# Twenty-Third Meeting of the Arizona Riparian Council and Non-Native Plant Identification Workshop

The Lodge at Cliff Castle
Camp Verde, Arizona
April 16-18, 2009

## Who's Invading Our Riparian Space?

Program and Abstracts
2009

# Twenty-Third Annual Meeting
# Arizona Riparian Council
## Who's Invading Our Riparian Space?
### The Lodge at Cliff Castle
### Camp Verde, Arizona
### April 16-18, 2009

## Thursday, April 16th

7:30 - 8:00 ***Registration***

8:00 - 8:15 ***Welcome*** – Kris Randall, Arizona Riparian Council President

8:15 - 9:00 ***The Economics of Invasive Species*** – Dr. Charles Perrings, ecoServices Group, School of Life Sciences, Arizona State University at the Tempe campus

9:00 - 9:30 ***Fixing Broken Ecosystems: Lessons from a Dam Decommissioning and Exotic Fish Removal in Fossil Creek, Arizona*** – Dr. Jane Marks, Department of Biological Sciences, College of Engineering, Forestry, and Natural Sciences, Northern Arizona University

9:30 - 10:00 ***Invasive Plants in Riparian Areas of the Verde Valley*** – Jeff Schalau, Associate Agent, Agriculture and Natural Resources, University of Arizona Cooperative Extension in Yavapai County

10:00 - 10:15 **Break and Poster Viewing**

10:15 - 10:45 ***Tamarisk: Value to Wildlife, Water Use, and Interactions with Native Plants – Implications for Management*** – Dr. Ed Glenn, Environmental Research Lab, Department of Soil, Water and Environmental Science, University of Arizona

10:45 - 11:15 ***Strategies for Dealing with Invasive Species through the Arizona Invasive Species Management Plan*** – Brian McGrew, Arizona Department of Agriculture Member, Arizona Invasive Species Advisory Council

11:15- 11:45 ***Panel Discussion and Audience Q&A***

11:45 - 1:15 ***Lunch***

1:15 - 1:45 ***Business Meeting and Introduction to Technical Session***

1:45 - 2:00 ***The Role of Genetics in Riparian Restoration and Coping with Climate Change*** – Tom Whitham and Alicyn Gitlin, Department of Biological Sciences and the Merriam-Powell Center for Environmental Research, Northern Arizona University

2:00 - 2:15 ***Invasive Salt Cedar is an Agent of Selection in the Native Foundation Species, Fremont Cottonwood*** – Brian Cardall, Steve Shuster, Gery Allan, and Tom Whitham, Department of Biological Sciences Department of Biological Sciences and the Merriam-Powell Center for Environmental Research, Northern Arizona University, Northern Arizona University

2:15 - 2:30 ***Experimental Treatments Indicate Fremont Cottonwood is a Foundation Species that Enhances Performance of Other Plant Species and Increases Arthropod Diversity and Abundance*** - Sharon Ferrier, R.K. Bangert, Alicyn R. Gitlin, L. Hagenauer, K. Kennedy, Tom G. Whitham, and G.J. Allan, Department of Biological Sciences and the Merriam-Powell Center for Environmental Research, Northern Arizona University, Northern Arizona University

2:30 - 2:45 ***Beavers and Bugs: A Mammalian Herbivore Changes Arthropod Communities on*** **Populus fremontii** - Rachel Curmi, Department of Biological Sciences, Northern Arizona University, Northern Arizona University

2:45 - 3:00 ***Break and Poster Viewing***

3:00 - 3:15 ***Geomorphic Response to Land Use Change, Middle Verde River, Arizona*** - Sharon R. Masek Lopez, Water Resources Program, The Hopi Tribe

3:15 - 3:30 ***Weeds and Vegetation: Letting Invasive Plants Join the Community*** - Garry Rogers, Agua Fria Open Space Alliance, Inc.

3:30- 3:45 ***Weed Management to Support Habitat Restoration Efforts in the Riparian Corridor of Picture Canyon along the Rio De Flag, Flagstaff*** - Stephanie Yard, Natural Channel Design; A. Hendricks, Forest Management & Conservation, Arizona State Forestry Division; and J. Davison, Utilities Department, City of Flagstaff

3:45 - 4:00 ***Weed Management Strategy to Support Restoration Efforts along Wet Beaver Creek at the National Park Service Montezuma Well Unit*** - Allen Haden, Natural Channel Design; Dennis Casper, National Park Service - Montezuma Castle/Montezuma Well & Tuzigoot National Monument; and Stephanie Yard, Natural Channel Design

4:00 - 4:15 ***Volunteer Efforts to Remove*** **Arundo donax** ***(Giant Reed) from Sabino Canyon*** - Jim Washburne, Sustainability of semi-Arid Hydrology and Riparian Areas (SAHRA), University of Arizona, and Candice Rupprecht, Water Resources Research Center, University of Arizona

4:15- 4:30 ***Weed Management at White Bridge and Beasley Flats*** - Laura Moser, Coconino National Forest

4:30 - 5:00 Open discussion and overview of workshop

6:00 - 8:00 ***Tamarisk: From Good (and Pretty) to Bad and Ugly*** - Matthew K. Chew, School of Life Sciences, Arizona State University

## Posters (view during breaks)

***Filming the Invasion: Monitoring Invasive Species with Repeat Photography*** - Garry Rogers, Agua Fria Open Space Alliance, Inc.

***Verde Valley Geospatial Database and Hydraulic Model – Verde River, Arizona*** - Rob Ross and Abe Springer, Department of Geology, Northern Arizona University

**Tamarix** ***and Ecosystem Change: Perpetuation of a Mythology*** - Juliet C. Stromberg, Matthew K. Chew, School of Life Sciences, Arizona State University; Pamela L. Nagler, U.S. Geological Survey, Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona; and Edward P. Glenn, Department of Soil, Water and Environmental Science, University of Arizona

***Riparian Forest Change Following Extreme Disturbance: Case Study of San Pedro River, Arizona*** - Juliet C. Stromberg, Melanie G. F. Tluczek, and Andrea F. Hazelton, School of Life Sciences, Arizona State University

# Friday, April 17, 2009
# Non-Native Plant Identification Workshop

**Workshop Instructors:**

**John Brock**, Emeritus Professor, School of Applied Biological Sciences, Arizona State University at the Polytechnic Campus

**Kelly Steele**, Associate Professor, School of Applied Biological Sciences, Arizona State University

**Frances ("Ed") Northam**, Ph.D., Weed Biologist, University of Arizona Cooperative Extension Office

**C. Douglas Green**, Phoenix Chapter President, Arizona Native Plant Society

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**9:00 AM**

***Weed Biology: Society and Politics*** – Ed Northam

***The Native Plant Society and Weeds*** – C. Douglas Green

**Break**

***Weed Biology: The Ecological Traits of Weeds*** – John Brock

***Plant ID Review for Professionals*** – Kelly Steele

**Lunch Buffet**

**Afternoon Session: *Weed Identification by the Numbers***

Each of the workshop leaders will be discussing riparian (mostly) weed taxa identification techniques. This session will also include plant specimens to hone skills. We will also provide information for tomorrow's in-the-field session.

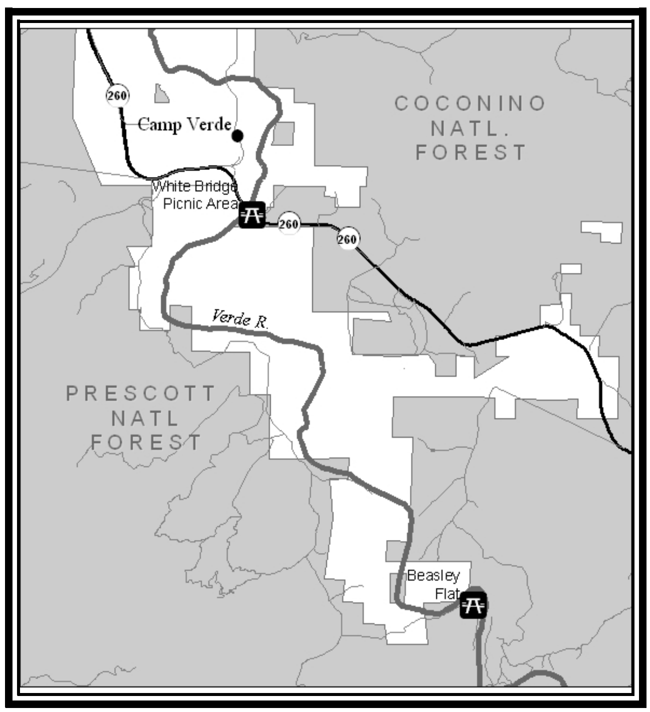
# Saturday, April 18, 2009
# Field Trip

**8:30 AM**

Meet in lobby. A box lunch will be provided. Plan to carpool if necessary and dress appropriately for going in the field. Don't forget water, sunscreen, hat, and shoes that could possibly get wet.

***Weeds In The Field***
A field trip to White Bridge and Beasley Flat for on-the-ground identification practice.

All classroom materials will be provided to workshop attendees. There will be a great field guide available for sale at a discounted price of $20.00.



# ABSTRACTS AND BIOGRAPHIES OF INVITED SPEAKERS

### *The Economics of Invasive Species – Charles Perrings, Professor, ecoServices, School of Life Sciences, Arizona State University*

The costs of invasive species include both direct and indirect effects. Direct effects comprise losses associated with pests and pathogens in agriculture, forestry, fisheries as well as effects on human health. Pimentel et al (2001) concluded that at the close of 20th century invasive species causes annual damage equal to around $60 billion in the USA. The indirect effects have not so far been costed, but introduced pathogens, predators or competitors have been implicated in the loss of native species over a wide range of ecosystems. This in turn affects the capacity of ecosystems to deliver the services that underpin much economic activity, and to absorb anthropogenic and environmental stresses and shocks without losing resilience. Maintenance of functional diversity, in particular, supports the provision of ecosystem services over a range of environmental conditions. To solve the economic problem requires defensive measures to mitigate import risks and to eradicate or control established invasive species. The optimal strategy depends on the relative costs and benefits of the alternatives. The talk will review the ways in which we can go about estimating the costs of invasive species and hence benefits of their removal.

### *Biography*

Charles Perrings was appointed Professor of Environmental Economics at Arizona State University in August 2005. Previous appointments include Professor of Environmental Economics and Environmental Management at the University of York; Professor of Economics at the University of California, Riverside; and Director of the Biodiversity Program of the Beijer Institute, Royal Swedish Academy of Sciences, Stockholm, where he is a Fellow. Between 1995 and 2005 he was editor of the Cambridge University Press journal, *Environment and Development Economics*, and he remains on the editorial board of this and several other journals in environmental, resource and ecological economics, and in conservation ecology. He is Past President of the International Society for Ecological Economics, a society formed to bring together the insights of the ecological and economic sciences to aid understanding and management of environmental problems. In 2008 he won the Kenneth E. Boulding Memorial Award for outstanding contributions to ecological economics. At ASU he directs (with Ann Kinzig) the ecoSERVICES Group within the College of Liberal Arts and Sciences. The Group studies the causes and consequences of change in ecosystem services – the benefits that people derive from the biophysical environment. It contributes to a number of international research projects on issues relating to biodiversity change, conservation and development, and supports training in biodiversity and ecosystem services both within ASU and internationally. It runs the Biodiversity and Ecosystem Services Training Network (BESTNet), a Research Coordination Network funded by the National Science Foundation. Charles Perrings is engaged in a range of activities both to build an international science of biodiversity and ecosystem change, and to better connect the science of biodiversity change with international policy. Through the ecoSERVICES Group, ASU advises the United Nations Environment Program on the policy implications of biodiversity change.

## ***Fixing Broken Ecosystems: Lessons from a Dam Decommissioning and Exotic Fish Removal in Fossil Creek, Arizona** – Jane Marks, Associate Professor, Department of Biological Sciences, College of Engineering, Forestry, and Natural Sciences, Northern Arizona University*

Although billions of dollars have been spent on stream restoration projects in the U.S. in the last 20 years fewer than 10% of projects have accompanying monitoring programs to test if restoration actions are achieving their objectives. Fossil Creek, Arizona is undergoing one of the largest stream restoration programs in the Southwest surrounding a dam decommissioning project. Primary objectives of this restoration were to restore native fish, and rebuild travertine dams. Water was returned to the river in 2005 after nearly a century of diversion. Prior to restoration of flows, exotic fish were removed from approximately 16 kilometers of stream using the chemical antimycin A. We used a Before -After - Control - Impact design to study how native fish respond to exotic fish removal and restoration of flow. Results show that over a 2-year period native fish increased dramatically where both flow was restored and exotic fish were removed. Exotic fish removal caused a large increase in fish densities whereas flow restoration alone caused a more modest but significant increase. Flow restoration where exotic fish remain elicited no response in native fish. A cost benefit analysis revealed a large added value of removing exotic species as part of habitat restoration programs. Travertine dams are also increasing in size and extant in Fossil Creek which may yield increases in primary productivity, nutrient retention, and native fish population densities.

### *Biography*

Through her research program Dr. Marks strives to integrate basic and applied research to understand how freshwater ecosystems are structured and how they respond to environmental disturbances. Her research team works closely with state and federal managers in the United States and Mexico to document how different management strategies affect freshwaters. By capitalizing on restoration projects as large ecological experiments they are testing if habitat restoration and removal of exotic species can revive native food webs and ecosystem processes. Their work in Fossil Creek, Arizona, focuses on a large dam-decommissioning project where they are studying how native and exotic species respond to restoration of flow and removal of exotic fish from one section of stream. This research is important for riparian restoration where managers strive to recreate natural ecosystems that support high levels of biodiversity. In Cuatro Cienegas, Mexico, they are studying how exotic species and water extraction affect native food webs. Finally as part of her sabbatical research program she initiated a project in Spain studying how food web structure and ecosystem processes change with different land-use patterns.

## *Invasive Plants in Riparian Areas of the Verde Valley – Jeff Schalau, Associate Agent, Agriculture and Natural Resources, University of Arizona Cooperative Extension in Yavapai County*

Several non-native, invasive plant species threaten the integrity of riparian areas across Arizona. In the Verde Valley area, the U.S. Forest Service is actively managing riparian invasive species saltcedar which include (*Tamarix ramosissima*), tree of heaven (*Ailanthus altissima*), and giant reed (*Arundo donax*). Pampasgrass (*Cortaderia selloana*), an invasive landscape plant, is also appearing in the Verde River system. Himalaya-berry (*Rubus discolor*), creeping waterprimrose (*Ludwigia* sp.), and Russian olive (*Elaeagnus angustifolia*) are other riparian obligate weeds which are present in these riparian areas. The terrestrial upland weeds: yellow starthistle (*Centaurea solstitialis*), Russian knapweed (*Rhaponticum repens*), Dalmatian toadflax (*Linaria dalmatica*), Siberian elm (*Ulmus pumila*) and hoary cress (*Cardaria draba*) also occur in close proximity to the Verde River. Effective management of these invasive plants requires an integrated approach that includes prevention as well as physical, cultural, biological, and chemical management methods. A brief overview of Arizona's coordinated weed management areas (CWMAs) will also be discussed.

### *Biography*

Jeff Schalau is an Associate Agent, Agriculture and Natural Resources for the University of Arizona Cooperative Extension in Yavapai County, since 1998. He studied Forest Management and Natural Resources at Humboldt State University in Arcata, California. Jeff provides science-based information to Yavapai County residents in the areas of forest health, watershed management, noxious/invasive plants, range management, and horticulture.

## *Tamarisk: Value to Wildlife, Water Use, and Interactions with Native Plants – Implications for Management* – *Edward P. Glenn, Professor, Soil, Water and Environmental Science, University of Arizona*

Tamarisk is the common name for a group of closely related *Tamarix* species and their hybrids that were introduced into the western United States in the 1800s. Tamarisk is both salt- and drought-tolerant and has become widely established on regulated rivers that no longer experience pulse flood regimes. The banks of these rivers and their aquifers have become salinized and water tables have declined. Native mesic trees and shrubs have declined, and Tamarisk and native salt-tolerant shrubs have increased on these rivers. Tamarisk has been regarded as a negative factor in riparian ecology and water relations, but recent research has challenged that viewpoint. Saltcedar provides important bird habitat, especially when it grows in mixed stands with native trees and in the presence of standing water. It has moderate water use, approximately 1 meter per year (50% of potential evapotranspiration) even in dense stands, and native replacement species have equal or greater water use. It does not out-compete native trees; rather, it provides replacement vegetation when river banks become too dry or saline for mesic species. Under favorable conditions, native trees out-compete Tamarisk, growing faster during their establishment year and eventually over-topping Tamarisk due to their greater height. Riparian management programs for regulated rivers should be aimed at maintaining mixed stands of native trees and saltcedar, by providing hydrological conditions that permit the return of native trees to the riverbanks.

***Biography***

Dr. Glenn's research interests include evapotranspiration and ecohydrology of riparian vegetation; phytoremediation and revegetation; arid zone conservation and environmental biology; desert botany; wetland & aquatic plants; seaweed aquaculture; and halophytes and salt tolerance mechanisms.

## *Strategies for Dealing with Invasive Species through the Arizona Invasive Species Management Plan – Brian McGrew, Arizona Department of Agriculture, Noxious Weed Program Coordinator*

Past methods of invasive species prevention and management lacked consistent and effective coordination between state and federal agencies and non-government stakeholders. In some cases efforts have proven to be sporadically effective and resources may have been better utilized. The Arizona Invasive Species Advisory Council (AISAC) was initially created in 2005 by Governor's Executive Order to develop a coordinated, multi-stakeholder approach for addressing invasive species issues in Arizona. In June 2006, recommendations to the Governor included that the AISAC be permanently established and a comprehensive invasive species management plan be developed. Through the cooperation and coordination of members and stakeholders of the Arizona Invasive Species Advisory Council, each with a role and responsibility in protecting Arizona from the economical and ecological impacts of an invasive species, a management plan was developed. This plan will address the critical issues for prevention and management associated with potential and existing invasive species threats. The Arizona Invasive Species Management Plan contains sixty-three recommendations under fifteen objectives. Most of which, focus on broad strategic components of invasive species prevention and management under the general categories of leadership & coordination, research & information management, anticipation & outreach, control & management, and funding. This presentation will demonstrate the process taken to develop the plan and the current steps and future goals of its implementation.

### *Biography*

Brian McGrew serves as coordinator of the Noxious Weed Program for the Arizona Department of Agriculture and is responsible for addressing regulatory issues of plant quarantine pests. Brian is also a staff member and facilitator for the Arizona Invasive Species Advisory Council.

# THURSDAY EVENING DINNER SPEAKER

***Tamarisk: From Good (and Pretty) to Bad and Ugly* – *Matt Chew, Ph.D., Center for Biology and Society, School of Life Sciences, Arizona State University***

Tamarisk has a history as long as history itself, playing a part in Sumerian epics, Egyptian and Persian religions, Greek myths and the pharmacopeia of many Old-World cultures. When and why tamarisks were first brought to North America remains undocumented, but by 1818 a specimen was growing in the Botanical Garden at Harvard College, and a few years later they were offered for sale at a Long Island plant nursery. Attractive, easy to propagate, and both salt and drought tolerant, tamarisks became popular with gardeners, and after the Civil War, Army Engineers planted thousands to stabilize Texas barrier islands. University of Arizona Professor J.J. Thornber and many others extolled the practicality of tamarisks for shade and shelterbelt planting, and the Soil Conservation Service set them out to slow gully erosion. So how, exactly, did this remarkable and adaptable success story transmogrify into a tale of woe? Join us for an appetizing look at the motivations and players behind the original effort to recast tamarisk as a monster.

***Biography***

Matt Chew had his first significant personal encounter with tamarisk along the Gila River west of Phoenix in 1973. He is fascinated by the extent to which scientists have participated in demonizing the plants. Matt is an ecologist and historian at the Arizona State University's (ASU) Center for Biology and Society, where he studies the history and philosophy of conservation biology, specializing in the conceptual structure of invasion biology. He has presented research talks in the US, Canada, Britain, Austria, and South Africa, to be continued later this year in Australia and Denmark. Matt's work has been published in several books, and in journals including *Science*. From 1993-2001 he was Natural Resources Planner for Arizona State Parks, where he coordinated the Streams and Wetlands and (later) Natural Areas programs. More or less concurrently he served on the Arizona Riparian Council's Board as a Member at Large. Matt is married to ASU plant ecologist Julie Stromberg and they live in an old farmhouse in south Phoenix. His talk is based in part on his article "The Monstering of Tamarisk: How Scientists Made a Plant into Problem" recently published in *The Journal of the History of Biology*.

# ABSTRACTS

Abstracts are listed alphabetically by first author.

Cardall, B. L., S. Shuster, G. Allan, and T. Whitham. Department of Biological Sciences, Northern Arizona University, Flagstaff, AZ 86011-5640. ***Invasive Saltcedar (*Tamarix *spp.) Is an Agent of Selection in the Native Foundation Species, Fremont Cottonwood (*Populus fremontii*).***

*Tamarix* is a highly invasive plant and has converted much of the riparian habitat in southwestern North American to a new exotic habitat type. We explored how this invasive shrub acts as an agent of selection favoring native cottonwood (*Populus fremontii*) genotypes that might be better competitors in this altered environment. Our study sites were in unregulated drainages with natural pulse flood hydrology. We tested the hypothesis that genetic diversity in *P. fremontii* is lower in stands heavily infested with *Tamarix* relative to stands that have not yet been invaded. Two major findings emerged: 1) nearby sites vary greatly in the success of *Tamarix* invasion where invasive cover varies from 2% to 42%, and 2) there is up to a three-fold reduction in the number of alleles ($N_a$), allelic richness (A), and unbiased gene diversity ($G_d$) in stands of *P. fremontii* heavily infested with *Tamarix*. These results could be explained by two, non-mutually exclusive hypotheses. First, *Tamarix* is an agent of selection such that most cottonwood genotypes are eliminated with only certain genotypes being able to survive in the presence of this exotic. This finding would suggest that rapid evolution has occurred in response to an invasive species in ~100 years, if it is correct. Second, sites with higher cottonwood genetic diversity are more resistant to invasion. We discuss implications of these findings in relation to community genetics and the extended community phenotype of *P. fremontii*. Ours is among the first studies to find molecular evidence indicating an exotic invasive species influences population structure in a widespread native foundation species.

Curmi, R. Biological Sciences Department, Northern Arizona University, S. Beaver St., Building 21, PO Box 5640, Flagstaff, AZ 86011-5640. ***Beavers and Bugs: A Mammalian Herbivore Changes Arthropod Communities on*** **Populus fremontii.**

To test the hypotheses that the North American beaver, *Castor canadensis*, changes arthropod communities on Fremont cottonwood (*Populus fremontii*) and also induces increased shoot growth as a result of herbivory, I conducted arthropod surveys and measured shoot elongation on trees which had been cut by beavers as well as those which had not. This was done in four riparian areas of northern Arizona. This is important because no known published studies have addressed the effects of a large mammalian herbivore on a diverse arthropod community. I found five major patterns: 1) species and richness did not differ significantly between beaver felled and control trees, 2) species indicator analyses revealed one significant arthropod species indicative of browsed trees and five species (two significant) which were indicators of specific sites, 3) species accumulation curves showed that control trees accumulate species more slowly than browsed trees, 4) differences in arthropod community composition were significant between sites, but not between treatments, and 5) shoot elongation was nearly two times greater on re-sprout than on unbrowsed trees. These findings suggest that, as a result of herbivory, beavers are changing the structure of the arthropod communities on *P. fremontii*, possibly by increasing habitat heterogeneity through the creation of greater architectural diversity and nutrient availability within this foundation tree species. In light of increased management of rivers, in addition to the degradation of riparian environments by overgrazing and invasion by exotic vegetation such as salt cedar (*Tamarix* spp.), the role of beavers in maintaining biodiversity through their long association with native riparian trees such as cottonwood deserves further research and consideration when deciding on restoration, conservation, and management strategies.

Ferrier, S. M., R. K. Bangert, A. R. Gitlin, L. Hagenauer, K. Kennedy, T. G. Whitham, and G. J. Allan. Department of Biological Sciences, Northern Arizona University, PO Box 5640, Flagstaff, AZ 86011-5640.
***Experimental Treatments Indicate Fremont Cottonwood Is a Foundation Species That Enhances Performance of Other Plant Species and Increases Arthropod Diversity and Abundance***.

In an experimental restoration treatment with the goal of creating Southwestern Willow Flycatcher (*Empidonax traillii extimus*) habitat, we tested the effects of plant source population, within-population genetic variation, neighborhood associations, and plant density on plant survivorship, performance, and arthropod colonization. Species, source population, and plant genotype influenced: 1) plant survivorship and performance, and 2) arthropod community composition, richness, abundance, diversity, and evenness. Differences in plant survivorship and performance indicate a genetic component to adaptation to the restoration site. Higher densities of Fremont cottonwood (*Populus fremontii*) were associated with increased Goodding's willow (*Salix gooddingii*) performance and number of coyote willow (*S. exigua*) ramets. Arthropod richness and diversity were higher on Fremont cottonwood than on willows, and increased in treatments with higher cottonwood densities. Community composition, abundance, diversity, and evenness of arthropods on Fremont cottonwoods differed between source populations and genotypes. Arthropod communities on coyote willow differed between treatments with high and low cottonwood densities. We conclude that Fremont cottonwood is a foundation species that drives ecosystem properties, and our work supports the hypothesis that increasing genetic diversity of Fremont cottonwood increases the diversity of its dependent athropod community.

Haden, A.[1], D. Casper[2] and S. Yard, P.E.[1]. [1]Natural Channel Design, Inc., 206 S. Elden St., Flagstaff, AZ 86001; and [2]National Park Service - Montezuma Castle/Montezuma Well & Tuzigoot NM, 527 S. Main Street, Camp Verde, AZ 86322. ***Weed Management Strategy to Support Restoration Efforts along Wet Beaver Creek at the National Park Service Montezuma Well Unit***

The Montezuma Well Unit of the Montezuma Castle National Monument is located along Wet Beaver Creek, a tributary to the Verde River in central Arizona. Restoration activities are being implemented through an Arizona Water Protection Fund grant on 40 acres of altered flood terrace habitat between Wet Beaver Creek and upland areas bounded and delineated by an irrigation ditch that flows from the outlet of Montezuma Well. This area was utilized for agricultural pastures before it was given to the National Park Service. The fallow fields have become infested with a variety of invasive native and non-native weed species. Project objectives are to manage invasive native and non-native plant species to promote native vegetation and habitats; to restore and protect the broadleaf riparian, transitional mesquite bosque, and grassland communities of the flood terrace between riverine and upland desert ecosystems; and, to enhance public educational opportunities for Monument visitors through the restoration of the riparian flood terrace.

A set of 18 target invasive species was compiled based on the experience of National Monument staff. While this list does not include all exotic and/or invasive species it contains those species that are most aggressive and/or difficult to control. The distribution of target species was identified during a series of site surveys. The relative abundance of target species was evaluated by estimating relative abundance in 30 random 1-$m^2$ plots along three, 900-foot long transects late in the 2008 growing season. Data were summarized to determine extent and level of infestation for each field. Russian thistle (*Salsola tragus*) and silverleaf nightshade (*Solanum elaeagnifolium*) were the dominant species in both extent and density.

Successful restoration of the project area will require effective management of the weed species. The weed management plan includes the characterization of non-native and invasive weed species and their distribution, identification of species targeted for treatment, potential management methods, and a strategy for short-term and long-term management. Effective control of invasive weeds is expected to require several treatments during different seasons to treat the diverse community of weeds. Several treatment methods will be required, including mowing, pulling and chemical treatments.

Masek Lopez, S. R. The Hopi Tribe, Water Resources Program, 5200 E. Cortland Blvd., Suite E-100, Flagstaff, AZ 86004. ***Geomorphic Response to Land Use Change, Middle Verde River, Arizona***.

Historic aerial photographs of the Verde Valley from 1968 and 1995/1997 were used in a geographical information system (GIS) study to statistically test the effects of tributary watershed characteristics on the geomorphology of the Verde River in two alluvial reaches at Cottonwood and Middle Verde. Watershed characteristics and geomorphic response variables were mapped using U.S. Geological Survey topographic maps, georeferenced historic aerial photographs, the Arizona Land Resource Information System (ALRIS) streams layer, and Yavapai County GIS layers for roads, building footprints, floodplain and 2-foot contours. A surficial geology map was used to interpret erodibility of watersheds. Sinuosity and area data were calculated in GIS and exported as data tables. Simple linear regression and multiple linear regression analyses were use to analyze relationships between watershed predictor variables and geomorphic response variables.

The surficial geology unit Young Piedmont alluvium (Yp) was found to have the greatest effect on river morphology. There was a positive relationship between fluvially active sediment (Yp) in tributary washes and channel width and scoured bare sediment width at the river. Tributary wash toe slope (gradient within 1.3 miles of river) was positively related to river sinuosity. Ranked percent impervious surface area was negatively related to river sinuosity.

These results were interpreted to mean that sediment discharge from tributary washes can increase the gradient of the river causing widening and straightening of the channel and reduction in sinuosity by meander bend cutoffs. Urbanization along tributary washes with higher than average slope and greater than average occurrence of Yp can cause greater than average changes in river sinuosity, beyond what would have been caused by watershed characteristics and climate variability alone. This is likely due to more rapid runoff, greater stream power in tributary washes, and mobilization of stored sediment in urbanized areas. A recommendation was made to use caution when developing roads and buildings in areas where adjacent tributary washes have slopes greater than 3.2% and a dominance of Young Piedmont alluvium, due to the greater probability of mobilizing stored channel sediment following urbanization.

Rogers, G. F., Ph. D., President, Agua Fria Open Space Alliance, Inc., PO Box 711, Dewey, AZ  86327.
***Filming the Invasion:  Monitoring Invasive Species with Repeat Photography*.** **(POSTER)**

Sequences of photographs of the same scene can be used to monitor changes in many landscape features. The sequences can be used for qualitative and quantitative measures of changes, and they have great value for public education. Properly matched photographs make the temporal process of an invasion apparent to everyone. Repeated photographs are particularly useful for recording and measuring changes in dynamic subjects. Photographs from permanently marked camera stations can be repeated seasonally or annually with minimal investment of time and expense. They provide a wealth of visual information that would be difficult and costly to record by other means.

Any camera and lens system can be used to repeat photographs. Digital systems are the most efficient as much of the metadata is automatically recorded and attached to the image file. The principal requirements for repeated photographs are that the center of the camera lens must be located in the same position as the original, and the aiming point must be the same. When repeating historical photographs the aiming point is marked on the field copy of the original photograph by laying two rulers diagonally from corner to corner and placing an X at the intersection. When new camera stations are being established a target can be used for the aiming point to simplify accurate repetitions. Examples, list of useful information, and a field data form are provided at http://aguafriaopenspace.org.

Rogers, G. F., Ph. D., President, Agua Fria Open Space Alliance, Inc., PO Box 711, Dewey, AZ 86327.
***Weeds and Vegetation: Letting Invasive Plants Join the Community.***

North American Invasive Plant Mapping Standards (IPMS) have been developed by the North American Weed Management Association, and improvements have been suggested; however, the IPMS has yet to be integrated with the U.S. National Vegetation Classification Standard (VCS). Integration would add to the requirements of the IPMS, but would provide benefits. Recommendations for improving the IPMS include enlarged mapping scales that coincidentally match those of most existing plant communities. Integrating these standards would add valuable information to each. The associations formed by groups of similar plant communities are the foundation of the VCS, but they are largely unmapped in the United States. The relationship between disturbance, weeds, and plant communities could be assessed if plant-community information were gathered during weed surveys. Integration would be a conceptually simple matter by adding the 'entity' concept and the 'relevé' method to the IPMS. Application by weed specialists might require additional training, but time requirements in the field would not expand dramatically. The benefits of integration and enhanced plant community-level mapping products would largely go to vegetation ecologists and land-use managers, since the adaptive strategies of invasive species often allow them to occupy disturbed sites at the community level. Weed managers would benefit from integration of these standards if invasion-resistant communities were mapped. In all cases, enhanced knowledge of the association between weeds and plant communities of specific places would be valuable intelligence for all land-use managers.

Ross, R., and A. Springer. Department of Geology, Frier Hall, Knoles Drive, Northern Arizona University, PO Box 4099, Flagstaff, AZ 86011. ***Verde Valley Geospatial Database and Hydraulic Model – Verde River, Arizona.*** **(POSTER)**

The Verde Valley area of central Arizona has a complex system of geology, hydrogeology, riparian habitat, and land/water use. To better understand this system, the Water Advisory Committee of Yavapai County and its Technical Advisory Commission have expressed interest in developing a geospatial database for the area, as well as developing the framework for an in-channel hydraulic model. There are several irrigation ditches along the Verde River, which divert portions of the baseflow, and return unused water to the river channel. In 2009, we are monitoring headgate and return flow with pressure transducers, which deliver stage data for the diverted and returned flow.

This project consists of two phases. The first phase consisted of compiling all known geographic information system (GIS) data about irrigation in the Middle Verde River valley, placing it all into one geospatial database with a common projection system, and editing the information over high resolution aerial orthophotos. The second phase uses these GIS and stage data gathered to create a hydraulic in-channel flow model over a set river reach, encompassing four major irrigation ditches.

We have selected Watershed Modeling System (WMS) software to use as an interface with the Army Corps of Engineer's Hydrologic Engineering Center River Analysis System (HEC-RAS) to create this hydraulic model. WMS facilitates the use of point-specific discharge/recharge data, as well as the ability to tie the surface hydraulic model into regional groundwater models, such as that of the USGS. LiDAR data are being used to create an elevation model to serve as the model framework, and detailed channel surveying is being done to provide detailed cross sectional information for input into WMS/HEC-RAS.

Stromberg, J. C.[1], M. G. F. Tluczek[2], and A. F. Hazelton[1]. [1]School of Life Sciences, Arizona State University, PO Box 874501, Tempe AZ 85287-4501; and [2]Applied Biological Sciences, Arizona State University-Polytechnic, Mesa AZ 85212. ***Riparian Forest Change Following Extreme Disturbance: Case Study of San Pedro River, Arizona.*** **(POSTER)**

Extreme flood events can shape riparian vegetation patterns for decades. Near the turn of the 19th century in southern Arizona, intense floods triggered downcutting of the Upper San Pedro River and substantially altered hydro-geomorphology. Formerly abundant marshlands were largely replaced by pioneer riparian trees which began to establish in the widening floodplain in the early 1900s. These forests now are valued by stakeholders and are the target of conservation efforts. Our goal was to better understand the magnitude and causes of variability in the spatio-temporal patterns of forest development along this semiarid region river. To this end, we quantified recent (1955 to 2003) change in vegetation over a 100-km length of the river. Using a time-series of aerial photographs, seven cover types were mapped within three geomorphic zones. Since 1955, the channel has narrowed and wooded cover on the floodplain has increased by over 150%. The increase at the southern end of the river, where stream flows are largely perennial, is a result of *Populus/Salix* forest expansion; the increase in the drier northern sector largely reflects expansion of drought-tolerant *Tamarix*. Trees have established episodically during periods with favorable flow conditions for recruitment. We interpret the expansion of these pioneer forests to be part of a long-term, biogeomorphic response to historic river entrenchment, with the temporal pattern shaped by climatic cycles and the spatial pattern shaped by anthropogenic water withdrawals and associated water availability gradients. Other cases of progressive expansion of pioneer riparian trees following extreme disturbance exist on western North American rivers, suggesting that long-term fluctuations in pioneer forest area are the norm in dryland regions. Vegetation changes on the pre-entrenchment surfaces (river terraces) differ from those in the active floodplain. On these surfaces, hydrogeomorphic changes including increased depth to water table have contributed to expansion of deep-rooted *Prosopis* woodlands, and agricultural land conversion has contributed to sharp declines in riparian *Sporobolus* grasslands. Overall, the study indicates that riparian vegetation patterns are a product both of recent cultural and natural phenomena and of past extreme events that set in motion long-term trajectories of change.

Stromberg, J. C.[1], M. K. Chew[1], P. L. Nagler[2], and E. P. Glenn[3]. [1]School of Life Sciences, Arizona State University, PO Box 874501, Tempe AZ 85287-4501; [2]U.S. Geological Survey, Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson AZ 85721; and [3]University of Arizona, Soil, Water and Environmental Science, Tucson AZ 85706. **Tamarix *and Ecosystem Change: Perpetuation of a Mythology.***

Scientific research papers and review articles are an important avenue for conveying information to resource managers regarding ways in which introduced species modify ecosystems. The biases of the authors can shape the message that is conveyed. Our objective was to assess ways in which scientists have contributed to perceptions of *Tamarix*, an introduced plant species that is now abundant in western USA. Originally introduced to western USA to provide ecosystem services such as erosion control, *Tamarix* by the mid 1900s had became vilified as a profligate waster of water. This large shrub continues to be indicted for various presumed environmental and economic costs, and millions of dollars are expended on its eradication. To accomplish our objective, we conducted a qualitative review of published research on *Tamarix*, focusing on review articles. Our review indicates that scientists have played a key role in driving changes in perceptions of *Tamarix* from valuable import to vilified invader, and (in some instances) back to a productive member of riparian plant communities. Over the years many scientists have sustained a negative perception of *Tamarix* by, among other things, 1) citing outdated or anecdotal sources or otherwise citing sources inappropriately, 2) inferring causation from correlative studies, 3) applying conclusions beyond the domain of the original studies, and 4) emphasizing findings that present the species as an extreme or unnatural agent of change. As a result of these actions, a mythology has propagated indicating that *Tamarix* evapotranspires more water than other woody riparian species, routinely salinizes habitats, consistently provides inferior habitat for migratory songbirds including the endangered southwestern willow flycatcher (*Empidonax traillii extimus*), and sustains little to no biodiversity. Recent research is challenging the prevailing dogma regarding *Tamarix*'s role in ecosystem function and habitat degradation, and many scientists now recommend management shifts from "pest plant" eradication to systemic, process-based restoration.

Washburne, J.[1], and C. Rupprecht[2]. [1]SAHRA, The University of Arizona, POB 210158b, Tucson, AZ 85721; and [2]Water Resources Research Center, 350 N. Campbell, Tucson, AZ 85719. ***Volunteer Efforts to Remove Arundo donax (Giant Reed) from Sabino Canyon.***

Floods and debris flows in July of 2006 removed significant riparian vegetation and dispersed rhizomes from *Arundo donax*, which had been slowly moving up-stream for 20 years. Suddenly, *Arundo* was everywhere. Without prompt action, this highly invasive plant was posed to radically change the character of the canyon forever. Through the dedicated efforts of many individuals and organizations, the spread of *Arundo* has been checked and progress is being made on the tough job of cutting down and digging out rhizomes from the larger stands. Community buyin to this effort has been great and volunteers have contributed over 2,000 hours during 11 public participation days to help remove almost 900 bundles of canes and 600 40-lb bags of rhizomes. This effort has been coordinated by a partnership between Sabino Canyon Volunteer Naturalists (SCVN), Master Watershed Stewards (MWS), Arizona Rivers, and Tucson Audubon working closely with the U.S. Forest Service and Friends of Sabino Canyon. Several factors, besides personal enthusiasm, have come together to make this effort successful. The fact that the USFS recognizes *Arundo* as a local invasive species has allowed them to fully support this effort and supervise follow-up applications of an herbicide (glyphosate/Rodeo). An early donation from Friends of Sabino Canyon allowed us to buy gloves and tools for groups of up to 50 volunteers. Volunteers with SCVN have worked tirelessly to help organize, publicize and serve as team leaders for much of the last season. Significant coordination, expertise and other resources have been provided by MWS, Tucson Audubon and Arizona Rivers. Finally, we hope to track the effectiveness of this effort through a GIS database of plant locations created by MWS volunteers. None of this would have been possible without all of these resources coming together and working smoothly as a team. Challenges for the next work season, which starts in October, include: maintaining enthusiasm in the face of some re-growth, tackling more remote or difficult to access stands, coordinating with related efforts off-site and maintaining public participation and education. Please read more about this effort at: www.sahra.arizona.edu/education2/arundo/.

Whitham, T., and A. Gitlin. Department of Biological Sciences and the Merriam-Powell Center for Environmental Research, Northern Arizona University, Flagstaff, AZ 86011. ***The Role of Genetics in Riparian Restoration and Coping With Climate Change.***

Climate change in the American Southwest is among the greatest in North America and poses severe challenges for maintaining and restoring riparian habitats. Here I review the observed and predicted patterns of climate change and how these impacts are likely to affect riparian restoration in Arizona. Common garden studies with cottonwoods and willows demonstrate strong genetic and source population effects on survival and performance. Importantly, the genotypes that performed best in the past may not do well under future climatic conditions. Our findings argue that it is important to apply a genetics-based approach in restoration that takes advantage of provenance trials to identify which genotypes and source populations have the highest probability of surviving future conditions. Such trials can be incorporated into restoration plantings with relatively little additional cost and can also be used to identify superior genotypes that perform best with exotics.

Yard, S, P.E.[1], A. Hendricks[2], and J. Davison[3]. [1]Natural Channel Design, Inc., 206 S. Elden St., Flagstaff, AZ 86001; [2]Forest Management & Conservation, Arizona State Forestry Division, 3650 Lake Mary Road, Flagstaff, AZ 86001; [3]City of Flagstaff - Utilities Department, 211 W. Aspen Ave, Flagstaff, AZ 86001. ***Weed Management to Support Habitat Restoration Efforts in the Riparian Corridor of Picture Canyon along the Rio De Flag, Flagstaff.***

The Rio de Flag is the primary watercourse winding through Flagstaff, Arizona. Picture Canyon project area is located on City of Flagstaff and Arizona State Trust Lands along the Rio de Flag east of Flagstaff. In the project area the stream runs through a narrow basalt canyon and supports a wetland plant community watered by effluent discharges from the City of Flagstaff's Wildcat Hill Wastewater Treatment Plant. The canyon itself is culturally significant and provides pristine habitat for many species reliant on water. It is highly valued for recreation due to its proximity to the Arizona Trail and the presence of an uncommon northern Arizona riparian ecosystem.

Sometime in the past, the stream channel below the canyon was straightened and channelized removing a number of natural meanders. The channelized section has no access to an adjacent floodplain and supports a very limited riparian plant community. Existing vegetation primarily consists of patches of bulrush (*Scirpus* spp.) in the channel proper. Noxious weeds, such as Scotch cottonthistle (*Onopordum acanthium*), yellow starthistle (*Centaurea solstitialis* L.), diffuse knapweed (*C. diffusa*), Russian thistle (*Salsola tragus*), and horehound (*Marrubium vulgare*) have invaded the site due to soil disturbance from trenching activities as well as stream flow transport.

With the assistance of a grant from the Arizona Water Protection Fund, restoration activities will focus on managing noxious weed; restoring channel meander and floodplain function; restoring native riparian and wetland plant communities; increasing plant species diversity; creating additional wetland habitats; improving water quality; increasing wildlife habitat; and providing recreation and aesthetic benefits.

The project area has been extensively mapped for weed distribution by a team of volunteers from the City of Flagstaff, Arizona State Forestry Division, Coconino County, Coconino National Forest, Arizona Game and Fish Department, Coconino Natural Resource Conservation District, Northern Arizona University, and Northern Arizona Audubon Society. Sixteen target invasive species were identified and treatment strategies developed.

Management methods include prevention of the spread of weeds, suppression of new infestations, physical control methods such as pulling and mowing, seeding with competitive vegetation, prescribed burning, and the use of herbicides for weed control. The integrated weed management strategy will incorporate active methods such as herbicides and mechanical removal to provide short-term management and the establishment of competing vegetation as a long-term strategy.