches of the Salt, San Pedro, and Santa Cruz. The *Carabell* case will likely be the most important CWA case decided since the *SWANCC* decision in 2001.

(Noteworthy cont. From pg. 8) significantly higher. Soil respiration rates were consistently higher at the high-flow site. All other comparisons were statistically similar.

It was assumed that a shallower rooting distribution of the understory compared to the overstory trees contributed to the lower ANPP of the understory at the high-flow site. In addition, depth to ground water, soil nutrient availability, solar irradiance, stream flows during the growing season, and temperature could have had an influence. These influences were later discounted. The lack of a significant difference in ANPP was thought to be a combined result of a small seasonal difference in stream flows between the sites. Not withstanding, changes in aboveground standing biomass averaged 29% higher at the high-flow site during a decade. Lower ANPP values for arid, high-elevation western riparian ecosystems are probably due to variable stream flow, low and variable precipitation, short growing seasons, low relative humidity, and low water storage capacities and nutrient availability of the poorly developed soils.

The results suggest that NPP of montane riparian ecosystems located along gaining stream reaches is not specifically tied to stream flow. Understory aboveground NPP may be the most sensitive productivity measure, and therefore important, indicator of altered stream flow. Finally, the results suggested that the only productivity measure likely to provide a sensitive, cost-effective index for evaluating the effect of stream flow diversion on western montane riparian areas is understory ANPP.

Wiesenborn, W.D. 2005. Biomass of arthropod trophic levels on *Tamarix ramosissima* (Tamaricaceae) branches. *Environmental Entomology* 34(3):656-653.

Biomass approximates matter and energy available to consumers and provides a common unit for comparing or combining taxa with different body masses. Abundances and body dry biomasses of arthropod taxa on *Tamarix ramosissima* branches in this study were quantified as dry mass per plant dry mass on three trees at each of three sites. Biomass comparisons were for primary-consumer arthropods. The study sites were near surface water at Las Vegas Wash, Nevada.

The biomass of two phytophagous arthropod taxa, *Opsius stactogalous* Fieber and *Chionaspis* spp., made up 97.7% of the total arthropod biomass. (Phytophagous means plant eating or feeding on plants.) Their biomass was positively correlated to the percent water of branches. *O. stactogalous* is a small leafhopper native to Europe and common on naturalized *Tamarix*.

The biomass of *O. stactogalous* was strongly associated with those of its parasites *Polynema saga* (Girault) and *Gonatopus* spp., the predatory Dictynidae, and weakly associated with those of omnivorous *Attalus* spp. and *Formica xerophila* M. Smith. Biomass of *Chionaspis* spp. was only associated with the biomass of predatory *Cybocephalus californicus* Horn. The predatory Salticidae was not associated with any taxon.

Increasing biomass of arthropod primary consumers with increasing water content of *T. ramosissima* branches agreed with the generalization that water concentration in plant tissue favors development of phytophagous insects. However, water content of branches varied between sites due to ground water depth variations.

The relationship between parasitism rate and host density suggests neither parasite species regulates *O. stactogalous* populations. The varied diets of secondary consumers reflected their weak association in that they also ate detritus, fungi, other insects, plant exudates such as nectar, and insect egested honeydew (phloem fluid). In addition, *Formica* sp. have been known to attend and eat leafhoppers.

Prey specificity differed between spider families Dictynidae and Salticidae. A lack of association between the biomass of Salticidae and *O. stactogalous* or *Chionaspis* suggested that these spiders fed indiscriminately.

A low percentage of secondary-consumer biomass and large fluctuations in biomasses of *O. stactogalous* and *Chionaspus* spp. between years suggest populations of phytophagous arthropods on *T. ramosissima* are not regulated by natural enemies. They vary among tree populations and through time. *O. stactogalous* and its secondary consumers provide greater diversity of prey but in the form of a widely fluctuating biomass. *Chionaspus* spp. offer the most biomass, but they are small and support a small biomass of secondary consumer. So they may not be eaten by vertebrates. *T. ramosissima* branches offer vertebrates arthropod prey with low diversity and highly variable biomass, therefore they are not reliable.

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, 2006. Please call or write with suggestions, publications for review, announcements, articles, and/or illustrations.

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CALENDAR

Arizona Riparian Council 20th Annual Meeting, Museum of Northern Arizona, Flagstaff, AZ. April 27-29, 2006. Workshop (limit of 50) on 27th, meeting on 28th, field trip and workshop exercises on 29th. For more information contact Cindy Zisner at Cindy.Zisner@asu.edu or Tom Hildebrandt at tomarc@cox.net.

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 for time and location.

National River Rally 2006, The Mount Washington Hotel & Resort, Bretton Woods, New Hampshire. May 5-9, 2006. For more information, http://www.rivernetwork.org/rally.

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