Arizona Riparian Council

Volume 22, No. 3 **December 2009**

GENETIC DIVERSITY OF COTTONWOOD (*POPULUS* SP.) BEFORE, DURING, AND AFTER ESTABLISHMENT OF *TAMARIX*

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***Note**: At the Arizona Riparian Council Spring 2009 Meeting, it was made known that the newsletter occasionally highlights the works of graduate students. Brian Cardall and Alicyn Gitlin are the first since that meeting to commit to this endeavor. We hope to do justice to Brian's intent and his work. Below we present a small subset of the research Brian and Alicyn discussed; he was working on so many projects that they won't all fit here!*

INTRODUCTION

Tamarix as a Codominant Riparian Tree

The introduced shrub *Tamarix* (common names tamarisk, saltcedar; a complex of *Tamarix* species and their hybrids (Gaskin and Schaal 2002) often becomes dominant in bottomland terraces, where it has been documented to increase fire frequency, aggrade floodplains, alter soil chemistry, increase shading, decrease mycorrhizal availability, change aquatic leaf litter dynamics, and to support communities dominated by generalists and lacking native specialists, even when hydrologic regime is kept constant (Busch 1995, Bailey et al. 2001, Titus et al. 2002, Kennedy and Hobbie 2004, Yard et al. 2004, Beauchamp et al. 2005, Nagler et al. 2005, Birken and Cooper 2006, Blinn and Ruiter 2006, Ladenburger et al. 2006, Ulery and Rosel 2006, Zhaoyong et al. 2006, Going and Dudley 2007, Brand et al. 2008, Durst et al. 2008, Moline and Poff 2008, Pollen-Bankhead et al. 2009, Siemion 2008, Tepedino et al. 2008). Altering water availability and flood regimes may suppress *Tamarix* and encourage native dominant tree growth (Stromberg 2001, Rood et al. 2005, Glenn et al. 2008). However, *Tamarix* and native trees both germinate during spring flood pulses, and managed flows often lead to *Tamarix* resurgence and co-dominance (Stromberg 1998, Stevens et al. 2001, Sher et al. 2002, Tallent-Halsell and Walker 2002, Cooper et al. 2003, Bhattacharjee et al. 2006, Mortenson et al. 2008). Also, managing flow is only possible in locations with upstream flow control structures, while *Tamarix* dominance does occur on uncontrolled rivers, even with perennial flow (Stromberg 1998, Cooper et al. 2003, Kennedy and Hobbie 2004, Whiteman 2005, Birken and Cooper 2006).

There is evidence that *Tamarix* alters floodplain conditions in ways that impact native riparian trees. *Tamarix* inhibits cottonwood (*Populus* spp.) germination by altering soil chemistry through an interaction with the introduced leafhopper *Opsius stactogalus*, one of the most common arthropods on *Tamarix* (Wiesenborn 2005, Siemion 2008). In certain climatic conditions, *Tamarix* increases surface salinity, which can also decrease cottonwood germination (Shafroth et al. 1995, Rowland et al. 2004, Ladenburger et al. 2006, Ulery and Rosel 2006, Siemion 2008).

Once established, *Tamarix* persists during dry periods that

Cont. pg. 3 .... *Tamarix*

Inside This Issue

President's Message

Happy holidays. This time of year there is so much to plan and do; presents to buy, greeting cards to send, festivities to attend, and so much more. The ARC Board has been busy too. We have begun planning for our next annual meeting. We came up with the idea of focusing on restoration of riparian and marshland habitats in Yuma, as well as southwestern Arizona, Mexico, and California. As you will recall ARC had an annual meeting in Yuma in 1998 where the meeting focused on the Multi Species Conservation Plan for the Lower Colorado River. Our 2010 meeting will be March 18-20 and details on the location are still being worked on. I encourage everyone to save that date and plan on attending the meeting. Our plenary session will feature speakers who are doing or have done restoration projects and they will discuss some of the issues they faced in implementing their projects. They will share some of their valuable lessons learned.

As part of the meeting we will have an all-day workshop on marshland habitats, their function and wildlife that use these valuable areas. There will be a section on marshland bird identification. We are working with Courtney Conway and his group to develop this workshop which should be very interesting and informative. On Saturday, there will be a field trip where we will go to two or three marshland habitats in the Yuma area. We will look at restoration projects and see numerous wetland birds such as the yellow-headed blackbird, least bittern, along with the usual suspects of sandpipers, stilts, and ducks. More details of the meeting will be developed and posted to the ARC listserve. Stay tuned and mark your calendars for March 18 - 20, 2010! That's only three months away.

I would like to bring everyone's attention to the document you are currently reading – the ARC newsletter. Quality, informative, timely articles have been the norm for the newsletter and I would like to extend my appreciation to Cindy Zisner who has worked to make the newsletter an outstanding publication. Serving as the editor for many years, Cindy has been able to get people to submit articles that discuss riparian areas or issues pertinent to Arizona which our members appreciate reading not only for valuable content but also for enjoyment. Cindy wants to start stepping down from this job. ARC is looking for one or more people who would like to volunteer and take on this very important job.

As the editor, you would have the opportunity to identify what issues are currently important to the riparian areas in Arizona as well as the Southwest and then work with the people who are dealing with those issues and help them tell their story. If you want to be at the forefront of riparian issues, this is your opportunity. Please contact me or Cindy and we can tell you more. The ARC needs you. Arizona's riparian areas need you too.

I hope you have a happy, safe and joyous holiday season and I look forward to seeing you at the annual meeting in March. Happy New Year!

Kris

Kris Randall, President

Tamarix. . . . . **from pg.** 1

kill codominant native woody species and on sites outside the active floodplain (Cleverly et al. 1997, Gitlin et al. 2006). In upper terraces, where vegetation might otherwise succeed to dryland or upland vegetation that uses less water (Scott et al. 2009), *Tamarix* can persist indefinitely and increase cover, despite its inability to propagate without flooding (Cleverly et al. 1997, Stromberg 1998, Birken and Cooper 2006, Sexton et al. 2006). Along river margins, *Tamarix* colonizes bare ground after any flood pulse and expands during dry periods (Stevens et al. 2001, Cooper et al. 2003, Birken and Cooper 2006).

It is unclear whether *Tamarix* impacts water availability for other riparian trees, or if it merely occupies drier locations. Although removing *Tamarix* has not been linked to a decrease in depth to groundwater, it does lessen diurnal fluctuations in groundwater depth, which might benefit adjacent trees (Dahm et al. 2003, Martinet et al. 2005). The removal of *Tamarix* surrounding Goodding willow (*Salix gooddingii* Ball) caused decreased water stress and increased growth of willows (Busch and Smith 1995), but the duration of this effect is unknown. Increased groundwater salinity near the Colorado River has been attributed to *Tamarix* water consumption (Nagler et al. 2008), which could exacerbate cottonwood drought stress (Rowland et al. 2004, Pataki et al. 2005).

Cottonwoods are a Foundation Species

Several studies have identified cottonwoods as contributing disproportionately to species richness and driving a diverse array of ecosystem processes (e.g., Carothers et al. 1974, Hunter et al. 1987, Farley et al. 1994, Ellis 1995, Bailey et al. 2001, Schweitzer et al. 2004, Wimp et al. 2004, Smith et al. 2006, Wimp et al. 2007, Bangert et al. 2008, Brand et al. 2008, Durst et al. 2008, Hinojosa-Huerta et al. 2008, Sabo et al. 2008, Whitham et al. 2008). This has been observed in the wild and experimentally. In experimental restoration sites along the lower Colorado River created to enhance Southwestern Willow Flycatcher (*Empidonax traillii extimus*) habitat, higher cottonwood densities not only supported richer and more diverse arthropod communities, they also increased the growth of Goodding's willow, the number of coyote willow (*S. exigua* Nutt.) ramets, and caused the arthropod community of adjacent plants to differ from sites with less cottonwood (S. Ferrier, in prep.). We do not mean to imply that cottonwoods are the only dominant tree with disproportionate effects on ecosystems. For example, many migrant bird species rely exclusively on honey mesquite phenology (*Prosopis glandulosa* Torr.) to cue stopover locations along the lower Colorado River (McGrath et al. 2009). We focus on cottonwood-*Tamarix* interactions because of the large amount of information accumulated through various research groups groups, including ecohydrology, genetics, community ecology, demographics, chemistry, and nutrient cycling.

Although mature cottonwood forests are essential for several species, especially timber specialists (Farley et al. 1994, Ellis 1995, Rumble and Gobeille 2004), even a few cottonwoods (or other native trees) present in a *Tamarix*-dominated plant assemblage can greatly increase its habitat value (van Riper III et al. 2008). Cottonwoods create structural diversity (Scott et al. 2003, Bangert et al. 2008, van Riper III et al. 2008), provide links between groundwater and terrestrial food webs (Sabo et al. 2008), create a stable and climatically resilient terrestrial food web base (Smith et al. 2006, Wimp et al. 2007, Durst et al. 2008), control nutrient cycling (Schweitzer et al. 2004), and influence growth and survival of surrounding native plants (S. Ferrier, in prep.).

The expenses and difficulties associated with removing *Tamarix* from some areas has led to the suggestion that native tree species be planted into some *Tamarix*-dominated areas without removing the *Tamarix* (Nagler et al. 2008, van Riper III et al. 2008, Dewine and Cooper 2007). Box elder (*Acer negundo* L.) shows promise as a natural suppressant of *Tamarix* (Dewine and Cooper 2007). Other native trees might need to be planted in fire breaks to inhibit fire and drought mortality if stands are intended to reach mature closed-canopy status (Cleverly et al. 1997, Nagler et al. 2005, Gitlin et al. 2006). Due to their habitat value, and because cottonwoods are easy to propagate and grow rapidly, they are commonly planted during riparian habitat restoration projects. The proposition of planting cottonwoods into *Tamarix*-dominated stands raises questions about the tolerances of native trees to altered floodplain conditions.

The Importance of Genetic Diversity

Human activities are reducing the genetic diversity of many forest species through logging practices and development, which also reduces available habitat (Andersen et al. 2007, Schaberg et al. 2008). Yet, tree populations with higher levels of genetic diversity have demonstrated greater resilience to environmental pressures such as climatic extremes and herbivory, including *Tamarix* and cottonwood (Sexton et al. 2002, Gaskin and Schaal 2002, Wimp et al. 2004, Bangert et al. 2008 Friedman et al. 2008). Also, several studies of experimental and natural populations across spatial scales have linked the genetic diversity of dominant plants with increased levels of associated biodiversity (Wimp et al. 2004, Bangert et al. 2008, Whitham et al. 2008), and although we know of some works in progress that have not found such a link, we know of none that have found an inverse correlation. As genetic diversity becomes more depauperate in forest trees, there is less potential for species to adapt in response to natural selection. As a result, dependent communities are likely to become less diverse.

Assisted migration is the act of proactively moving species, from areas where habitat is altered by climate change, to nearby locations that have an appropriate climate regime or are projected to develop an appropriate climate in the near future (Hoegh-Guldberg et al. 2008). Assisted migration has been proposed primarily as a method to maintain viable populations of rare, charismatic, and economically important species. Less attention has been paid to moving common dominant species that provide essential habitat to a suite of species, but are not themselves rare or threatened. This type of assisted migration can aid in the conservation of trees that are adapted to extreme conditions, while increasing resilience to environmental changes and habitat value in restoration sites. Hydrologic change might constrict the habitat of riparian species in a manner similar to climate change.

Project Goals

In light of the above-mentioned issues, we have designed research projects to address the following questions: 1) What are the natural levels of genetic diversity of cottonwood stands in the wild? Since cottonwoods are already being planted during restoration projects, is there a potential or a need for assisted migration at the intraspecific scale, within the geographic range already occupied by this species, to improve the habitat value and sustainability of planted populations?; 2) Has the genetic diversity of cottonwoods decreased in recent history? Is there evidence that natural selection has recently acted on cottonwoods, concurrent with the altered conditions that accompany, and are sometimes caused by, *Tamarix* dominance? Here, we present unpublished results, which at this time are only preliminary, and describe our plans for future studies. Please contact A. Gitlin or my coauthors if you would like to learn more.

Results/Discussion

Natural Levels of Cottonwood Genetic Diversity

Cottonwood genetic diversity varies more across rivers than within them. Genetic analysis of 15 microsatellite loci from cottonwood trees in four rivers (Indian Creek, UT; Little Colorado River, AZ; Dry Beaver Creek, AZ; Hassayampa River, AZ) identified a high level of genetic differentiation between rivers and between the northern, Great Basin Desert Rivers and southern, Sonoran Desert Rivers (Cardall, in prep.). This supports the findings of Friedman et al. (2008), who found a latitudinal gradient in genetic relatedness of cottonwood and a corresponding gradient in temperature adaptation. The Cottonwood Ecology Group at Northern Arizona University is currently engaged in a number of projects to refine our understanding of cottonwood genetic diversity at the river, watershed, and regional scales, and to correlate diversity with environmental factors to determine whether we can increase the survival, habitat values, and climatic resilience of riparian restoration projects. Several studies have found that experimental and wild cottonwood forests with high genetic diversity support greater biodiversity across spatial scales (Wimp et al. 2004, Bangert et al. 2008, Whitham et al. 2008). Experimental cottonwood plantings from different source populations have demonstrated differing levels of survival when placed in a homogenous environment, though the source of the best surviving trees differed when the experiment was repeated a year later – indicating a genetic × environmental interaction (S. Ferrier et al., in prep.).

To address the hypothesis that cottonwood genetics will vary along gradients of stress and environmental diversity, Geographic Information Systems (GIS) are being used to model environmental similarity and vulnerability to climate change in central Arizona (Gitlin, in prep.). Factors such as climate, slope, and flow variability are incorporated into the models. Cottonwood genetics are being sampled between environmentally differentiated areas and along drought vulnerability gradients to determine whether wild populations are structured in a way that reflects their geographic location. For example, trees in drier locations might experience chronic stress and exhibit unique adaptations; trees along rivers with specific flood or temperature regimes might time seed release or the onset of dormancy to coincide with local conditions (e.g., Friedman et al. 2008). Studies in experimental common gardens address questions that will impact restoration success, such as: do flowering and reproductive phenology overlap sufficiently to create sustainable populations, while varying enough to match a range of changing environmental parameters? (Gitlin et al. in prep.).

Evidence for Changes in Genetic Diversity Simultaneous with *Tamarix* Occupation

While some reports predict catastrophic loss of mature closed-canopy cottonwood forests (Haase 1972, Howe and Knopf 1991, Busch and Smith 1995, Andersen et al. 2007), others build a case for cottonwoods experiencing a peak population size previously unseen (Knopf 1986, Webb and Leake 2006), or decadal-scale fluctuations of riparian forest coverage independent of anthropogenic influence (Friedman and Lee 2002). One way to determine if cottonwoods had a higher population size in the past than at present is to test for recent genetic bottlenecks (Tajima 1989). A genetic bottleneck occurs when a population is reduced significantly in size relative to its original size for at least one generation. Bottlenecks can be identified through genetic analyses because the proportion of loci that are heterozygous, i.e., the number of loci that show different combinations of alleles, is higher than expected based upon the total number of possible alleles. As population size decreases, so too does the number of possible allelic combinations. Preliminary tests for genetic bottlenecks on six rivers spanning northern Arizona to northern Utah identify four rivers with significant ($P<0.05$) differences from predicted levels of heterozygosity (BOTTLENECK 1.2.02; <http://www1.montpellier.inra.fr/URLB/bottleneck/bottleneck.html>, accessed August 12, 2009). Two other rivers (Kanab Creek in Utah and the Hassayampa) have less than half of their samples processed, and do not have the statistical power to determine significance yet.

Surveys during the drought years of 2003 and 2004 revealed that increased cottonwood mortality in first- to third-order drainages across the Colorado Plateau and in four parallel Arizona watersheds correlated with *Tamarix* density in the immediately surrounding area (Colorado Plateau, $P<0.0001$; Arizona watersheds, $P=0.0014$) (Gitlin et al. 2006), while temperature, precipitation, flow status, distance to water, and presence of upstream dams did not correlate. As mortality in some sites exceeded 50%, we were led to question whether there were genetic differences between surviving and perishing trees.

The survey of cottonwood genetic diversity at Indian Creek, Little Colorado River, Dry Beaver Creek, and the Hassayampa River was structured to address the question of whether *Tamarix* could be an agent of selection on cottonwood. Along each river, areas of high and low *Tamarix* density were chosen. Twenty cottonwoods were sampled from each site, and the distance to the five closest *Tamarix* shrubs was measured (Fig. 1). Although the data are still be analyzed, preliminary results suggest there is no significant genetic differentiation between areas of high and low tamarisk cover within rivers. However, a different story emerges when individual trees across rivers are analyzed. Across rivers, the levels of genetic variation in cottonwoods occurring closest to *Tamarix*, especially those <~7 m from the nearest five *Tamarix*, are differentiated in a Principal Components Analysis (along an Eigen vector corresponding to the first axis, with <50% of variance explained) (Cardall, in prep.). This indicates that the genetic makeup of cottonwoods most closely associated with *Tamarix* is somehow different from trees in moderate-to-low density stands. There is evidence that some of the microsatellite loci surveyed have experienced positive or negative selection, but further experimentation is needed before it can be determined whether that selection can be attributed to *Tamarix*; we cannot reject other alternative hypotheses such as drought, groundwater depth, herbivory, etc.

There is also preliminary evidence for certain cottonwoods being genetically better adapted to the conditions that accompany, and are sometimes caused by, *Tamarix* dominance. A seed germination experiment revealed higher levels of germination of first-generation (F_1) *P. fremontii* ×*P. angustifolia* hybrids over *P. fremontii* seeds in treatments consistenting of Flagstaff municipal tap water and tap water with a 0.25 M NaCl concentration (Cardall, in prep.). This indicates that some cottonwood genes might enable germination in saline locations, and could indicate a mechanism behind genetic differentiation between cottonwoods growing in sites of unequal salinity along the Rio Grande (Rowland et al. 2004).

Figure 1. Brian Cardall measuring* Tamarix *density on the Little Colorado River. Photo by Anna Schmidt-Cardall.

Summary and Conclusions

It is difficult to place a value judgment on what conditions are optimum for both ecological communities and the human inhabitants surrounding riparian areas. There are several ways that scientists attempt to reconstruct the past, including repeat photography (Hastings and Turner 1965, Webb and Leake 2006, Andersen et al. 2007), dendrochronology and sediment reconstruction (Friedman and Lee 2002, Birken and Cooper 2006), correlating site attributes with vegetation cover (Stromberg 1998, Lite et al. 2005), and genetic surveys (Gaskin and Schaal 2002, Friedman et al. 2008). All of these are problematic to some extent, and yet all influence the decisions we make with regard to river management. As we move into a future of climatic uncertainty and water scarcity, where many of the landscapes most vital as habitat and agriculture have been developed, and even during extreme economic and energy insecurity, we need to find ways to conserve and preserve the ecosystems with which we coexist. The scientific studies presented above are an attempt to improve the efficiency of management actions with regard to river restoration in the Southwest.

Thank you Brian Cardall for inspiration, motivation, and for just plain showing up. Thank you Anna Schmidt-Cardall for encouraging the completion of this article. This material is based upon work supported by Science Foundation Arizona under Grant No. GRF 0001-07.

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BRIAN LAYTON CARDALL

Brian Layton Cardall, 32, left mortality on June 9, 2009. At the time of his death, he was in the midst of doctoral studies in biology, with emphasis on ecological genetics, at Northern Arizona University in Flagstaff, Arizona. He earned BA and Masters degrees from Utah State University, where he met and fell in love with his wife, Anna Marie Schmidt. Brian climbed mountains, painted landscapes, and performed original music with his guitar. His primary focus, though, was his daughter Ava who he loved taking with him as he did his scientific field work. He looked forward to the arrival of a new baby daughter in September. (Bella Aspen was born Sept. 16th, and Mom, baby, and big sis Ava are doing very well.)

His wife Anna remembers Brian this way: "Brian loved his work. He was deeply intrigued by the natural world and was passionately driven everyday to learn more about it. He had the highest integrity to his work that I have ever witnessed in anyone. He knew his contributions to his field were important and unique. He was most passionate about being a father to his precious toddler, Ava Skye. He opened her inquisitive eyes and mind to the world he loved. He is deeply missed. May we all strive to live such an intentional and passionate life."

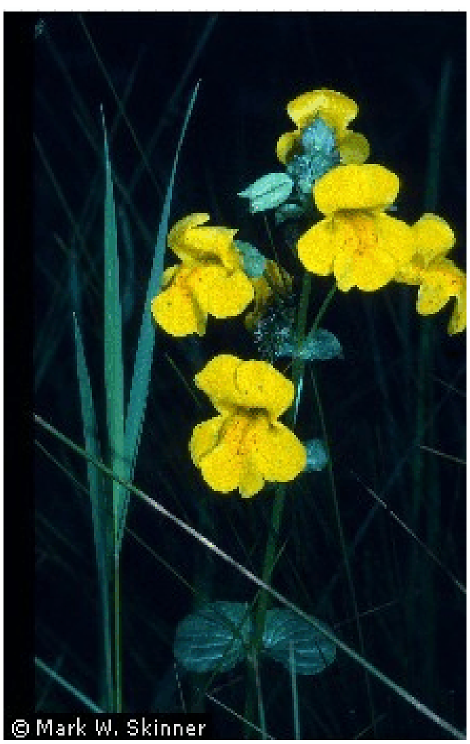
SPECIES PROFILE

SEEP MONKEY FLOWER (*MIMULUS GUTTATUS*)

by Carol Birks, Arizona Department of Water Resources

Springtime is wonderful in the desert. The weather is warm, breezes blow and the landscape comes alive with color, especially along the washes, streams and rivers, thanks to the wide variety of flowers that riparian areas.

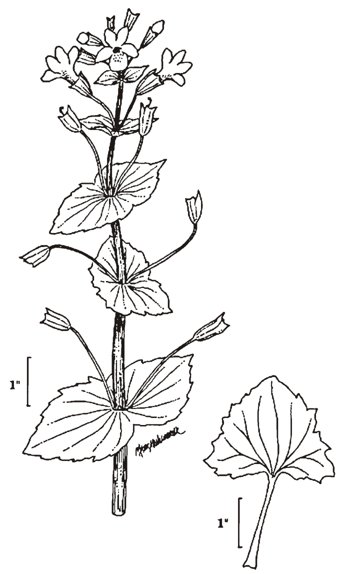
Seep monkey flower (*Mimulus guttatus*) is also called spotted or yellow monkey flower and is a common plant along Arizona's waterways. This member of the Figwort or Scrophulariaceae family is easy to spot in the spring and summer due to its 3-ft height, yellow, two-lipped flowers and bright green leaves. The flowers may have red or maroon spots on the wide, hairy throat of the lower lip petal. The species name, *guttatus* means spotted or speckled. The plant can be either an annual with fibrous roots or a perennial with stout stolons. These prostrating stems creep along the soil surface and spread the plant, just like strawberry runners.



Mimulus guttatus (photo courtesy of Mark W. Skinner).

The brightly colored flowers suggest the plant is pollinated by insects and not the wind. Monkey flower does, indeed, rely on bees and self pollination is prevented by the movement of the flower's stigmas. When a bee enters the flower in search of nectar it first brushes against the two lobed stigma. It immediately folds shut and is pressed against the inside of the flower. The bee next contacts the anthers, takes nectar and withdraws from the flower. No pollen from within the flower touches the closed stigma as the bee leaves the blossom. The bee then carries the pollen to the open stigma of another blossom.

Other animals also utilize this plant. The flowers attract hummingbirds and muskrats, a common inhabitant of riparian areas, will eat the plant throughout the summer. Grazers and browsers, cattle and deer, do eat the monkey flower plant though it is not a favorite food.



Mimulus guttatus (USDA-NRCS PLANTS Database nd).

Western Native American tribes and early settlers had several uses for this plant. A decoction made from boiling the stems and leaves was used in steam baths for back or chest soreness. Monkey flower tea was taken for stomachaches and a poultice was made from the leaves and stems to help heal wounds and burns. The leaves were also eaten raw or cooked even though they are slightly bitter.

The name *Mimulus* comes from a Latin word "mime," a reference to the funny clown face made by the fat flower shape. The common name, monkey flower, is another reference to the funny shape of the flower. Funny or not, seep or yellow monkey flower is a beautiful native plant with some historical significance. Its riparian habitat here in the Southwest is fragile and should be protected so we can continue to enjoy this common flower and all the other forms of life found in these unique areas.

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FRIENDS OF THE RIO DE FLAG RECENTLY FORMED IN FLAGSTAFF, ARIZONA

The Friends of the Rio (Friends) is a coalition of individuals and organizations that support the preservation and restoration of the natural beauty and beneficial functions of the Rio De Flag and its tributaries. The Rio De Flag stream channel is a natural wonder that traverses the length of Flagstaff and through the surrounding community. It enters the city on the north from the Fort Valley area with its watershed originating off the south and west facing slopes of the San Francisco Peaks on the Coconino National Forest Service. The Rio flows through Willow Bend area, the I-40 wetlands, Foxglen Park and the Continental area before leaving the city through Picture Canyon. It then flows through the southwest corner of Doney Park into the Logan's Crossing area in Coconino Co. before joining the Little Colorado River. The Rio flows through Flagstaff in a variety of conditions ranging from totally open natural channel sections to channelized sections in many residential neighborhoods to completely underground sections in various parts of the city. Sections of the Rio have been rerouted from its original course as early as 1892.

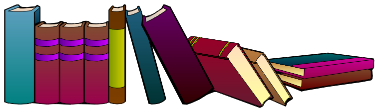
The Friends' mission is to promote the Rio De Flag's natural stream system as a unique and valuable natural resource, an asset, and amenity to the city of Flagstaff and the surrounding community. The goal for the Friends will be to educate, protect, restore, cleanup and improve the Rio De Flag and its tributaries to maximize their beauty, educational, recreational, and natural resource values, including the riparian habitats they provide.

Interests and activities that individuals or organizations can become involved with or support through the Friends of the Rio:

- Public education about rivers, streams, watersheds, riparian areas
- Clean-up and maintenance
- Recreational activities
- Public information services/outreach
- Wildlife observation
- Riparian habitat protection and preservation
- Riparian restoration planning and implementation

Special projects that the Friends support: Picture Canyon, Bonito to Rte 66 Daylight Committee, Logan's Crossing, and Leroux Springs Historic Site.

For more information contact: Friends of the Rio de Flag at k.satterfield@yahoo.com or friendsoftheriodeflag.org



NOTEWORTHY PUBLICATIONS

by Elizabeth Ridgely, Gila River Indian Community

Bentrup, G., and T. Kellerman. 2004. Where should buffers go? Modeling riparian habitat connectivity in northeast Kansas. *Journal of Soil and Water Conservation* 59(5):209-215.

Riparian buffers are being created on agricultural lands to address significant water-quality problems. Society and landowners are demanding many other environmental and social services (e.g., wildlife habitat and income diversification) from this practice. Resource planners therefore need to design these systems in the right places to provide multiple services.

Nationwide, traditional agriculture is probably the largest contributor to the decline of riparian areas. Because some of the most fertile soils are often located in riparian areas, there is often a perceived economic benefit for converting these areas to cropland and consequently many riparian areas have been degraded or eliminated in agricultural regions. Riparian areas are critical landscape features for managing water quality and other related agricultural land issues such as habitat fragmentation and stream bank stabilization. These areas are being targeted for restoration using riparian buffers; plantings designed and managed to achieve specific environmental objectives. When riparian buffers are promoted for use on private lands, these plantings must often accomplish several objectives to encourage landowner acceptance and adoption.

A geographic information system (GIS)-based assessment method was established for quickly identifying where buffers can be placed to restore connectivity of riparian areas for the benefit of terrestrial wildlife. This study presented a potential GIS-based method for analyzing riparian connectivity for wildlife management at spatial scales 2,500 km^2 (2,193 mi^2). An area in northeastern Kansas was selected to evaluate this tool.

In Iowa, researchers found that riparian forests support an average of 506 breeding pairs of birds per 40 ha (99 ac) compared to 339 pairs in upland forests. In addition to providing habitat functions, riparian corridors facilitate species dispersal and movement, which are critical for maintaining viable populations in highly disturbed landscapes. Productivity and survival of terrestrial mildlife species has been shown to be low in narrow riparian corridors due to edge effects like predation and parasitism. However, the overall benefits to wildlife populations appear to outweigh the greater negative impacts of an eradicated riparian area. Research suggests that one of the most effective approaches for riparian restoration in regards to terrestrial wildlife is to protect the remaining habitat patches and to restore structural connectivity in the gaps between these remnant riparian areas. Reestablishing riparian vegetation in these gaps provides critical habitat, restores linkages between patches, and promotes dispersal and gene flow between wildlife populations. These are the crucial factors for maintaining long-term species survival.

The premise for this connectivity is that riparian remnants must be close enough to other riparian patches to facilitate the exchange of individuals. This strategy has been used in upland corridors but has not been applied in riparian areas. Based upon this approach, the goal of this study was to develop a GIS-based method using readily available data for locating where riparian buffers could be implemented to benefit terrestrial wildlife that primarily use riparian areas for habitat and movement corridors. The specific objectives of the study were to: (1) identify riparian remnants; (2) determine where buffers could be implemented to reestablish connectivity between remnants; and (3) identify road barriers to riparian connectivity. The GIS dataset was provided by the USGS National Land Cover Dataset. It includes census, topography, agriculture, soil characteristics and wetland data.

Prior to agricultural development, riparian vegetation in the ecoregion was a mosaic of vegetation types, including woodland, wetlands, and savannah communities. The resulting riparian landscape pattern consists of riparian remnants separated by areas that are cropped to the edge or near-edge of the stream channel. The study utilized a generic minimum patch size of 0.1 ha (0.25 ac) and a dispersal distance threshold of 0.16 km. (525 ft). Each of these was buffered by ½ the dispersal threshold distance. Where the dispersal distances touched or overlapped, the gap was close enough for successful movement between the riparian remnants. Where areas exceeded the connectivity threshold were designated critical gaps that could benefit from being reconnected. It is a conservative minimum based on species reviewed. This approach provides for many species of similar or greater dispersal capabilities. This is a coarse-filter technique. The stream network is a 1:100,000-scale vector dataset from the US Census Bureau's Topologically Integrated Geographic Encoding Referencing (TIGER) Database.

Fixed width buffer distances were used. For example, higher-order streams had wider distances since they typically have a wider floodplain and more spatial extent of riparian vegetation. Barriers to movement of energy and species such as roads were analyzed in terms of how close they were to riparian areas, because proximity can lead to increased mortality unless safe passage is provided under or over the road. Roads that bisected the riparian habitat at a perpendicular angle had less of an impact than those that were parallel.

Species with limited dispersal capabilities were used as indicators for riparian connectivity. Existing habitat and dispersal data were reviewed for several wildlife species that may serve as indicators for riparian connectivity. The species were chosen because (1) they are primarily found in the riparian communities in the ecoregion, (2) generally do not use cropland habitats, (3) have relatively low dispersal capabilities, and (4) are documented to use riparian corridors for dispersal.

To improve connectivity, results indicated that 22% of the perennial stream length in the study area would need riparian buffers. First-order streams showed the greatest distance apart (gaps) perhaps because they are vulnerable to removal, may be intermittent, may flood less frequently, and are less incised. In addition, implementing buffers in short critical gaps may be more efficient if they occur on one piece of property and are away from roads. This approach has been used to select areas for riparian buffers to filter agricultural pollutants from surface water and shallow groundwater flow. However, this type of methodology has limitations in terms of overestimation, and needs to be field-checked. First-order stream (those that are nearest the headwater and with no tributaries, second-order streams are formed by two first-order streams and so forth) analysis will require higher quality land cover data possibly from digital orthophotos. The weighting of the importance of land use needs to be incorporated. This coarse-filter approach appears to be appropriate for large area planning including single or multi-county inventories and can be used singly or in combination with other GIS resource assessments to guide riparian buffer design and implementation for both environmental protection and agricultural production goals.

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 April, the deadline for submittal of articles is March 15, 2010. Please call or write with suggestions, publications for review, announcements, articles, and/or illustrations.

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CALENDAR

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.

Arizona Riparian Council Spring Meeting, ***Wetlands on the Edge: Challenges of Wetland and Riparian Restoration***, March 18-20, 2010, Yuma, AZ. Check http://azriparian.org for updates or contact Cindy.Zisner@asu.edu for more information.