Arizona Riparian Council

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A SYNOPSIS OF "PROPAGULE BANKS AS REFUGIA FOR PLANT DIVERSITY IN SOUTHWESTERN RIPARIAN ECOSYSTEMS"

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In the arid Southwest, site hydrology and flood disturbances exert a strong influence on riparian plant associations. The extreme flood regimes of Southwestern rivers also drive riparian corridor patch dynamics (*sensu* Pickett and White 1985). Large-scale patch dynamics are driven by high-magnitude floods that can scour entire patches. Plant associations present before scour do not necessarily reestablish in the same location as environmental conditions may become more appropriate for other associations. The conversion of vegetation patches occurs fairly rapidly in dynamic low-elevation Southwestern riparian ecosystems (Stromberg et al. 1997).

In unpredictable environments, ruderals, which typically are highly fecund herbaceous annuals or short-lived perennials, tend to be present in large numbers (Menges and Waller 1983, Grime 2001). Indeed, a significant proportion of the plant species in low-elevation Southwestern riparian ecosystems are herbaceous species, primarily ruderals (Wolden et al. 1994, Smith et al. 1998, Bagstad and Stromberg in press, Makings 2003). Most herbaceous species produce persistent seeds and/or vegetative remnants capable of resprouting and comprise the majority of species found in propagule banks (Bazzaz 1996, Thompson 2000). Thus, one would expect to find a significant proportion of the herbaceous species present in low-elevation Southwestern riparian ecosystems to be represented in propagule banks.

Many rivers in the Southwest have been impounded or diverted. When flood regimes are arrested or altered, flow patterns can become out of sync with phenological stages and life cycles of local vegetation (Nilsson et al. 1997, Poff et al. 1997, Patten 1998, Middleton 1999, Shafroth et al. 2002). Many rivers also have been diverted or altered by groundwater pumping. Without a permanent source of water, many riparian species cannot survive. As conditions become less favorable for hydrophytic and mesophytic riparian species, plant associations begin to change as xerophytic riparian and upland species begin to establish (Stromberg et al. 1996). But what of riparian species stored in propagule banks?

The first objective of my dissertation research, under the guidance of Dr. Julie Stromberg (School of Life Sciences, Arizona State University), was to establish baseline information on the role of propagule banks in maintaining plant diversity in riparian ecosystems using the Hassayampa River Preserve (HRP) as a reference site. This information then served as reference data for another low-

(Cont. pg. 3 . . . . . Banks)

Inside This Issue

PRESIDENT'S MESSAGE

It seems like only yesterday that Tom Hildebrandt and I were elected Vice President and President of the Council at the 2002 Spring Meeting in Wickenburg. But at the upcoming 2005 Spring Meeting being held in Parker, the Council will be holding elections for the offices of Vice President and President. I am writing to encourage anyone within the membership who has an interest in shaping the future of the Council to run for one of these positions. It is important for the Council to have fresh faces join the leadership group so that the organization can remain strong and active.

As you may have figured out from above, the term for these offices is three years. And although that may seem like a long time, I can assure you that the time goes by quickly. The Council's Board of Directors generally meets once a month to plan for meetings and conduct Council business. Prior management experience is not required! I was never president of anything prior to running in 2002. The Board works cooperatively to accomplish many tasks and organize events. Although the President and Vice President are in place to provide direction and leadership to the Board, running this organization is definitely a team effort and no one person carries all of the weight. Being an officer of the Council does require a time commitment. I can assure you however, that the commitment is not overwhelming.

I have been associated with the Council for 10 years now. My experience as President has been very rewarding and educational for me and I highly recommend the experience. Tom Hildebrandt plans on running for re-election as Vice President, but I have decided not to run for President this spring. If you would like to know more about the President or Vice President positions, or any other position on the Board of Directors, please feel free to contact me or any Board Member directly. Our contact information is included on the inside back cover of this newsletter. Also, if you know of someone else who may be interested, please discuss this opportunity with them and have them contact us. Finally, if you would like to run, please let any Board Member know as soon as possible so that we can prepare ballots in advance of the meeting.

Jeff Inwood, President

BIOSKETCH FOR TOM HILDEBRANDT FOR ARC VICE PRESIDENT

Tom Hildebrandt is the Regional Wildlife Program Manager for the Arizona Game and Fish Department's Mesa office. Tom has been involved with the Arizona Riparian Council since its earliest days and currently serves as Vice President. Tom was introduced to SW riparian systems through his Master's degree work at Arizona State University (ASU) on Bald Eagles. He continued this interest while serving as crew leader of a riparian inventory team from Dr. Bob Ohmart's lab at ASU, working along the Pecos River in New Mexico. Tom's work with Game and Fish has resulted in significant involvement with the management of properties and habitats along the Gila River west of Phoenix, further intensifying his interest in riparian habitats and issues. Tom wishes to continue his service to the Council as Vice President and he is dedicated to maintaining his active involvement with the issues and opportunities associated with riparian areas in this state.

The Verde River watershed has produced copious runoff so far this winter. Here the Verde River delivers 15,000 cfs at its confluence with the Salt River in this New Year's Day (photo courtesy of Tim Flood).

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elevation Southwestern river, the Agua Fria, which is impounded and diverted. In the Agua Fria riparian corridor, hydromesic riparian species are intermixed with both xerophytic riparian species and those more typical of the Sonoran Desert. For my second objective, I asked, was a riparian legacy still present in Agua Fria propagule banks? My third objective involved experimentation. Results of the HRP propagule bank investigation suggested that propagule bank manipulations could increase diversity in *Prosopis* spp. understories, now dominated by Mediterranean grasses. I designed an experiment to determine if manipulating the propagules bank via soil removal in *Prosopis* spp. forests would decrease Mediterranean grass abundance and increase native plant abundance and species richness.

STUDY SITES AND METHODS

Objective 1

Study sites were selected within a 1-km free-flowing perennial reach at the Hassayampa River Preserve. Three, 100-m^2 sites were selected for study within active channel bar, *Populus-Salix* forests, *Hymenoclea* shrublands, and *Prosopis* spp. forests patch types. Within each site, five, 1-m^2 plots were randomly selected. Herbaceous and woody vegetation surveys were conducted. Three soil cores were collected within each plot for a total of 45 soil samples per patch type. Soil cores were divided into depths of litter, 0-2 cm, 2-5 cm, and 5-8 cm. Soil cores were placed in a growth chamber for two years under conditions that mimicked local weather conditions of the study sites. Plants that emerged were counted and removed from samples when they could be identified.

Objective 2

The Agua Fria riparian ecosystem below New Waddell Dam is located within 50 km of the HRP. Study sites were selected along a 4-km stretch of the dewatered channel below the dam. Immediately below the dam, semi-permanent pools are supported by dam seepage and occasional spring flow from the Morgan City Wash. Two kilometers downstream from the dam, the channel is completely dry. A *Tamarix-Salix* (saltcedar-Goodding willow) forest, which is supported by semi-permanent pools, is located immediately below the dam. Located adjacent to the *Tamarix-Salix* forest are *Baccharis-Bebbia* (desert broom-sweet bush) shrublands. A fairly dense *Tamarix* forest is located further downstream below a berm in an ephemeral reach. Approximately 4 km below the dam, in a reach that is completely dry, is a mixed *Hymenoclea-Bebbia* (burro brush-sweet bush) shrubland. Three 100 m^2 sites were selected for study within each of these patch types. Study methods used at the HRP were repeated within each of the study sites.

Species located in propagules banks of the HRP and Agua Fria riparian ecosystem were placed into a variety of life-history categories based on characteristics such as life form (grass vs. forb) and wetland indicator score categories. Species were also placed into life-history categories based on the classification scheme of Grime (1977). For each river, Sorenson's similarity coefficient was used to determine the degree of similarity in extant vegetation within patch types, and between propagules banks of the various patch types. Differences in mean number of individuals by category between patch types, and between depths within patch types were analyzed using ANOVA. Correlation analysis was conducted to determine the relationship between wetland indicator scores and depth. Sorenson's similarity and separate variance t-tests were used to test for significant differences in categories between rivers. All analyses were conducted at the α=0.05 level.

Objective 3

Based on results from the HRP propagule bank study, I conducted a propagule bank manipulation experiment in *Prosopis* spp. forest understories. I selected five, 100 m^2 sites within *Prosopis* spp. forests whose understories were dominated by Mediterranean grasses. Vegetation surveys were conducted within each site before treatment application. Treatments of litter removal, 2 cm and 5 cm soil removal, and control were randomly applied to eight randomly located plots within each site by volunteers from the HRP and Arizona State University. Plot maintenance and herbaceous sampling was conducted monthly for 13 months and a final time 2 years after treatment application. Vegetation was categorized by life form, origin (native vs. exotic), life span (annual vs. perennial). Species were also

placed into life-history categories based on the classification scheme of Grime (1977). Species diversity was determined using the Shannon-Weiner index. Differences between categories over time were determined using uneven univariate repeated measures analysis ($\alpha = 0.05$). General linear model was used to determine if significant differences occurred between categories in year two data ($\alpha = 0.05$).

RESULTS

The salient points of my research were:

At the HRP (Objective 1)

- Approximately 50% of species found during vegetation surveys and 30% found during a three-year flora were also present in propagule banks.
- Within the propagule bank, upland ruderals increase with increasing distance from the channel, while riparian ruderals are evenly distributed across the floodplain.
- The relative abundance of wetland species (as indicated by wetland indicator scores) increases with increasing depth within the soil profile (Fig. 1).
- Most species within propagule banks are generalists; i.e., they are commonly found in more than one extant plant association.
- Species composition of propagule banks between associations is more similar than that of extant vegetation.

At the Agua Fria (Objective 2)

- Although there is low similarity in plant species composition between extant associations of the Hassayampa and Agua Fria, there is a relatively high degree of similarity in propagule bank composition between the rivers (Table 1).
- With the exception of the *Tamarix-Salix* forest, relative abundance of wetland plants is generally greater in deeper soil depths than in surface soils or extant vegetation.
- Although the majority of individuals in the propagule banks of xerophytic *Hymenoclea-Bebbia* shrublands are upland, almost 50% of species are riparian.

Soil Manipulation Experiment at HRP (Objective 3)

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Mediterranean grass cover was significantly lower in 5 cm soil removal plots than in control plots two years post-treatment. Forb cover did not vary between treatments (Fig. 2).

- Species richness did not differ, but a species diversity index (based on richness and evenness) was significantly higher in treatment plots than in control plots two years post-treatment.

DISCUSSION AND MANAGEMENT APPLICATIONS

Objective 1

The results of the HRP propagule bank investigation reveal that a high percentage of plant species are recruiting from propagule banks. The

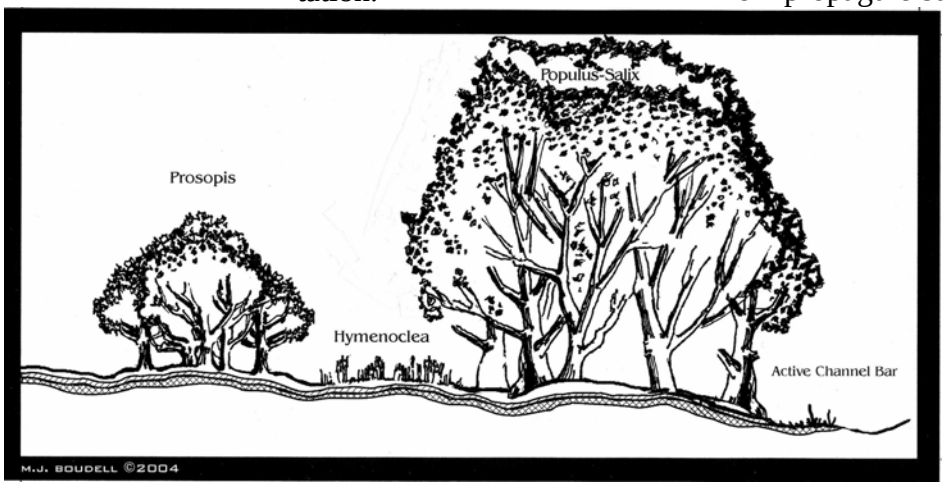

Figure 1. *Illustration of soil propagule bank distribution by life-history classification across the Hassayampa River Preserve floodplain. Soil layer key: white surface layer = majority of individuals are upland ruderals; diagonal lines = mixture of upland and riparian ruderal and riparian competitor individuals; hatch marks = majority of individuals are riparian ruderals and competitors. Illustration is not to scale.*

Table 1. *Sorenson's Similarity scores between Agua Fria River and Hassayampa River extant vegetation and propagule banks.*

	Extant vegetation	Propagule bank
Tamarix-Salix vs. *Populus-Salix*	0.25	0.44
Tamarix vs. *Populus-Salix*	0.19	0.48
Baccharis-Bebbia vs. *Hymenoclea*	0.29	0.47
Hymenoclea-Bebbia vs. *Hymenoclea*	0.21	0.48

Notes: High values indicate greater similarity.

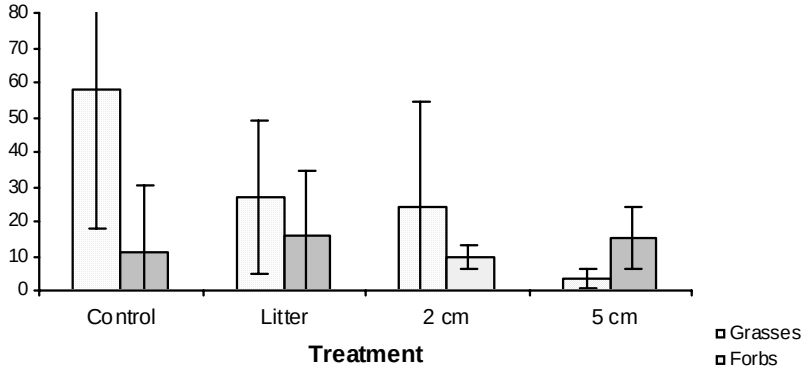

Figure. 2. Comparison of mean cover of grasses and forbs per m2, ± 1 SD, amongst control, litter, 2 cm, and 5 cm soil removal plots (n = 5; ‡ = data square root transformed).

majority of these species are generalists, which are capable of establishing in several patch types. Many of the species recruiting from propagule banks are recruiting from a common pool as opposed to a particular propagule bank (i.e., propagule banks of channel bars and, *Hymenoclea*, *Populus-Salix* and *Prosopis* patches all were fairly similar in composition) (Fig. 1). This pattern likely develops because large floods disperse propagules widely across the floodplain. Indeed, a common propagule bank is supporting a riparian metacommunity wherein many of the species in the riparian corridor are not limited to particular patch types, but are common to many patch types.

If plant associations within dynamic riparian corridors are indeed part of a metacommunity in which hydroregimes sustain propagule networks, then managers of riparian ecosystems must consider these dynamics in order to understand and manage riparian ecosystems. When these hydroregimes are altered by activities such as diversion or impoundment by dams, propagule dispersal networks can be disrupted. Focused management of dominant or more charismatic associations such as riverine marshes or *Populus-Salix* forests, instead of management of the entire metacommunity, could jeopardize all riparian plant associations by disconnecting associations from the propagule network.

Objective 2

Results of the Agua Fria propagule bank investigation reveal that while extant vegetation of the HRP river is very different from that of the impounded Agua Fria, their propagule banks are similar. Propagule banks of the Agua Fria riparian ecosystem contain a diverse mixture of species with varying life history characteristics. All propagule banks of the Agua Fria, even in the most xerophytic community, contain many riparian species.

The propagule banks of the impounded Agua Fria have the potential to contribute to the recovery of understory riparian vegetation. If flow is restored to the channel, riparian plant associations will develop, and in time the Agua Fria riparian ecosystem may develop a higher degree of similarity to free-flowing low-elevation

riparian ecosystems. However, with increasing time without flood flows, the riparian legacy will diminish as the riparian propagule bank is depleted and unreplenished.

Objective 3: Manipulating propagule banks in Mediterranean grass-dominated *Prosopis* spp. forests revealed that removing soil to 5 cm significantly reduced Mediterranean grass populations (which have short-lived seeds restricted to the litter layer), which decreased competition pressure on Sonoran forbs (many of which have long-lived seeds located in surface and deep soil layers). These manipulations increased species richness and cover of many common forbs, such as *Amsinckia intermedia* (fiddleneck), over time. While cover of Sonoran forbs and species richness did not significantly differ from control plots two years post-treatment, species diversity was significantly higher.

Manipulating *Prosopis* propagule banks to increase diversity in understory associations takes time as species recruit from propagule banks, disperse from surrounding associations, and establish self-sustaining populations. Perhaps seeding, in conjunction with propagule bank manipulations, can be used to augment Sonoran populations in *Prosopis* understories.

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2005 ARIZONA RIPARIAN COUNCIL SPRING MEETING

The 2005 Arizona Riparian Council Spring Meeting will be held this year from April 1-2, 2005 in Parker, Arizona, at the Blue Water Resort and Casino. The theme of this year's meeting is *The Lower Colorado River and the Multi-Species Conservation Plan.*

The plenary session topics will include:

- ★ an overview of the Multi-Species Conservation Plan presented by Leslie Fitzpatrick of the U.S. Fish and Wildlife Service,
- ★ Barbara Raulston of the Bureau of Reclamation will tell us about the wildlife and habitat management under the Plan,
- ★ the water management issues will be presented by Terry Fulp of the Bureau of Reclamation, and
- ★ a presentation on the tribal perspectives on the Plan.

We are also doing something a little different this year. The Arizona Water Protection Fund and the Council are sponsoring a restoration workshop to be held the day before (Thurs March 31) and the day of our field trips (April 2). The presenters of this workshop are Tom Moody, Chris Hoag, and Fred Phillips. For more information on the workshop see page 8.

Please also join us Friday evening, for a Caribbean Beach Party at the Cantina located right along the river at the Resort. Register early for the workshop and ARC meeting as there is a limit on the participants for the workshop. You will not be allowed to register for the workshop at the door.

The Blue Water Resort and Casino is holding a block of rooms for us until March 10. Costs are $39 for Weds/Thurs and $69 for Fri /Sat. Their toll free number is 1-888-243-3360.

Please register for the meeting and join us in Parker. There is a registration form enclosed in this newsletter. You may also find a copy at *http://azriparian.asu.edu/2005/registration.pdf* to print off and mail in. At this time we don't take credit cards, but we will take checks and purchase orders.

ARC WATER RESOURCES COMMITTEE REPORT – JANUARY 2005

The recent focus of the Committee has been to assist the Board in submitting comments at the Governor's Water Listening Sessions as she explores what will be done to Arizona's water resource policies. These may be viewed on the ARC website under the "Issues" button.

The underpinnings of water resource policy are changing as never before. Drought and continued escalation of demand has resulted in unprecedented agreements regarding how water will be used and who will pay.

The U. S., Arizona, California, and Nevada have agreed to share funding for the Lower Colorado Multi-Species Conservation Plan (MSCP). Overall, the MSCP will provide

Cont. pg. 14 . . . . . Committee

RESTORING RIPARIAN HABITATS: REMOVING EXOTIC SPECIES; RESTORING NATIVE SPECIES; STREAMBANK STABILIZATION

The Arizona Riparian Council and Arizona Water Protection Fund are sponsoring a 2-day workshop on the restoration of native riparian plant communities, the removal of exotic species, and the use of native plants in streambank protection for landowners and practitioners. The workshop is intended to provide "hands-on" experience with a variety of low-cost, effective bioengineering practices to protect stream banks and restore riparian habitats.

Workshop Topics:

- Riparian ecology
- Nature of rivers
- Riparian planting zones
- Removal of exotic plant species
- Riparian plant propagation
- Reestablishment of native plants communities
- Bioengineering and streambank erosion control measures

Chris Hoag, Fred Phillips, and Tom Moody will lead the workshop. Chris is a Wetland Plant Ecologist with the NRCS Plant Materials Center in Aberdeen, Idaho, and a leading expert in stream bioengineering and has broad experience in designing and installing bioengineering practices in the arid West. Fred is a landscape architect whose Flagstaff firm specializes in the removal of tamarisk and other exotic species to reestablish native riparian systems in the Southwest. Tom is a consulting engineer in Flagstaff and has designed stream restoration projects in Arizona and Utah. A day-long field session will provide hands-on experience installing several streambank practices. Due to the hands-on nature of the fieldwork, the workshop is limited to 30.

WHEN: March 31, 2005 (classroom) and April 2, 2005 (Field)
WHERE: Parker, AZ
COST: A fee of $75 (ARC members) or $100 (non-members). Lunches will be provided.

WORKSHOP SCHEDULE

March 31, 2005

Day 1: Lecture including riparian plant communities, removal of exotics, stream morphology, and bioengineering practices using native plants.

April 2, 2005

Day 2: Field day. Participants will visit a restored site and install a variety of streambank practices using native plants.

All participants should bring water, warm clothing, and rubber boots or hip waders for Field Day activities. Lunch provided.

Please see the ARC website for a draft agenda at *http://azriparian.asu.edu/2005/workshop.pdf*

NOTEWORTHY PUBLICATIONS

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

Cole, J., D. Gutzler, D. Meko, K. Wolter, and M. Lenart. 2004. Climate experts discuss Southwest drought. *Southwest Climate Outlook* September.

According to tree-ring reconstructions back to 1500, the current drought is not a 1-in-500 year event. In comparison to five-year moving averages that include the current dry period, there are other droughts in the past 500 years that exceed it.

In New Mexico, the 1950s drought was six or seven years long. The current one is arguably four. Over the last year or two, the center for the Southwest drought seems to have shifted westward – where New Mexico might have been in the middle of the drought a year or two ago, the central part of these severe drought has moved farther west toward Arizona.

From a hydrological perspective, despite relatively abundant rains recently, there is still a very severe hydrologic drought. However, there can still be a good year for rainfall and snowfall within a drought.

Some say the easiest criterion for recognizing the end of a drought is when the reservoirs are full. Reservoir filling, is a nice integrator because it doesn't respond to the little blips that are seen in a climate data record and paleodata – a record that goes back beyond instrumental records. Although, some reservoirs like Lake Powell take more than a year to fill with rainfall.

In terms of ecosystems, it is much more complex. There can be a tremendously wet year that refills the reservoirs and alleviates hydrologic drought. However, that still probably would not alleviate environmental drought, as far as stress on trees and on forests go, because it's just rapid runoff for them.

The Salt River Project is being evaluated in terms of the joint drought occurrence on the Upper Colorado River Basin and the Upper Colorado River Basin together with the Salt River drainages in Arizona. The Salt River by itself, is a good hydrologic indicator of moisture conditions, integrating them over a mountainous area in eastern Arizona. The years 2000 and 2002 had lower flow than anything in the previous record of instrumental data for the Salt River. In this location, 5-year moving averages or 10-year moving averages are no more severe than the 1950s drought. However, if it lasts a few more years, then it's going to start reaching an all-time severity in the instrumental record.

Over the last year in the Colorado Front Range, the public consumed consistently less water. It was 27% less than normal. This was because there were very severe restrictions on using water, and because it was more expensive. There was also a very wet, consistently cloudy, and cool summer. These factors, together with an abnormal snow pack, resulted in the reservoirs being refilled. The predictions were that this would take at least three years of near-normal precipitation rather than the one year that it actually took.

El Niño kicked in at the beginning of July 2004. The 2002-2003 El Niño was a little bit warmer, regarding sea surface temperatures in the region of the tropical Pacific known as Niño-3.4. If Niño-3.4 is used as the benchmark to define El Niño, that index currently has one of the strongest signals. Using the official National Oceanic and Atmospheric Administration (NOAA) definition, there is already a moderate event.

Although sea surface temperatures in the Pacific are warming up, there is not much response in the atmosphere, and the atmosphere's response in the Pacific is what drives the connections to climate in North America.

According to Klaus Wolter, Meteorologist with the Climate Diagnostic Center of Boulder, Colorado, Arizona's teleconnections to the El Niño-Southern Oscillation (ENSO), is a very reliable and robust wet signal in the winter if El Niño is strong. For the top five or six events, it's almost a one-to-one relationship. Below those strong events, the correlation becomes much weaker. Looking at different model projections for the next six months, the amount of moisture that comes into southern California and Arizona depends on the degree of warming in the eastern Pacific, which has been on the cool side so far. For July

and August a prediction for a shift in the odds of 5 to 10 percent in Arizona towards the wet has stayed. For the early winter, there are better-than-normal odds for moisture. The forecast for January through March continues this trend towards wetness in Arizona, while remaining undecided for New Mexico.

David Gutzler, Professor of Earth and Planetary Sciences from the University of New Mexico discussed how El Niño relates to some of the decadal-scale oceanic variability and what that might mean this winter. One of the uncertainties in making El Niño-based forecasts is that not all El Niños are alike and we don't understand what determines the differences in teleconnections and precipitation from one year to the next. There are some hints in the data that there may be long-term modulations in how El Niño affects storm tracks.

Several people have looked at whether decadal-scale oceanic variations could modulate the predictability of precipitation in the Southwest based on El Niño. There is some indication that, in the 1950s and 1960s when conditions were relatively drier across the Southwest, El Niño provided somewhat less of a basis for predicting a wet winter and spring across the Southwest than in the subsequent decades after the Pacific Decadal Oscillation (PDO), a shift in the late 1970s. During some decades, El Niño reliably produces wet, cold-season precipitation in the Southwest, whereas in other decades that forecast is less reliable. The PDO is less reliable as a predictor than it used to be because the PDO has flip-flopped to shorter time scales. After the 1997-1998 El Niño event, the PDO made a shift back to its "negative" phase, which is what things were like in the 1950s and 1960s. The index is back to positive, which is the wet phase for the Southwest. However, it continues to vary.

David Brown and Andrew Comrie at the University of Arizona looked at the precipitation correlations in the Southwest with El Niño during PDO warm and cool phases. This was in a paper in the May 2004 issue of *Geophysical Research Letters*. Their conclusion for the period of time during the cool phase of the PDO in the 1950s was that if there were warm El Niño-like conditions in the fall, there were drier conditions in the following winter. Only during the warm phase of the PDO did one see this more typical connection with warmer El Niño conditions being associated with wetter conditions in Arizona.

This is contrary to what has been assumed about El Niño in the Southwest. The belief has been that to break up a long-term drought, a really wet year is needed. The idea was that a wet winter is needed to drive a big snowpack at the headwaters of the rivers and fill up the reservoirs. It was thought that the way to do that was with a big El Niño. But, there are modes of variability that make it difficult for the climate system to produce a big El Niño-driven wet year in ways that are still not understood well enough to make predictions. The next El Niño does not look like it is going to be a strong event compared to the really big ones like 1997-98 or 1982-83, when there were tremendous warm anomalies in the ocean. Unusually warm sea surface temperatures in the region indicate an El Niño.

There was a severe drought in Arizona from 1994 through 1996 and then coming into the El Niño of 1997. Either the 1997 El Niño ended that short drought or maybe it is just a little El Niño in the middle of another drought. Whereas, the PDO has time scales that are longer – 20 or 30 years between being in one mode or another if the time frames are calculated accurately.

Different people's reconstructions of the PDO before about 1910, do not agree. These are reconstructions developed using the best available records for 20th Century sensitivity, which match the 20th Century, but they do not carry back in time looking like a coherent system.

There is a relationship between the seasonality of the rainfall in Arizona and the drought. Winter drought is not always occurring at the same time as summer drought, but sometimes they do occur in the same year and the stress on ecosystems, might depend on that. There was a lot of dieback of trees in the 1950s that seemed to coincide with a failure of summer and of winter rains. The cold season and warm season rains may have to be looked at separately in summarizing drought for some purposes. In 2004 there was a very dry rainfall total from the cold season, and it was spotty. The summer rains were 75% of normal. Those circumstances are going to stress the trees in the mountains in Arizona.

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LEGAL ISSUES OF CONCERN

Richard Tiburcio Campbell, U.S. Environmental Protection Agency

PERCHLORATE: THE LATEST REGULATORY FIREWORKS

On May 21, 2000, the Los Angeles Police Department responded to reports of an explosion at an apartment complex in downtown Los Angeles that had blasted a hole through the floor of one apartment through the ceiling of the apartment below.[1] A bloodied and bruised Gary Weksler had, for the second time, blown up an apartment using a recipe for the manufacture of illicit substances whose prime ingredient was a component of rocket fuel – perchlorate. Weksler's clumsiness with perchlorate was somewhat understandable considering he had lost several fingers in a fireworks display gone bad some years earlier.[2] Of course, a prime ingredient of fireworks is – what else? – perchlorate. Clearly, Mr. Weksler had not reached an understanding of what constituted a safe level of this highly volatile chemical. However, what constitutes a safe level of perchlorate is not always easily discernable. Just ask those federal and state regulators who have been trying to come up with a Maximum Contaminant Level (MCL) for perchlorate over the past few years. Nevertheless, recent events indicate that federal and state regulators will soon have sufficient data to determine whether and/or what level of perchlorate should be safely be allowed in this Nation's water supplies, including the Colorado River. Whether final disposition of this issue can be arrived at with everyone's fingers still intact is another matter.

WHY IS THERE PERCHLORATE IN THE COLORADO RIVER?

The presence of perchlorate in this Nation's surface and groundwater supplies is another hidden cost of the Cold War slowly coming to light. In addition to its usefulness in the production of fireworks, the excellent explosive properties of perchlorate made it an essential ingredient in the manufacture of solid rocket propellants and munitions during the Cold War years. Perchlorate was used throughout the Nation since the 1950's. However, the initial introduction of perchlorate to the Colorado River is remarkably and primarily traceable to a single rocket fuel production facility located in Henderson, Nevada, currently owned by the Kerr-McGee Corporation. For decades, this facility discharged process water containing ammonium-perchlorate into unlined evaporation ponds that seeped into the aquifer underlying the Las Vegas Wash. This soluble, slow-degrading, persistent, and very mobile contaminant worked its way underneath the normally dry ephemeral wash for a distance of 12 miles until it entered Lake Mead. In 1999, perchlorate was measured to be flowing into Lake Mead at a rate of 900 pounds ***per day***. From Lake Mead, perchlorate flowed into the main stem of the Colorado River and then into various domestic and agricultural (via Lake Havasu) water supplies. In addition to the Colorado River contamination, several aquifers in southern California have been contaminated by perchlorate due to the defense industry's predilection toward locating rocket propulsion and munitions facilities in that region.

WHAT ARE THE HEALTH CONCERNS ASSOCIATED WITH PERCHLORATE?

The impact of perchlorate on mental and physical growth in fetuses, infants and children is the primary reason perchlorate is a top issue for regulators. Perchlorate interferes with the function of the thyroid glands by disrupting iodine uptake, which regulate hormones in the body. Consequently, perchlorate increases the risk of behavioral changes, delayed development, decreased learning capability in children (or, to put it another way, "it actually makes children more stupid").[3]

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[1] *People v. Weksler*, 2002 Cal. App. Unpub. LEXIS 5012 (Cal. App. 2002).

[2] *People v. Weksler*, 2002 Cal. App. Unpub. LEXIS 5012 (Cal. App. 2002).

[3] Statement by Environment California advocate Sujatha Jahagirdar, as reported in Stiff Perchlorate Limits in Drinking Water Urged," THE SAN BERNARDINO SUN (January 24, 2005);

Perchlorate in sufficient quantities also poses a risk of impaired metabolism and thyroid tumors in adults.

EXISTING STANDARDS

While the health risks are known, the scientific data needed for regulatory action is just coalescing. Thus, for now, perchlorate remains an unregulated contaminant and thus there is no federal water quality standard (i.e., MCL). Consequently, current federal and state "standards" (i.e., alert levels, health goals, and monitoring triggers) vary widely. Arizona Department of Health Services has a nonenforceable 14 parts per billion (ppb) "health-based guidance level"(think of seven drops of water in an Olympic-sized swimming pool). Nevada has a 18 ppb clean up action level and public notice standard. New Mexico has a 1 ppb interim groundwater screening level. In January 2002, EPA issued a draft risk assessment proposing a 1 ppb standard for perchlorate, and this assessment was provided to the National Academy of Sciences (NAS) for review. While NAS has been reviewing the data, California announced a Public Health Goal (PHG) of 4 ppb for perchlorate in March 2002 (which was promptly met with lawsuits from the defense industry). The establishment of a PHG in California is significant because that State's Health and Safety Code requires the establishment of an MCL as close to the PHG as possible.[4]

Since 2002, the occurrence of perchlorate in drinking water and food supplies has steadily gained in noteriety. In 2003, a University of Arizona scientist found percholate in the outer leaves of Yuma lettuce irrigated with Colorado River water.[5] On April 14, 2004, the nonprofit organization *American Rivers* announced its belief that approximately 400 pounds of ammonium perchlorate are still discharged daily into the Colorado River from the Henderson, Nevada, site located near Las Vegas, and perchlorate levels below Hoover Dam were found as high as 24 ppb.[6]

In response to the *American Rivers* report, on April 15, 2004, Governor Napolitano pledged to meet with the State's congressional delegation to find a solution and organized a task force to gather data.[7] Governor Napolitano's interagency task force, formed in April 2004, included the Arizona Department of Environmental Quality, the Arizona Department of Water Resources, and Arizona Department of Agriculture, to analyze Colorado River water samples. The task force ultimately found in December 2004 that perchlorate levels in Colorado River water used for drinking in Arizona were below the state's HBGL of 14 ppb (though it should be noted that a groundwater well in Yuma tested above 15 ppb for perchlorate).[8,9]

In June 2004, the nonprofit *Environmental Working Group* (*EWG*) published the results of a Texas Tech University study it commissioned that found perchlorate on average of 1.3 parts per billion (ppb) in nearly all the milk it tested from randomly purchased milk in Lubbock, Texas (thought to be from the occurrence of perchlorate in animal feed). *EWG* also released the previously unpublished results of California Department of Food and Agriculture sampling that found an average level of 5.8 ppb of perchlorate in several California milk silos.[10]

On March 11, 2004, after resolving the defense industry's legal objections, California officially announced a new PHG for perchlorate in drinking water of 6 ppb.

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http://www.sbsun.com/Stories/0,1413,208~12588~2669159,00.html.

[4] CA Health and Safety Code § 116365(a).

[5] "Perchlorate in Arizona - Occurrence Study of 2004" at 31 (issued Dec. 10, 2004). http://www.azdeq.gov/function/about/download/perch1201.pdf

[6] *See* American Rivers, "America's Most Endangered Rivers of 2004" (April 2004) http://www.amrivers.org/index.php?module=HyperContent&func=display&cid=2723

[7] "Gov. to Seek Halt to River Pollution," ARIZONA DAILY STAR (April 15, 2004).

[8] "Perchlorate in Arizona - Occurrence Study of 2004" (issued Dec. 10, 2004). http://www.azdeq.gov/function/about/download/perch1201.pdf

[9] "Chemical in Colorado River no Danger, Napolitano Says", ARIZONA DAILY STAR (Dec. 10, 2004).

[10] "Rocket fuel toxin found in Calif. milk." ARIZONA DAILY STAR (June 22, 2004).

California's determination will likely be impacted by the results of the recent findings made by the NAS in its long-awaited review of EPA's 1 ppb determination.

THE JANUARY 2005 FINDINGS OF THE NATIONAL ACADEMY OF SCIENCES

The NAS's findings, issued on January 10, 2005, made no clear recommendation with regard to what MCL should be set for perchlorate except to say that EPA's 1 ppb may be too low:

> *[T]he perchlorate dose required to cause hypothyroidism in adults would probably be more than 0.40 mg/kg per day, assuming a 70-kg body weight. ... In pregnant women, infants and children, and people who have a low iodide intake or pre-existing thyroid dysfunction, the dose required to cause a decrease in thyroid hormone production may be lower.*

NAS report it at 44. Many news reports indicated that NAS was supporting an MCL that would be 23 times higher than the 1 ppb level proposed by EPA in 2002. This news was misleading since the NAS did not recommend a ppb MCL, but rather a reference dose of 0.0007 milligrams per kilogram of body weight.[11] Translating the reference dose into parts per billion leaves room for interpretation, with environmentalists arguing the NAS report justifies a 2.5 ppb MCL, while industry believes NAS's study allows for a 250 ppb standard.[12]

THE UNREGULATED CONTAMINANT MONITORING RULE AND FUTURE RULEMAKING

While the debate over what the correct MCL is waged, EPA will be wrapping up its collection of perchlorate occurrence data from selected water systems throughout the nation. The water systems are sampling for perchlorate, and other unregulated contaminants pursuant to the SDWA's Unregulated Contaminant Monitoring Rule (the "UCMR").The intent of the UCMR is to help EPA determine which contaminants EPA should regulate based on contaminant concentrations in public water systems and the contaminants' adverse health effect levels. These emerging contaminants, including MTBE and perchlorate, have not been monitored before, but have the potential to be found near or in drinking water supplies or recently have been identified as potential health problems.

The UCMR was published on September 17, 1999, and put water systems serving greater than 10,000 persons on notice that they had three years (between January 1, 2001 and December 31, 2003) to sample for 12 currently unregulated contaminants, including MTBE, DCPA, and, or course, perchlorate.[13]

Most systems completed their sampling by the end of 2003, though a number of systems, including several in Arizona, required prompting by EPA in the form of administrative orders that were issued to these system in early 2004. The orders required these systems to complete their UCMR sampling by early this year. Once all the data is collected and analyzed by EPA must meet a statutory deadline of August 2006 for making a determination on which contaminants to regulate under the SDWA.[14] If EPA determines that regulation of perchlorate with an MCL is necessary, then a regulation would be proposed in 2008, unless the data shows an urgent risk to public health, which may cause the timeline to be shortened.

CONCLUSION

In the coming years a determination will be made by EPA and the States with regard to whether perchlorate needs to be regulated, and if so, what MCLs will serve to protect the health of adults, children, infants, and the unborn. However, the effect of perchlorate on the riparian environment, e.g., aquatic species, remains

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[11] NAS report at 4. *http://books.nap.edu/books/0309095689/html/4.html#pagetop*.

[12] *See* e.g., "Area Water is Safe to Drink, Study Says," PASADENA STAR-NEWS (January 15, 2005)("The report identified a safe level for total daily intake of the chemical that is 23 times higher than that proposed by the [EPA] in 2002.")

[13] The complete list of unregulated contaminants may be found in List 1 of the "Table 1–Unregulated Contaminant Monitoring Regulation (1999) List", at 40 C.F.R. § 141.40(a)(3)

[14] *See* Safe Drinking Water Act § 1412(b)(1)(B), 42 U.S.C. § 300g-1(b)(1)(B).

largely unknown. This author is unaware of any significant studies that have been performed, though University of Arizona Professor Charles Sanchez did note in regard to his study on the occurrence of perchlorate in Yuma lettuce that the relatively lower concentrations of perchlorate he found at the Imperial Diversion Dam near Yuma may "be due to biological factors, such as uptake by aquatic and riparian plant species along the river..."[15] In addition, the Texas Tech study noted an accumulation of perchlorate in the heads of fish and suggested a developmental effect on frogs. Clearly, additional studies on the effect of perchlorate on the riparian environment need to be performed.

[15] "Measuring Perchlorate Levels in Lettuce - Preliminary Study Analyzes Factors Affecting Uptake 2003 Arizona Agricultural Experiment Station Research Report (2003); *http://cals.arizona.edu/pubs/general/resrpt2003/article13_2003.html*; *see also* Susarla, A., N.L. Wolfe and S.C. McCutcheon, "Perchlorate Uptake in Lettuce Seedlings," presented at the August 22-26, 1999 meeting of the American Chemical Society, available at *http://www.ewg.org/reports_content/rocketlettuce/pdf/perchlorate_environment.pdf*

Publications cont. from pg. 10

A really stressful drought period is one in which there is year-round dryness. That is one of the things that tended to characterize the big Southwest drought of the 1950s. The relationship between winter precipitation and summer precipitation was out-of-phase, and it broke down. In wetter periods, there does seem to be some tendency for wet winters to be followed by dry summers and the other way around. This would tend to mitigate drought somewhat, since we get most of our precipitation in the summer. If there is a flip-flop between winter and summer it is difficult to have long, persistent anomalies because one dry season gets followed by a wet season and vice-versa. One of the major puzzles for drought dynamics is what makes a wet anomaly or a dry anomaly persist across the seasonal cycle. This is because a lot of our understanding of how these teleconnection-driven anomalies work is mostly a cold season picture. There is not a good, strong correlation between El Niño indices and summer precipitation.

The climate experts conclude that despite a developing El Niño, which typically indicates a wet winter, the intense drought gripping the Southwest will not likely be alleviated.

Committee . . cont. from pg. 6

$626 million for habitat protection and enhancement in the reach of the River below Hoover Dam, not including the Colorado Delta in Mexico. This landmark agreement is the primary subject of our next annual meeting, in April, at Parker.

A recent agreement between Arizona and Nevada for underground storage of Colorado River water also raises the potential of up to $100 million for the riparian protection and restoration. This funding could go to the Lower Colorado MSCP or to a variety of projects on Arizona rivers via the Arizona Water Protection Fund.

Also recently passed is the Arizona Water Settlements Act (AWSA), a sprawling piece of legislation that will diminish flows on the Gila River in Arizona, and likely initiate lawsuits regarding endangered species issues in this state. The legislation also provides funding for water development in the Upper Gila Basin in New Mexico. The actual language does not require that the money be used for diversion per se; actual uses of the money will be developed with input from New Mexico's citizens, and in compliance with environmental laws. The AWSA also sets up a water market that will allow interchanges of surface and groundwater water rights on the Verde, Gila and Colorado Rivers. Look for a future article by Committee member Jim Lombard to better understand how this complicated law will affect riparian ecosystems.

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, 2005. Please call or write with suggestions, publications for review, announcements, articles, and/or illustrations.

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CALENDAR

Arizona Riparian Council Spring Meeting, March 31-April 2, 2005. Plenary session and technical papers on April 1. Restoration workshop on March 31 and April 2 with limited enrollment. Will be held at the Blue Water Resort and Casino in Parker, Arizona. See page 7 for more information or contact Cindy.Zisner@asu.edu or (480) 965-2490.

Water and the Environment: The Role of Ecosystem Restoration, April 6, 2005, Radisson Tucson City Center Hotel, Tucson. Sponsored by the Water Resources Research Center, University of Arizona. See *http://www.cals.arizona.edu/AZWATER/conf2005/* for more information. For questions or special requests, contact Cas Sprout at: csprout@cals.arizona.edu (520) 792-9591 x 55; Fax: (520) 792-8518.

35th Annual Institute of Desert Ecology, April 14-17, 2005, Catalina State Park, Tucson. For more information, contact Jessie Shinn, Institute Director, (520) 628-1730; jessie.shinn@qwest.net.

Arizona Riparian Council Board Meeting. Board meetings are held monthly, contact Cindy Zisner, Cindy.Zisner@asu.edu or (480) 965-2490.

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APOLOGIES FOR THE LATENESS OF THE NEWSLETTER!!