Upper Gila River Science Forum, October 21-22, 2006

Coordinators:
Cliff Dahm, University of New Mexico
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Robert Glass, Sandia National Laboratories

Summary

The initial Upper Gila River Science Forum was held on October 21-22, 2006, at Western New Mexico University in Silver City, New Mexico. The goal of the science forum was to bring together national and international experts from outside New Mexico to present their collective knowledge on the science of effective river ecosystem management. These scientists were asked to inform those in attendance of the lessons learned and the pitfalls encountered when they applied science to the management of river ecosystems in the western United States and Australia. Key questions that were asked of the forum speakers were: 1) how is science best integrated into the decision making process? 2) what potential gaps in scientific information must be filled? and 3) what are sensitive and useful measurements of the health and sustainability of river ecosystems?

Six speakers presented at the Upper Gila River Science Forum. Stuart Bunn, a river ecologist and director of the Australian Rivers Institute, spoke on general principles of setting environmental flows and his experience in dryland rivers of Australia. David Meko, a dendrochronologist from the tree ring laboratory at the University of Arizona specializing in paleohydrograph reconstruction, provided a long-term perspective on river flow and variability in the southwestern United States. Robert Wissmar, a landscape ecologist at the University of Washington, presented a landscape perspective for assessing key interactions between streams and riparian zones. Julian Olden, a fisheries biologist at the University of Washington, showed clear connections between flow modification and the success of invasive fish species and summarized existing fish data from the Lower Colorado River basin. John Bolte, a biological and ecological engineer at Oregon State University, presented the process used to successfully assess alternative futures in the Willamette River basin using stakeholder input, geographic information systems (GIS), and various modeling procedures. Finally, Dave Goodrich, a hydrologist at the Agricultural Research Service and the University of Arizona specializing in riparian zone evapotranspiration, showed how the hydrological and biological sciences were integrated with the social sciences for decision-making on the Upper San Pedro River in Arizona. A lively hour and a half discussion between members of the audience and the speakers followed immediately after the presentations.

The six presenters then spent the following day with the science forum coordinators (Robert Glass, David Cowley, and Cliff Dahm) in further discussion concerning the science needed in the Upper Gila River basin to support the decision-making process associated with New Mexico’s benefits in the 2004 Arizona Water Settlements Act. Two critical observations were reached, the first on overall process and the second on the science that is done in context of this process. The group then defined the set of scientific information they would find most useful for the decision making process.

Overall Process:
Successful water development or remediation projects from across the globe demonstrate that the process for fully incorporating science within decision making must include 1) identifying important ecological, cultural, and economic assets, 2) developing a robust

framework for integration and synthesis of scientific information, 3) ensuring ongoing stakeholder engagement, education, and information exchange, including an ongoing commitment to monitoring of the success (or otherwise) of management interventions and 4) considering future conditions and scenarios (as well as quantifying uncertainty) for the river corridor and the human population in the basin. If scientific studies are not directed in the context of this process, they will likely yield little value to the decisions that are ultimately considered.

Framework for Integration and Synthesis of Scientific Information:
In context of the overall process, a framework for integration and synthesis of scientific information is specified and must be formulated with clear guiding principles. Such principles should link hydrology to the ecological components of the ecosystem and account explicitly for the influence of current and future anthropogenic modifications to the environment. A knowledge base founded on a wide range of natural and human-altered riverine systems will yield a core set of guiding principles that include: 1) flow is a master variable in aquatic systems that determines physical habitat and ultimately drives ecological processes and shapes biotic composition, 2) aquatic species have evolved life history strategies primarily in direct response to natural flow regimes, 3) maintenance of natural patterns of longitudinal and lateral connectivity is essential to the viability of populations of many riverine species, 4) the invasion and success of non-indigenous and invasive species in rivers can be facilitated by the alteration of flow regimes and 5) anthropogenic impacts must be integrated into environmental assessments of river ecosystems.

Most Useful Scientific Information:
The types of scientific information that would be most useful in assisting a science-based decision making process include: 1) reach-based water budgets along the river with particular emphasis on interactions between surface water and ground water, 2) placement of the hydrology of the Gila River in context of similar arid and semi-arid land river ecosystems in the United States and across the globe, 3) detailed physical characterization of the river and adjacent riparian zone (e.g., geomorphology and habitat mapping), 4) current distributions of fish and aquatic invertebrate species with emphasis on off-channel and tributary inputs and threats from non-indigenous species, 5) high resolution landscape characteristics for the river basin (e.g. topography, soils, land use/cover, human cultural attributes) and their projected changes in the immediate future, 6) historical and paleoclimatic data to understand long-term precipitation and discharge patterns, and 7) response of current ecological, cultural, and economic assets to flow magnitude and variability.

Preamble

From the NM ISC briefing package:

Mirroring New Mexico State statutes, Congress directed in the 2004 Arizona Water Settlements Act that the New Mexico Interstate Stream Commission approve any expenditures of monies or contracts for water received by New Mexico in the settlement. Even before the Act was signed into law, the Commission adopted a policy to guide it through the planning and decision process:

> **"The Interstate Stream Commission recognizes the unique and valuable ecology of the Gila Basin. In considering any proposal for water utilization under Section 212 of the Arizona Water Settlements Act, the Commission will apply the best available science to fully assess and mitigate the ecological impacts on Southwest New Mexico, the Gila River, its tributaries and associated riparian corridors, while also considering the historic uses of and future demands for water in the Basin and the traditions, cultures and customs affecting those uses."**

Under State statute, the Governor also is responsible for ensuring the equitable distribution of interstate waters. This policy was adopted and approved by the Office of the Governor, with the further directive that the process be carried out within a fully inclusive and transparent public involvement process.

The process used to decide and plan how best to utilize the benefits received in the 2004 Arizona Water Settlements Act must therefore be comprehensive, utilize the best available science and data, fully consider both present and future demands for water, employ the best and most efficient management, protect the unique and valuable ecology of the Gila Basin, and be fully inclusive and transparent. To mesh these often contradictory tasks will be neither easy nor simple. The responsibility for the first important step in this process, providing the citizens of New Mexico the information they need with respect to possible impacts on endangered species, one of the most critical questions that must be answered, lies with the Gila-San Francisco Coordinating Committee.

The Gila-San Francisco Coordinating Committee commissioned the Science Forums.

Goals of the science forums

The goals of the Science Forum were to:

1. Present independent perspectives from scientists well versed in river and watershed ecosystem management to help inform decision making in the Upper Gila River Watershed.
2. Review the Upper Gila River water management issues in context of similar watershed efforts in the US and internationally.
3. Assist in the identification and prioritization of scientific and technical needs required to support water management decisions in the Upper Gila River Basin.
4. Provide independent input for the development of strategies to meet those needs throughout the watershed.

The first science forum, our process and organization

For the first Science Forum, a small number of experts were invited as panelists representing a variety of key areas that together with the coordinators would frame the breadth and scope of the task. While certainly not exhaustive, the areas chosen were: Ecology and eco-hydrology of watersheds; Native species conservation, biology and ecological impact of invasive species, endangered species management, biological diversity (including population genetics); Fluvial and watershed hydrology; Climate and climate fluctuation/change, paleoclimatic studies and hydrologic reconstructions; and Management of natural and agro-ecosystems.

The forum was designed with the following components.

1. Introduction and call to task by the NM ISC (Friday evening October 20, 2006)
2. Public interaction between the panelists and the community at large (Saturday October 21, 2006)
3. Retreat by the coordinators and panelists to synthesize understanding and formulate recommendations (Sunday October 22, 2006)

The panelists were:

a. John Bolte: Professor and Head of the Dept. of Biological and Ecological Engineering at Oregon State University.
b. Stuart Bunn: Director of Australian Rivers Institute at Griffith University in Brisbane, Queensland, Australia.
c. Dave Goodrich: Research Hydraulic Engineer with the USDA-Agricultural Research Service and an Associate Adjunct Professor in the Dept. of Hydrology and Water Resources at the University of Arizona.
d. David Meko: Associate Professor at the Laboratory of Tree-Ring Research at the University of Arizona.
e. Julian Olden: Assistant Professor at the School of Aquatic and Fishery Sciences at the University of Washington.
f. Bob Wissmar: Professor at the School of Aquatic and Fishery Sciences at the University of Washington.

Two page curriculum vitaes for each of the panelists are found in the **Appendix**.

The NMISC's Upper Gila River Briefing Packet 7-3-2006 was given to the panelists to facilitate their preparations. Pre-Forum Brochure and Forum day programs are found in the **Appendix**. This material was also presented to them along with a question and answer session on the evening of October 20 by ISC representatives. Members of the Gila-San Francisco Coordinating Committee were also present at this exchange.

On October 21, each panelist gave an hour long public presentation at the Bessie-Forward Global Resource Center on the campus of WNMU after which an hour and a half open panel discussion commenced with questions from the floor. The entire day of open presentation and discussion was recorded for public broadcast. The pre-forum brochure and forum day programs are found in the **Appendix**.

Complete presentations and extended abstracts from each Panelist also are found in the **Appendix**.

On October 22, the science coordinators and panelists convened at the Lichty Center on the Upper Gila River. Context was first provided through an overview slide show of the Upper Gila River and a short field trip to nearby river and riparian zone access points. A structured discussion then commenced with the following sequence:

1. critical questions
2. information needs
3. recommended integrative framework for scientific investigations

These are summarized in subsequent sections.

A high level summary presentation of the Upper Gila River Science Forum is found in the **Appendix**.

Critical questions identified

We asked the invited experts to identify critical questions that need to be answered to support water management decisions in the Upper Gila River. Below are questions in the order that they were identified.

1. What is the water budget in each reach (node) of the Gila River (e.g., between gauging stations)? What is the relative contribution of surface and groundwater to the water budget? What are the current sources of water withdrawals (i.e., exports)? It was determined that a realistic flow plan for the Upper Gila River cannot be developed without knowing the magnitude and location of water sources and losses throughout the upper basin.
2. What is the extent and depth of the unconsolidated alluvial aquifer?
3. What are spatial differences in geomorphology between the various reaches? Do the different reaches differ substantially in spatial geomorphology such as width of the floodplain or depth of the alluvium?
4. Is there a regional groundwater system to which the Gila River contributes water?
5. Is there connectivity between shallow alluvial groundwater (GW) and deeper GW systems?
6. What is the interannual variability in flow? How representative is the gauge record with respect to longer term variability? Paleoclimatic studies or framing the Gila River in context with other rivers with longer records could help understand the significance of drought intensity/duration on the Gila River.
7. How does the Gila River compare to other dryland river systems (e.g., Puckridge *et al*. 1999, Kingsford 2006)? Calculation of ecologically-relevant hydrological metrics to characterize the Gila River, including measures of flow frequency, duration, timing, coefficient of variation, intensity ramping, etc. (reviewed in Olden and Poff 2003) would enable multivariate analyses to compare the Gila River to other dryland river systems. The goal of such an analysis is to help understand the possible ecological consequences of flow alterations.
8. What is the residence time of the typical flood event in the shallow alluvial aquifer? How does this relate to the planned timing of diversion of new water rights?
9. What are the important ecological assets that the users of the Gila River want to protect? How are these influenced by river flow? Ecological assets may include ecosystem goods & services, agroecosystems, cottonwood forest, and other attributes of river corridors valued by humans. For example, if cottonwood trees were an important ecological asset, what is their age spatial distribution and is there adequate succession or regeneration? Do present-day values need to consider a historical context?
10. What are the indicator species that allow us to assess the ecological health of the Gila River system? What biophysical metrics are indicative of the attributes of ecological health?
11. What is the spatial and seasonal distribution of downwelling and upwelling areas in the Gila River? What are baseline seasonal trends in physical, chemical and biological processes important to the ecology of the Gila River? What reach or reaches would be most affected by new water diversions? Are those reaches most-

affected amenable to thermal mapping, nutrient regeneration, and various forms of sampling? Has any of the existing fish sampling data used the location of downwelling/upwelling regions as a design criteria?

12. How has the Gila River system changed since human colonization of the valley? What is the natural state of the system? This could help people understand the changes that have already occurred, and provide important context for restoration or mitigation efforts. For example, were there historically more wetlands in the system, or larger beaver populations? Is flood storage an important component of the system?

Information needs

Each expert was asked to state what information would be most helpful to support water management decisions in the Upper Gila River. While not specified, each expert focused on their individual area expertise/experience. Across the group we have an integrated picture limited only by the breadth of expertise and experience of the panelists.

Stuart Bunn: 1a) compile and analyze available data for water budgets on a nodal basis, 1b) identify ecological assets (including ecosystem goods & services) that people in the region value most highly, 1c) place the Gila River in context with other dryland river systems, 2) of assets in (1b), determine how they respond to flow, 3) use (2 and 1a) to identify knowledge gaps that impede decision-making or the ability to predict future condition, and 4) fill knowledge gaps in any way possible (uncertainty may remain).

Robert Wissmar: 1) spatially characterize the river corridor landscape using Lidar dataset, 2) measure physical dimensions in constrained and unconstrained reaches, including valley width, channel gradient, vegetation, land covers (e.g., agricultural fields, residential, roads, etc.), 3) compile derived interpretations including stream power, sediment budgets, frequency of pools, gravel deposits, etc., and 4) model and simulate flood duration and its effects on channel and floodplain geometry.

Julian Olden: 1) Collate existing data on fish, macro-invertebrate and aquatic plant species distributions throughout the mainstem and tributaries with the purpose of developing a central database. The database should be spatially-explicit, i.e., interfaced with a Geographic Information System, which provides the opportunity to understand (and ultimately predict) species distributions at different spatial scales. 2) Collate descriptors of reach- and catchment-level habitat which are considered important for shaping fish, macro-invertebrate and aquatic plant communities. Landscape-level data (see John's requests) are also needed to quantify patterns of land-use in different basins, and to calculate metrics of habitat fragmentation and connectivity. This information should also be formalized into a single, geo-referenced database. 3) Develop hydrologic models and regionalization analyses (models linking discharge to rainfall, air temperature, land cover and other physical variables) that reconstruct reach-scale discharge throughout the basin (or in the least at multiple locations throughout the basin). With this information, flow regimes (i.e., magnitude, frequency, duration, timing and rate of change in flow events) can be calculated and associated with patterns in native and non-native communities. Future scenarios of environmental flows can then be related to population and community metrics (defined in #1) to predict changes in biological communities associated with potential water diversions. 4) Conduct fish community surveys within specific reaches (identified by #1) to eliminate gaps in our knowledge with respect to the longitudinal distribution of high nuisance, invasive fish species and at-risk native species. 5) Collate existing data on life-history and ecological traits of the native and non-native fishes of the Upper Gila River Basin to develop conceptual models (which can be parameterized using the information gained in #1-4) relating altered flow regimes to the distribution of at-risk species and the future invasion potential of non-native species.

John Bolte: 1) identify landscape attributes and spatial resolution needed for quantification and classification of land use/land cover, 2) obtain satellite imagery (Landsat, SPOT,) characterization of the entire basin, 3) acquire topography (10-30 m pixel size) DEM, 4) characterize soils (STATSGO, SSURGO), 5) identify human cultural parcel dimensions, ownership, water rights associated with parcels, point withdrawals of water, 6) plug all data into GIS layers, 7) integrate with population growth characteristics past, present and projected, 8) summarize property values (including water), zoning and building permits, 9) exogenous drivers (including interbasin transfers).

Dave Meko: 1) Assemble the existing paleoclimatic data and instrumental climatic data relevant to documenting the interannual variability in runoff. The paleoclimatic data should include hydrologic and climatic reconstructions as well as the basic tree-ring chronologies in a search radius around the basin reflecting the spatial coherence of precipitation in this part of the Southwest. The instrumental data should include gauged streamflow, precipitation, temperature, drought indices, and whatever snow-depth or snow-water-equivalent data that might be available. 2) Assess existing tree ring coverage of drought-sensitive conifers in runoff-producing parts of the basin and determine where the coverage might be improved, 3) Evaluate seasonal moisture signals in the partial-width components (latewood and earlywood) of selected conifer species in the basin (pilot study). The objective would be to determine whether tree-ring data from the basin are suitable for resolving interannual variability of winter vs. monsoon moisture. 4) In riparian areas, especially those that might be impacted by decisions on water withdrawals, identify tree species (e.g., hackberry, black walnut, and cottonwood) useful for long term dendrohydrologic information related to long-term stresses due to fluctuations in ground water and surface water.

Dave Goodrich: 1) develop an understanding from the local people what they want through professionally-facilitated stakeholder meetings (local & regional) that explain to the people that there is variability and the system was probably different historically and will probably be different in the future (e.g., ecological attributes, focused areas of development or retention in agriculture or economic enhancement), 2) quantify extent and depth of the alluvial aquifer (e.g., aero-magnetic geophysical survey, USGS/NM Bureau of Mines data) and something about its hydraulic conductivity, aqueous geochemistry, and isotopic characterization (source & age of water), 3) identify & engage all relevant stakeholders.

Recommendations for an Integrated Investigative Framework

A framework for integration and synthesis of scientific information is required and must be formulated with clear guiding scientific principles. Science and technical needs certainly will include the characterization of the hydrology, the drainage basin, the ecosystem of the river corridor, and existing and potential future human activities in the region. However, a series of disconnected and independent science projects will not adequately inform the decision making process. Instead, projects organized around a solid integrative framework based on clear guiding scientific principles are required. Guiding scientific principles link hydrology and hydrologic modification to the biological components of the ecosystem. Understanding built from a wide range of riverine systems yields a core set of guiding principles that include: 1) flow is a master variable in aquatic systems that determines physical habitat and ultimately drive ecological processes and shape biotic composition (Poff et al. 1997), 2) aquatic species have evolved life history strategies primarily in direct response to natural flow regimes (Poff and Ward 1990, Lytle and Poff 2004), 3) maintenance of natural patterns of longitudinal and lateral connectivity is essential to the viability of populations of many riverine species (Ward 1989), 4) the invasion and success of non-indigenous and invasive species in rivers can be facilitated by the alteration of flow regimes (Bunn and Arthington 2002) and 5) anthropogenic impacts must be integrated into environmental assessments of river ecosystems (Allan 2004).

What constitutes an integrated investigative framework for providing environmental flows to sustain river ecosystems? John Bolte provided a well-developed example from the Willamette River basin in Oregon. A predicted doubling of population in the basin by 2050 led to an integrated planning process that generated the Willamette River Basin Planning Atlas (www.oregonstate.edu/Dept/pnw-erc/) and a decision support model (Evoland) that informs decision making in the basin. Dave Goodrich described an integrated approach for river management and flow evaluation in the Upper San Pedro River that engaged local residents, managers, and scientists in decision making for the future of this arid land ecosystem. The presentations by these participants in the Upper Gila River Science Forum are two useful examples of integrated investigative frameworks for science-based decision making.

The science of environmental flows, sustaining river ecosystems, and integrative research frameworks for river management has grown exponentially (Richter et al. 2006). Four examples clarify the meaning of integrative investigative frameworks applied to river flows: 1) Southwest Florida Water Management District (SWFWMD), 2) Texas Instream Flow Program, 3) United States Geological Survey (USGS), and 4) Australian Rivers Institute. The SWFWMD is charged by state statute with determining "the minimum flow for a given watercourse shall be the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area." The approach that has been adapted by the SWFWMD includes an integrated set of scientific studies that includes hydrograph analyses, climate variability, depths for fish passage wetted perimeter inflection points, modeling of physical habitat, and inundation patterns (www.swfwmd.gov). This science-based approach has allowed the development of critical environmental flows and levels throughout the annual hydrograph that balances the needs of human populations with sustaining healthy rivers. The Texas Instream Flow Program was recently reviewed by the National Research Council of the National Academies (National Research Council 2005). Ten major recommendations were made with two being particularly relevant to an integrative framework. The two recommendations are 1) a suite of measurable, ecological indicators should be established that are responsive to instream flows, and 2) individual technical evaluations should be integrated into instream flow recommendations. The USGS also has recently reviewed the status of river science at the USGS (www.nap.edu/catalog/11773). The need for integration of science-based information that crosses traditional disciplines is identified as critical for river management and determining environmental flows. Two crosscutting science activities, surveying and mapping the nation's river systems according to key physical and landscape features and expanding work on predictive models that simulate interactions between physical-biological processes, are highlighted as highest priority river science questions. An excellent example of applying this approach for a regional river of interest is the recent report on the Bill Williams River in Arizona (Shafroth and Beauchamp 2006). Science studies report on streamflow relations with riparian vegetation, birds, fish, aquatic invertebrates, mammals, reptiles, amphibians, and floodplain invertebrates utilizing an integrative framework. Finally, the Australian Rivers Institute (e.g., Bunn and Arthington 2002, Arthington et al. 2006) describe principles and procedures for integrative investigative frameworks for setting environmental flow rules and evaluating the effects of altered flow regimes for river and floodplain ecosystems. Keys to defining environmental flows to sustain riverine ecosystems are hydrological classification methods combined with ecological calibration.

What are key elements of an integrative framework for the Gila River? Ideas from the science forum and discussion with the science forum coordinators and presenters include:

1. Thorough in-depth analyses of the long-term hydrographs and climatic and paleoclimatic linkages to river flow in the Gila River Basin.
2. Detailed mapping of the geomorphology and habitats of the riverine floodplain.
3. Characterization of ground water/surface water interactions and delineation of source waters under various flow regimes.
4. Ecological studies firmly grounded in ecosystem hydrology and organism response to flow variability and flow alteration.
5. An ecosystem or ecohydrology perspective on synthesizing and integrating various research components.
6. Substantive involvement of local stakeholders concerning the status and desired future conditions of the riverine corridor.

An integrative investigative framework is best implemented at the initiation of research rather than imposed after the fact. Decisions regarding priority areas for science in the Gila River basin should be firmly linked to a clearly articulated integrative investigative framework. An example of one approach to an integrated scientific framework for the Gila River is presented in the **Appendix** of this report.

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URLs

1)http://ag.arizona.edu/AZWATER/EWSR/
Multi-disciplinary project (Water Resources Management, Hydrologic Modeling, Economics, Paleoclimatology) on enhancing water-supply reliability in the Colorado River Basin

2)http://www.ncdc.noaa.gov/paleo/pubs/woodhouse2006/woodhouse2006.html
Updated reconstructions for Colorado River at Lees Ferry

3)http://fp.arizona.edu/khirschboeck/srp.htm
Study of joint drought in UCRB and Arizona for Salt River Project

Appendices

The following are compiled in sequence below.

1. letter of participation from Coordinators to Science Forum Panel (2 pages)
2. brochure for forum (2 pages)
3. program/handout for forum (2 pages)
4. 2 page NSF like CVs of presenters (2 pages each)
5. extended abstracts of presentations (1 page each)
6. presentations (2 slides per page, PDF converted)
7. A high level summary presentation of the Upper Gila River Science Forum
8. Science Forum Coordinators presentation of an example approach to an integrated scientific framework for the Gila River (2 slides per page, PDF converted)

1. Letter of participation from Coordinators to Science Forum Panel

Dear John, Julian, Bob, Stuart, Dave and David,

We thank all of you for agreeing to participate as panelists in the first Upper Gila River Science Forum. This letter serves as an introduction both amongst our group and to the task we have been asked to help accomplish. First, introductions all round. We, the "Coordinators" of the Science Forums are: Robert Glass (Sandia National Laboratories), Cliff Dahm (University of New Mexico) and Dave Cowley (New Mexico State University). And the panel for the first forum is:

Dave Goodrich: http://www.ars.usda.gov/pandp/people/people.htm?personid=2059
David Meko: http://www.ltrr.arizona.edu/~dmeko/
Stuart Bunn: http://www.griffith.edu.au/centre/riverlandscapes/
John Bolte: http://bioe.orst.edu/Faculty/bolte/
Julian Olden: http://www.fish.washington.edu/people/olden/
Bob Wissmar: http://www.fish.washington.edu/people/wissmar/

The purpose of the Science Forums are to provide an independent and external view of the scientific issues that must be resolved as part of the Upper Gila River Settlement Decision Process. The New Mexico Interstate Stream Commission's description of this process is attached. Figure 6 on page 15 shows where the Science Forums fit within the process. There are 5 other activities that also feed the Gila-San Francisco Coordinating Committee (GSFCC, the center oval) besides the Science Forums. Additional information may be found at http://www.ose.state.nm.us/isc_colorado_gila_sanfran_committee.html.

The goals of the Science Forums are to:
1) identify scientific and technical needs required to support the decision process;
2) prioritize these needs and help develop an optimal strategy to fulfill them;
3) place the Gila and its water management issues in context of other analogous efforts across the US and abroad; and
4) be independent and observable.

For the first Science Forum, we decided to invite a small number of experts representing a variety of key areas that could work with the coordinators to frame the problem as a whole. While certainly not exhaustive, the areas chosen were: Ecology and eco-hydrology of watersheds; Native species, established exotic species, endangered species, population genetics, diversity; Fluvial and watershed hydrology; Climate and climate fluctuation/change, paleoclimatic studies and hydrologic reconstructions; and Management of natural and agro-ecosystems.

Preliminary Agenda: October 20-23, 2006
Friday: Introduction (Lichty Center, we will be staying there, ~20 minutes from WNMU)
- Arrive by 5PM or before
- Dinner (Lichty Center)

-After dinner introduction to the Upper Gila River Settlement Decision Process the role of the Science Forums and our individual/group goals

Saturday: Science Forum (WNMU)

-Each panelist will have an hour for presentation and questions/answers followed by a two hour structured discussion amongst the panel, coordinators, and forum attendees

Sunday: Integration and Synthesis by coordinators and panel (Lichty Center)

-We will take a first cut at goals 1-3 as a group

-Formulate a plan for publication and subsequent Science forums

-Hopefully experience some of the Gila

Monday: Path forward (Lichty Center)

-Breakfast followed by discussion of path forward. Break ~10AM

It is our hope that you all will choose to continue to be involved in subsequent Forums and what we believe will be a productive exchange over water management issues within the arid Southwest in the next few years. An expected outcome of the first Forum is a first cut at goals 1-3 (while maintaining 4), and a plan for subsequent Science Forums that would refine, expand and fill in the gaps. It is also hoped that by pooling our experiences, we will be able to design a path that would accomplish these goals as quickly as possible, there is only about a 2 year window of opportunity for the Science Forums to have an impact on the decision process on the Gila.

Finally, we are responsible for documenting the Forum. At a minimum we will generate a report for the NMISC that will include your bios, summaries of your talks (likely the talks themselves as appendices), and a write up of our discussions from the weekend. Beyond this, we are interested in crafting a publication or series of publications for the open literature. Please keep this in mind as it will be a topic of discussion on Sunday.

Again, we thank you for your participation and look forward to the first Science Forum. This is going to be a lot of fun. Please get back to us with any questions that you may have and please also confirm that your email address. Further details will be forthcoming.

Sincerely,
Bob, Cliff and Dave

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olden@u.washington.edu

2. Brochure (insert following)

3. Program/handout for forum

Upper Gila River Science Forum **October 21, 2006** Western New Mexico University Bessie-Forward Global Resource Center Main Auditorium Coordinators: David Cowley, New Mexico State University Cliff Dahm, University of New Mexico Bob Glass, Sandia National Laboratory	
7:45-8:45	Registration
8:45-9:00	**Craig Roepke**, New Mexico Interstate Stream Commission, & **Science Forum Coordinators** *Introductions and Purpose of the Science Forum*
9:00-9:50	**Stuart Bunn**, Australian Rivers Institute, Griffith University, Queensland, Australia - "*Environmental Flows and Australian Dryland Rivers"*
10:00-10:50	**David Meko**, Laboratory of Tree-Ring Research, University of Arizona - *"Long-term Variability of Streamflow in the Southwest"*
11:00-11:50	**Robert Wissmar**, School of Fishery & Aquatic Sciences, University of Washington - "*Stream-Riparian Landscape Perspectives and the Upper Gila River*"
12:00-1:00	Lunch (on your own)
1:00-1:50	**Julian Olden**, School of Fishery & Aquatic Sciences, University of Washington - "*Introduction, establishment and impact of non-indigenous fishes in the Lower Colorado River Basin*"
2:00-2:50	**John Bolte**, Department of Biological & Ecological Engineering, Oregon State University - "*Alternative Futuring in the Willamette River Basin"*
3:00-3:50	**Dave Goodrich**, USDA-Agricultural Research Service, University of Arizona - *"Integrating Science and Decision-Making in the Upper San Pedro: Research Results and Lessons Learned"*
4:00-5:30	Open Forum
5:30-7:30	Mixer - one-on-one with speakers & coordinators

Description with Science Forum Program

Upper Gila River Science Forum

This initial science forum on the Upper Gila River is designed to bring in national and international experts on river ecosystem management. These researchers, both individually and collectively, have considerable experience working on real-world river management projects. These individuals can help inform the scientific process as we gather key scientific information needed to protect and sustain the Upper Gila River of New Mexico. Science is an objective quest for understanding, and science builds on the past and the experience of others to accumulate this understanding and to identify key uncertainties that need to be addressed. Defining what scientific questions need to be addressed, helping frame the required research questions and approaches, and learning from the experience of others are key components of this first Upper Gila River science forum.

We will hear from each of the six speakers for approximately 45 minutes with 10 minutes reserved for questions after each presentation. Three of the presentations will occur before lunch and three will follow the lunch break. The speakers will discuss river ecosystem management and environmental flows from their extensive experience worldwide. They have been charged with helping us to understand what we need to know scientifically about the Upper Gila River and the surrounding catchment. A central theme for this inaugural science forum is defining the constraints for sustainable river ecosystems. How do we sustain a healthy river that is robust to fluctuations in the natural environment? The focus in this first forum will be on environmental or ecological sustainability. After the six presentations, there will be an open forum for the audience to address questions to the presenters and further discuss ideas generated by the talks.

This science forum is not intended to discuss specific alternatives or policy directions for water management in the Upper Gila basin. The forum is intended, however, to assist in determining specific scientific research that needs to be completed to provide the information for a comprehensive, ecosystem-based evaluation of future management decisions. What is the science that needs to be done to inform the decision making process? What are the gaps in scientific information that should be filled in the next few years? What are sensitive and useful measurements that should be carried out to better define the health and sustainability of the Upper Gila River? We hope this inaugural science forum will assist us in answering these and similar questions.

4. Curriculum vitae

Professor Stuart E. Bunn

Institution and Position

Director, Australian Rivers Institute,
Griffith University,
Nathan campus,
Queensland, AUSTRALIA, 4111.

Office:	(+61-7) 3735 7407	Fax:	(+61-7) 3735 7615
Email:	S.Bunn@griffith.edu.au	Web:	www.rivers.edu.au

Qualifications: BSc Hons *(West Aust.)* 1980; PhD *(West Aust)* 1985

Recent Employment History

1999- present	Professor in Ecology, Griffith University
1999-2002	Director, Land and Water Australia

Research Experience and Interests

- river and riparian ecology and aquatic food webs;
- aquatic ecosystem health assessment;
- environmental flow allocations.

Recent Distinctions

- President, Australian Society for Limnology (2006 –);
- Water Champion, Earth Dialogues Meeting, Brisbane 2006;
- Education and Capacity Building Taskforce, UNESCO-IHP (2006 –);
- Steering Committee, Global Water System Project (2005 –);
- Scientific Committee for Water Research, International Council of Science (1999-02).

Major Grants Received

Over $10 million in R&D funding, including grants from Cooperative Research Centres (Catchment Hydrology, Freshwater Ecology), the Australian Research Council (Discovery, RIEF and Linkage), Land and Water Australia, South East Queensland Healthy Waterways Partnership, Department of Environment and Heritage Australia and Griffith University.

Consultancies

Over 30 environmental consultancies with industry and government agencies; including environmental flow assessments, environmental assessments of mining on river systems, river and riparian restoration and development of ecosystem health monitoring programs.

Publications

12 book chapters, 85 journal articles and over 80 other technical publications and reports. Over 100 citations per year (ISI Web of Knowledge).

Oral presentations

Over 50 invited conference and workshop papers, 40 conference papers and 75 invited lectures and seminars.

Selected publications on environmental flows and river ecosystem health

Tockner K, **Bunn SE,** Gordon C, Naiman RJ, Quinn GP & Stanford JA (in press). Floodplains: Critically threatened ecosystems. *In*: N Polunin (ed). *Future of aquatic ecosystems*. Cambridge

Arthington AH, **Bunn SE**, Poff NL & Naiman RJ (2006). The challenge of providing environmental flow rules to sustain river ecosystems. *Ecological Applications* **16**, 1311-18.

Bernhardt E, **Bunn SE**, *et al*. (2006). The challenge of ecologically sustainable water management. *Water Policy* **8**, 475-9.

Udy JW, Fellows CS, Bartkow M, **Bunn SE,** Clapcott JE & Harch BD (2006). Measures of nutrient processes as indicators of stream ecosystem health. *Hydrobiologia* **572**, 89-102.

Fellows CS, Clapcott JE, Udy JW, **Bunn SE,** Harch BD & Davies PM (2006). Benthic metabolism as an indicator of stream ecosystem health. *Hydrobiologia* **572**, 71-87**.**

Bunn SE, Thoms MC, Hamilton SK & Capon SJ (2006). Flow variability in dryland rivers: boom, bust and the bits in between. *River Research and Applications* **22**, 179-86.

Bunn SE, Balcombe SR, Davies PM, Fellows CS & McKenzie-Smith FJ (2006). Productivity and aquatic food webs of desert river ecosystems. *In:* RT Kingsford (ed). *Changeable, Changed, Changing: the Ecology of Desert Rivers.* pp 76-99. Cambridge.

Abal EG, **Bunn SE** & Dennison WC (eds) (2005). *Healthy Waterways, Healthy Catchments: Making the connection in south east Queensland*. Moreton Bay & Catchments Partnership, Queensland. 222p.

Douglas MM, **Bunn SE** & Davies PM (2005). River and wetland food webs in Australia's wet-dry tropics: general principles and implications for management. *Mar. Freshw. Res.* **56**, 329-342.

Hamilton SK, **Bunn SE**, Thoms MC & Marshall J (2005). Persistence of aquatic refugia between flow pulses in a dryland river system (Cooper Creek, Australia). *Limnol. Oceanog.* **50**, 743–54.

Hadwen WL, **Bunn SE**, Arthington AH & Mosisch TD (2005). Within-lake detection of the effects of tourist activities in the littoral zone of oligotrophic dune lakes. *Aquatic Ecosystem Health and Management* **8**, 159-173.

Rutherford JC, Marsh NA, Davies PM & **Bunn SE** (2004). Effects of patchy shade on stream water temperature: how quickly do small streams heat and cool? *Mar. & Freshw. Res.* **55**, 737-48.

Hadwen WL & **Bunn SE** (2004). Tourists increase the contribution of autochthonous carbon to littoral zone food webs in oligotrophic dune lakes. *Mar. Freshw. Res.* **55**, 701-8.

Bunn SE (2003). Healthy River Ecosystems: vision or reality? *Water* **30**, 7-11.

Bunn SE, Davies PM & Winning M (2003). Sources of organic carbon supporting the food web of an arid zone floodplain river. *Freshwater Biology* **48**, 619-635.

Hughes JM, Goudkamp K, Hurwood DA, Hancock M & **Bunn SE** (2003). Translocation causes extinction of a local population of the Glass Shrimp, *Paratya australiensis. Conservation Biology* **17**, 1007-12.

Bunn SE & Arthington AH (2002). Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. *Environmental Management* **30**, 492-507.

Naiman RJ, **Bunn SE,** Nilsson C, Petts GE, Pinay G & Thompson LC (2002). Legitimizing fluvial ecosystems as users of water: an overview. *Environmental Management* **30**, 455-67.

Bunn SE & Davies PM (2000). Biological processes in running waters and their implications for the assessment of ecological integrity. *Hydrobiologia* **422**, 61-70.

Bunn SE, Davies PM & Mosisch TD (1999). Ecosystem measures of river health and their response to riparian and catchment degradation. *Freshwater Biology* **41**, 333-345.

Loneragan NR & **Bunn SE** (1999). River flows and estuarine ecosystems: Implications for coastal fisheries from a review and a case study of the Logan River, southeast Queensland. *Australian Journal of Ecology* **24**, 431-440.

Dr. David M. Meko

EDUCATION

Pennsylvania State University, B. S., 1972, Meteorology
University of Arizona, M. S., 1974, Atmospheric Sciences
University of Arizona, Ph.D., 1981, Hydrology and Water Resources

EMPLOYMENT

2004-Present: Associate Research Professor, Laboratory of Tree-Ring Research (LTRR)
1994-2004: Principal Research Specialist, Laboratory of Tree-Ring Research
1991-1994: Adjunct Assistant Professor of Dendrochronology, Laboratory of Tree Ring Research
1988-1991: Research Associate, Laboratory of Tree-Ring Research, University of Arizona.
1986-1988: Hydrologist/Assistant Director, Water Resources Department, Tohono O'odham Nation, Sells, Aizona

PROFESSIONAL MEMBERSHIPS

Member of American Meteorological Society (Member, Committee on Statistics, 1995-97)
Member of American Geophysical Union

SELECTED PUBLICATIONS

Cook E. R., Meko D. M. and Stockton C. W. (1997) A new assessment of possible solar and lunar forcing of the bi-decadal drought rhythm in the western United States. *Journal of Climate* **10**, 1343-1356.

Cook E. R., Woodhouse C., Eakin C. M., Meko D. M. and Stahle D. W. (2004) Long-term aridity changes in the western United States. *Science* **306**, 1015-1018.

Dettinger M. D., Cayan D. R., Diaz H. F. and Meko D. M. (1998) North-south precipitation patterns in western North America on interannual-to-decadal timescales. *Journal of Climate* **11**, 3095-3111.

Meko D. M., Stockton C. W. and Boggess W. R. (1980) A tree-ring reconstruction of drought in southern California. *Water Resources Bulletin* **16**(4), 594-600.

Meko D. M. and Stockton C. W. (1984) Secular variations in streamflow in the western United States. *J. of Climate and Applied Meteorology* **23**(6), 889-897.

Meko D. M., Stockton C. W. and Blasing T. J. (1985) Periodicity in tree rings from the corn belt. *Science* **229**, 381-384.

Meko D. M. (1992) Spectral properties of tree-ring data in the United States Southwest as related to El Nino/Southern Oscillation. In *El Nino, Historical and Paleoclimatic Aspects of the Southern Oscillation* (ed H. F. Diaz and V. Markgraf), pp. 227-241. Cambridge: Cambridge University Press.

Meko D. M., Stockton C. W. and Boggess W. R. (1995) The tree-ring record of severe sustained drought. *Water Resources Bulletin* **31**(5), 789-801.

Meko D. M., Therrell M. D., Baisan C. H. and Hughes M. K. (2001) Sacramento River flow reconstructed to A.D. 869 from tree rings. *J. of the American Water Resources Association* **37**(4), 1029-1040.

Meko D. M. (1997) Dendroclimatic reconstruction with time varying subsets of tree indices. *Journal of Climate* **10**, 687-696.

Meko D. M. (2005) Changes in regional hydroclimatology and water resources on seasonal to interannual and decade-to-century timescales. In *Encyclopedia of Hydrological Sciences, Volume 5, Part 17, Climate Change* (ed M. G. Anderson), pp. 3073-3088. John Wiley & Sons, Ltd.

Meko D. M. (2005) Changes in regional hydroclimatology and water resources on seasonal to interannual and decade-to-century timescales. In *Encyclopedia of Hydrological Sciences, Volume 5, Part 17, Climate Change* (ed M. G. Anderson), pp. 3073-3088. John Wiley & Sons, Ltd.

Meko D. M. and Woodhouse C. A. (2005) Tree-ring footprint of joint hydrologic drought in Sacramento and Upper Colorado River Basins, western USA. *Journal of Hydrology* **308**, 196-213.

Meko D. M. and Woodhouse C. A. (in review) Dendroclimatology, dendrohydrology, and water resources management. In *Dendroclimatology: progress and prospects* (ed M. K. Hughes, T. W. Swetnam and H. F. Diaz). Springer.

Shamir E., Meko D. M., Graham N. E. and Georgakakos K. P. (submitted) Hydrologic model for water resources planning in the Santa Cruz River, southern Arizona. *Journal of the American Water Resources Association*.

Touchan R., Meko D. M. and Hughes M. K. (1999) A 396 year reconstruction of precipitation in southern Jordan. *Journal of the American Water Resources Association* **35**(1), 49-59.

Woodhouse C. A. and Meko D. M. (1997) Number of winter precipitation days reconstructed from southwestern tree rings. *J. of Climate* **10**, 2663-2669.

Woodhouse C. A., Gray S. T. and Meko D. M. (2006) Updated streamflow reconstructions for the Upper Colorado River Basin. *Water Resources Research* 42, W05415, doi:10.1029/2005WR004455.

CURRENT RESEARCH PROJECTS

"Extreme droughts in the Winnipeg River Basin, Canada." **PI: D. Meko**; Co-PI: Scott St. George. Manitoba Hydro

"A tree-ring based hydroclimatic assessment of synchronous extreme streamflow episodes in the upper Colorado and Salt-Verde River basins". PI: Katie Hirschboeck, **Co-PI: David Meko**. Salt River Project

"Hydroclimatic reconstruction and ancient blue oak mapping over the drainage basin of San Francisco Bay." **PI: D. Meko**. CALFED-- subcontracted through University of Arkansas

"Drought on the Colorado River: Tree-ring Perspective, A.D. 1200s to Present." PI: **D. Meko**. California Department of Water Resources

"The Current Drought in Context, A Tree-Ring Based Evaluation of Water Supply Variability for the Salt-Verde River Basin." PIs: Hirschboeck K. K. and **Meko D. M**. The Salt River Project

"Integrating Improved Water Supply Predictive Capacity and Response into Lower Colorado Basin Policy and Management." PIs: B. Colby, K. Jacobs, **D. Meko**, P. Troch. US Bureau of Reclamation

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http://www.fish.washington.edu/people/wissmar/

Education

B.S., Zoology, University of Utah, 1965
M.S., Zoology, University of Idaho, 1968
Ph.D., Zoology, University of Idaho, 1972
Thesis: Effects of Mine Drainage on Primary Production in
Coeur d'Alene River and Lake, Idaho

Professional Employment

1972-74 Research Associate, School of Fisheries (SOF), Univ. Washington
1974-79 Research Assistant Professor, SOF, Univ. Wash.
1979-84 Research Associate Professor, SOF, Univ. Wash.
1983-84 Visiting Professor, Western Washington University (Bellingham)
1984- Research Professor, Univ. Washington
1990- Professor, SOF, Univ. Washington
1991- Adjunct Professor, CFR, Univ. Washington

Select Publications:

Wissmar, R. C. and R. K. Timm (in press). Watershed and Stream Landscapes, Prince of Wales Island, Alaska. PNW-GTR- , USDA Forest Service, Portland Oregon.

Dahm, C. Larson, D., R. Petersen and R. C. Wissmar 2005. Response and recovery of lakes in the blast zone of Mount St. Helens, Washington. Pages 255-276 *in* VH Dale, FJ Swanson, CM Crisafulli (eds.), Ecological responses to the 1980 eruptions of Mount St. Helens. Springer-Verlag, NY.

Stolnack, S. M. D. Bryant and R. C Wissmar 2005. A review and critique of monitoring strategies applied to land management practices. PNW-GTR-625, USDA Forest Service, Portland Oregon.

Wissmar, R. C. and S. D. Craig. 2004. Factors affecting habitat selection by a small spawning char population, bull trout, Salvelinus confluentus: implications for recovery of an endangered species. Fish. Mgmt. Ecol. 11:23-31.

Hall, J. L. and R. C. Wissmar 2004. Redd site selection in Floodplain ponds by sockeye salmon. Transactions of the American Fisheries Society. 133: 1480-1496.

Timm, R. K., R. C. Wissmar, J. W. Small, T. M. Leschine, and G. Lucchetti 2004. Multi-Scale prioritization of riparian habitats for restoration and preservation. Environmental Management. 33: 151-161.

Wissmar, R. C., W. N. Beer, R. K. Timm 2004. Spatially explicit estimates of erosion-risk indices and variable riparian buffer widths in watersheds. Aquatic Sciences. 66: 446-455.

Wissmar, R. C., R. K. Timm and M. G. Logsdon 2004. Effect of land cover change on discharge regimes of urbanizing watersheds. Environmental Management. 34: 91- 98.

Wissmar, R.C. 2004. Riparian corridors of Eastern Oregon and Washington: functions and sustainability along lowland-arid to mountain gradients. Aquatic Sciences. 66: 373-387.

Wissmar, R. C. and R. K. Timm. 2003. Changes in land uses, hydrology and fish habitats in an urban drainage, Cedar River, Washington. Pages 709-714 in Proceedings of the First Interagency Conference in Watersheds, 27-30 October 2003, Bensen, AZ.

Wissmar, R. C. and P.A. Bisson. 2003. Strategies for restoring rivers: problems and opportunities. Pages 245-262 in R.C. Wissmar And P.A. Bisson, editors. Strategies for restoring river ecosystems: sources of variability and uncertainty in natural and management systems. American Fisheries Society, Bethesda, Maryland.

Wissmar, R. C., J. H. Braatne, R. L. Beschta, S. B. Rood. 2003. Variability of riparian ecosystems: implications for restoration. Pages 107-127 *in* R.C. Wissmar And P.A. Bisson, editors. Strategies for restoring river ecosystems: sources of variability and uncertainty in natural and management systems. American Fisheries Society, Bethesda, Maryland.

Wissmar, R. C. and P.A. Bisson. 2003. Strategies for restoring rivers: problems and opportunities. Pages 245-262 *in* R.C. Wissmar And P.A. Bisson, editors. Strategies for restoring river ecosystems: sources of variability and uncertainty in natural and management systems. American Fisheries Society, Bethesda, Maryland

Wissmar, R. C. and R. Beschta. 1998. Restoration and the management of riparian ecosystems. Freshwater Biol. 40 (3): 571-585

Bryant, M. D., D. N. Swanston, R. C. Wissmar, and B. E. Wright. 1998. Salmonid populations in the karst landscape of north Prince of Wales Island, southeastern Alaska. Trans. Am. Fish. Soc. 127:425-433.

Wissmar, R. C., J. Stanford, and B. K. Ellis. 1997. 15N natural isotope tracing of nitrogen in insect food webs of hyporheic habitats. Pages 166-171 in J. Gilbert, J. Mathieu, and F. Fournier (eds.), Groundwater/Surface Water Ecotones: Biological and Hydrological Interactions and Management Options. International Hydrology Series, Cambridge University Press, Cambridge, UK.

McIntosh, B.A., J.R. Sedell, J.E. Smith, R.C. Wissmar, S.E. Clarke and G.R. Reeves, and L.A. Brown. 1994. Historical changes in fish habitat for select river basins of eastern Oregon and Washington. Special Issue: Northwest Science.69: 36-53.

Benda, L., T. Beechie, R.C. Wissmar and A.C. Johnson. 1992. Morphology and evolution of salmonid habitats in a recently deglaciated river basin, Washington State, U.S.A. Can. J. Fish. Aquat. Sci. 49(6): 1246 -1256.

Reice, S., R.C. Wissmar and R.J. Naiman. 1990. Influence of spatial-temporal heterogeneity and background disturbance regime on the recovery of lotic ecosystems. Environ. Management 14 (5): 647-659.

Wissmar, R.C. and Swanson, F.J. 1990. Landscape Disturbance and Lotic Ecotones.pp.65-89. In: Naiman, R.J. and H. Decamps (eds.). Ecology and Management of Aquatic-Terrestrial Ecotones, Parthenon Press, London.

Wissmar, R. C., A. H. Devol, J. T. Staley and J. R. Sedell. 1982. Biological responses in lakes of Mt. St. Helens blast zone. Science 216:178-181.

Wissmar, R. C., J. E. Richey, R. F. Stallard, and J. M. Edmond. 1981. Plankton metabolism and carbon cycling in the Amazon River, tributaries and floodplain water (Peru-Brazil 1977). Ecology 62(6):1622-1633.

JULIAN DAVID OLDEN

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University of Washington, Box 355020; Seattle WA 98195
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Web: http://fish.washington.edu/people/olden/
Date of Birth: May 24, 1975

1. PROFESSIONAL PREPARATION

University of Toronto	Zoology	B.Sc., 1998
University of Toronto	Zoology	M.Sc., 2000
Colorado State University	Ecology	Ph.D. 2004
University of Wisconsin	Limnology	Post-doc (2005-06)

2. APPOINTMENTS

Assistant Professor, University of Washington, School of Aquatic and Fishery Sciences, Sept 2006 – present.

3. PUBLICATIONS (from 44 total published articles)

a. Ten most relevant

Olden, J.D., McCarthy, J.M., Maxted, J.T., Fetzer, W.W., and M.J. Vander Zanden. 2006. The rapid spread of rusty crayfish (*Orconectes rusticus*) with observations on native crayfish declines in Wisconsin (U.S.A.): Trends over the past 130 years. *Biological Invasions* 8:1621-1628.

Mercado–Silva, N., Olden, J.D., Maxted, J.T., Hrabik, T.R., and M.J. Vander Zanden. 2006. Forecasting the spread of invasive rainbow smelt (*Osmerus mordax*) in the Laurentian Great Lakes region of North America. *Conservation Biology* 20:1740-1749.

Olden, J.D., Poff, N.L., and K.R. Bestgen. 2006. Life-history strategies predict fish invasions and extirpations in the Colorado River Basin. *Ecological Monographs* 76:25-40.

Olden, J.D., Joy, M.K., and R.G. Death. 2006. Rediscovering the species in community-wide modeling. Ecological Applications 16: 1449-1460.

McCarthy, J.M., Hein, C.L., Olden, J.D., and M. J. Vander Zanden. 2006. Coupling long-term studies with meta-analysis to investigate impacts of non-native crayfish on zoobenthic communities. *Freshwater Biology* 51:224-235.

Olden, J.D., and N.L. Poff. 2005. Long-term trends in native and non-native fish faunas of the American Southwest. *Animal Biodiversity and Conservation* 28:75-89.

Oakes, R.M. Gido, K.B., Falke, J.A., Olden, J.D., and B.L Brock. 2005. Modelling of stream fishes in the Great Plains, USA. *Ecology of Freshwater Fish* 14:361-374.

Vander Zanden, M.J., Olden, J.D., Thorne, J.H., and N.E. Mandrak. 2004. Predicting the occurrence and impact of bass introductions on temperate lake food webs. *Ecological Applications* 14:132-148.

Olden, J.D., and D.A. Jackson. 2002. A comparison of statistical approaches for modeling fish species distributions. *Freshwater Biology* 47:1976-1995.

Olden, J.D., and D.A. Jackson. 2001. Fish-habitat relationships in lakes: Gaining predictive and explanatory insight using artificial neural networks. *Transactions of the American Fisheries Society* 130:878-897.

b. Ten additional

Olden, J.D. 2006. Biotic homogenization: A new research agenda for conservation biogeography. *Journal of Biogeography* 33:2027-2039.

Olden, J.D., Jensen, O.P. and M.J. Vander Zanden. 2006. Implications of long-term dynamics of fish and zooplankton communities for among-lake comparisons. *Canadian Journal of Fisheries and Aquatic Sciences* 63: 1812-1821.

Neff, B.D., and J.D. Olden. 2006. Is peer review a game of chance? *Bioscience* 56: 333-340.

Olden, J.D., and N.L. Poff. 2004. Ecological mechanisms driving biotic homogenization: Testing of a mechanistic model using fish faunas. Ecology 85:1867-1875.

Olden, J.D., Joy, M.K., and R.G. Death. 2004. An accurate comparison of methods for quantifying variable importance in artificial neural networks using simulated data. *Ecological Modelling* 178:389-397.

Olden, J.D., Poff, N.L., Douglas, M.R., Douglas, M.E., and K.D. Fausch. 2004. Ecological and evolutionary consequences of biotic homogenization. *Trends in Ecology and Evolution* 19:18-24.

Olden, J.D., and N.L. Poff. 2003. Toward a mechanistic understanding and prediction of biotic homogenization. *American Naturalist* 162:442-460.

Olden, J.D. 2003. A species-specific approach to modeling biological communities and its potential for conservation. *Conservation Biology* 17:854-863.

Olden, J.D., and D.A. Jackson. 2002. Illuminating the "black box": Understanding variable contributions in artificial neural networks. *Ecological Modelling* 154:135-150.

Olden, J.D., Jackson, D.A., and P.R. Peres-Neto. 2001. Spatial isolation and fish communities in drainage lakes. *Oecologia* 127:572-585.

4. Research Funding

2006 U.S. Geological Survey - Lower Colorado River Basin Aquatic Gap, *Forecasting the geography of fish invasions in the Lower Colorado River Basin*, $43,500 US

2004 The Nature Conservancy David H. Smith Conservation Postdoctoral Fellowship, *Conservation planning and prioritization for invasive species: Forecasting invasions and their impacts in freshwaters*, $155,000 US

2004 National Science Foundation – Dissertation Improvement Grant, *Thermal fragmentation and genetic differentiation of fish populations in a riverine landscape*, $11,600 US

2001 Natural Sciences and Engineering Research Council of Canada – PGS B, $38,200 CAN

1999 Natural Sciences and Engineering Research Council of Canada – PGS A, $34,600 CAN

5. Scholarly Activities

Professional

Editorial Board, *Global Ecology and Biogeography*, 2006 - present
Member, Upper Gila River Science Forum, Sept 2006 – present
Staff, Lower Colorado River Basin Aquatic GAP Program, Aug 2006 - present

Popular Media

Animal Planet Report: February 24th, 2006
National Geographic: http://news.nationalgeographic.com/news/2005/11/1111_051111_globalization.html
ABC News: http://abcnews.go.com/Technology/story?id=1322154

Mentorship

Undergraduate Research Scholar Program (2005, Ashley Swanson), *Undergraduate mentor for* Julia McCarthy (2005). *Graduate student mentor for* Matt Diebel (2005, PhD) and Norman Mercado-Silva (2005, PhD). *Committee member* for Julien Cucherousset (commencing 2004, PhD., Université de Rennes, Cedex, France).

Outreach and Communication

Cowpasture River Preservation Association, Colorado State University Student Chapter of the American Fisheries Society (Vice-president 2002, Member 2000-2004).

Society Memberships
Ecological Society of America (2000 – present), American Fisheries Society (2000 – present), Society of American Naturalists (2003 – 2004), Society for Conservation Biology (2003 – present), North American Benthological Society (2002-2004), International Biogeography Society (2005 – present).

Referee for International Societies
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RECENT RELEVANT PUBLICATIONS:

Wallick, R., S. Lancaster, and J.P. Bolte. (In Press). Determination of bank erodibility for natural and anthropogenic bank materials using a model of lateral migration & observed erosion along the Willamette River, Oregon, USA. River Research and Applications.
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Brugnach, M., J.P. Bolte and G.A. Bradshaw. 2002. Determining the significance of threshold values uncertainty in rule-based classification models. Ecological Modeling. 160:63-67.
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SYNERGISTIC ACTIVITIES:

1. Oregon State University PI for the multi-institution Pacific Northwest Regional Collaboratory, leading the development of web-based application architecture and software for delivering geospatial and remote-sensing based decision support tools for natural resource management and decisionmaking.

2. PI of a highly multidisciplinary EPA-funded project "Developing Methods and Tools for Restoration Decisionmaking: Design, Implementation and Assessment in the Willamette Basin." This project integrates ecological, economic, and social scientists with information engineers and stakeholder groups

to address the complexities of watershed restoration decisionmaking under constraints via spatially explicit multiobjective optimization.

3. CoPI of a multidisciplinary NSF Biocomplexity project “Interactions of riparian pattern, policy and biocomplexity in coupled human/riverine systems” studying the interactions of riparian policy evolution, land use, and riparian function in several Willamette basin watersheds. This effort, initiated Fall 2001, uses spatially explicit analysis with a multiobjective decisionmaking core and an agent-based simulation approach to evolve policy/pattern constructs to explore development of effective strategies for managing riparian areas under conditions of ecological and social function scarcity.

4. PI of an EPA project “Modular Simulation Tools” developing a range of software tools for simulation analysis, inferencing, and spatial analysis. These tools implement state of the art, computationally efficient analysis methodologies applicable to the analysis of complex systems, as well as associated visualization and data mining codes.

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1990-Present Adjunct Assist./Assoc. Prof., Dept. Hydrology & Water Resources, U. Arizona, Tucson, AZ
1988-Present Research Hydraulic Engineer, USDA, ARS, Tucson, AZ

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Professional Society Memberships: AGU, ASCE
Honorary Society Memberships: Chi Epsilon, Phi Kappa Phi, Tau Beta Pi, Sigma Xi
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Associate Editor - Water Resources Research (1999-2000)

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1990-present: AGU Surface Water Hydrology Committee
1999-present: Upper San Pedro Partnership Advisory and Technical Committees
2000-Present: Executive Committee NSF SAHRA Science and Technology Center
2001-Present: US Interagency Global Water Cycle Committee
2004-Present: UNESCO International Hydrologic Program Expert Working Group

JOURNAL PUBLICATIONS OF THE LAST FOUR YEARS
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5. Extended Abstracts

Environmental flows and Australian dryland rivers

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There is growing agreement among scientists and managers that environmental allocations of water are essential to protect freshwater biodiversity and maintain the essential goods and services provided by rivers and their associated wetlands. We know that flow is a major determinant of physical habitat in streams, which in turn is a major determinant of biodiversity. We also acknowledge that many aquatic species have evolved life history strategies primarily in direct response to the natural flow regimes, and that the maintenance of natural patterns of longitudinal and lateral connectivity is essential to the viability of populations of many riverine species. There is also evidence that the invasion and success of exotic and introduced species in rivers is facilitated by the alteration of flow regimes (Bunn & Arthington, 2002). However, despite growing recognition of these important relationships between flow and river health, ecologists still struggle to predict and quantify biotic responses to altered flow regimes and this in turn hampers our ability to establish simple environmental flow rules (Arthington *et al*. 2006). Determining the environmental flow requirements for dryland rivers poses additional challenges for water resource managers and scientists, largely because of their extremely variable and unpredictable flow regimes.

In this presentation, I will explore the important relationships between flow regimes and river ecosystem health, with a particular focus on Australia's dryland river systems. Australian dryland rivers are among the most variable and unpredictable in the world in terms of their flow. Although renowned for their spectacular floods over vast floodplains, rivers exist for much of the time as discrete waterholes, which are important refugia for aquatic biota. Recent work has shown that waterholes are filled by surface flows with little evidence of groundwater contributions (Hamilton *et al*. 2005). The permanence of these refugia is determined by waterhole size and shape and, most importantly, by the duration of dry spells and the timing of flow events. Flow is clearly a major driver of aquatic production in these systems and ultimately influences food availability for fish and other consumers. Changing flow regimes in dryland rivers not only threatens the physical presence of important aquatic refugia but also the balance of these boom and bust cycles of aquatic production that sustain river and floodplain biota (Bunn *et al*. 2006).

To conclude, I will briefly outline some recent work on a methodology to assist in the development of environmental flow rules (Arthington *et al*. 2006) and highlight some challenges for ecologically sustainable management of rivers and wetlands. The latter includes our ability to predict thresholds of ecological change in response to flow alteration, the implications of climate change on water entitlements (including environmental allocations), and our tendency to consider flow impacts in isolation from those resulting from (often associated) land use activity.

Long-Term Variability of Streamflow in the Southwest

Dr. David Meko

Climatic variation and climate change are increasingly recognized as important factors in the long-term planning for management of water resources. This is especially true in the southwestern United States, where water demand is rapidly overtaking available supply. Instrumental records of precipitation, temperature, streamflow, and other runoff-related variables are of limited usefulness for characterizing the variability of runoff because such records are generally restricted to the most recent hundred years. Tree-ring data from selected tree species growing on moisture-stressed sites can greatly extend the length of available time series for charting hydroclimatic variability. The tree-ring variable of greatest value for streamflow reconstruction is the index of annual tree-ring width, which for properly selected trees integrates the moisture conditions over the year. In some locations, seasonal variations in precipitation and runoff can also be reconstructed by separate measurement of earlywood-width and latewood-width components of the annual ring.

A statistical model is necessary for converting tree-ring data into estimates of past streamflow. Calibration of the model requires an overlap of time series of tree rings with an observed flow series that, as much as possible, represents flow under "natural" conditions (e.g., minimal distortion by river regulation or water withdrawals). Length of reconstruction can vary from a few hundred years to thousands of years, with longer reconstructions typically making use of remnant preserved wood as well as core samples from living trees. Because tree-ring chronologies are averages over many trees, it is important for robustness to maintain an adequate sample depth throughout the period of reconstruction. Some limitation on the maximum possible wavelength of climate variation retained in streamflow reconstructions is imposed by the need to detrend ring widths in converting them to dimensionless indices. Nevertheless, tree-ring records several centuries long are useful in identifying wavelengths of variation outside the range of gauged flow records, and in flagging low-flow and high-flow extremes that may simply have occurred before the start of the gauged record.

Historically, the Upper Colorado River Basin has been the focus of tree-ring reconstruction in the western United States. The most recently published study on the Colorado River corroborates earlier studies that reported a long-term water availability lower than implied by the gauged records. The study also emphasizes the occurrence of past droughts longer and more intense than those experienced in the period of gauged flows. At least four previous tree-ring studies have addressed the Gila River Basin. The tree-ring site density for these studies is too sparse and unevenly distributed to spatially resolve differences in runoff history in various parts of the basin (e.g., San Francisco vs. Upper Gila), but the studies clearly demonstrate the suitability of tree-ring data for streamflow reconstruction on the Gila. Three of the previous studies generated reasonably accurate reconstructions of annual flow for the gage on the Gila River at the head of the Safford Valley. A reconstruction from samples from living trees extends to A.D. 1663. A reconstruction from spliced living-tree and archaeological records extends to A.D. 534. Like the reconstructions for the Colorado River, these studies stress the great variability of runoff on timescales of decades to centuries.

Stream-Riparian Landscape Perspectives and the Upper Gila River

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Landscape perspectives were provided by 1) a synthesis of requisite stream and riparian functions and 2) multi-scale evaluations of critical landscape conditions that influence stream and riparian ecosystems. Riparian functions in river landscape were evaluated relative to: a) ecological and physiochemical functions of riparian and fluvial ecosystems, b) cumulative impacts of human actions, and c) management provisions that could prolong ecosystem functions. Some important riparian characteristics include the development of plant associations and their functions relative to hydrologic balances, cycling of elements, connectivity with fluvial systems and providing habitats for fish and wildlife. The ability of riparian and fluvial ecosystems to maintain themselves has been reduced by anthropogenic circumstances (e.g., agricultural, forestry practices, flow regulation and physical confinements). Management actions need to minimize critical conditions (e.g., erosion, water and temperatures) should include rehabilitating the connectivity and interactions between stream and riparian ecosystems (e.g., renewal of flood regimes), and protecting and restoring refuge habitats for fish and wildlife.

Several multi-scale approaches were presented that evaluate influences of changing land cover characteristics (e.g., forest and impervious surfaces) on the composition of watershed landscapes, hydrological regimes, habitat restoration and habitats preferred by fish. Spatially explicit models include the evaluation of changes in land covers and flood discharge regimes of tributary watersheds in river basins. Land cover changes in rural areas like the Gila River Basin can include reductions in forested areas through rapid land conversions characterized by scattered low-density residential, clustered dense commercial, residential developments and increases in transportation facilities near newly incorporated areas. Spatially explicit hydrologic simulations indicate annual flood frequencies can increase in watersheds in response to increases in impervious surfaces and declines in forests. Complimentary landscape models facilitate planning by delineating locations and sizes of critical problem areas. Analyses that provide GIS maps of erosion risk-categories allow definitions of lengths of stream channels exposed to different levels of erosion. Different erosion risk categories allow the identification of stream reaches that may require variable riparian buffer widths for protection of ecosystem functions. Subsequent analyses of land covers demonstrate alternative approaches for identifying priority river reaches and floodplain habitats for restoration and conservation. Large patches with positive indices indicate the most favorable habitats that can be characterized by low fragmentation, greater connectivity and greater habitat availability for fish and wildlife. Factors commonly preferred by many salmonid fishes where upwellings of subsurface waters, moderate water depths, and gravel/cobble sized substrates.

Introduction, establishment and ecological impacts of non-indigenous fishes in the Lower Colorado River Basin

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The Colorado River played a pivotal role in the settlement, growth and economic development of the American Southwest. Efforts to tame the Colorado River began soon after the arrival of western Europeans, and today hundreds of dams and diversion structures have created one of the most controlled rivers on Earth. The construction of water development projects began in the early 1900s, and by the 1960s much of the mainstem river had been converted into a system of dams and diversions. Dramatic hydrologic alterations have greatly changed the riverine ecosystem of the Lower Colorado River Basin. The case for conservation is most urgent as the distributions of native fish species continue to decline at unprecedented rates and the spread of non-indigenous fishes accelerate at an unparalleled speed. Of the 31 native fish species in the lower basin, 25 are extinct, extirpated, listed under the US Endangered Species Act or have suffered significant declines. In contrast, the deliberate introduction of non-indigenous fishes in the Lower Colorado River Basin began in the late 1800s and today more than 90 species have been introduced, over half of which are considered established and fast spreading. These fish species continue to prey on and compete with native fishes.

Based on a long–term dataset including > 30,000 fish records collected between 1840 and 2000 my presentation reported on rates of spread and current range sizes of non-indigenous fish species in the Lower Colorado River Basin. Of the 48 non–indigenous species examined, I show that fathead minnow - *Pimephales promelas* (74.1 km•year^{-1}), green sunfish - *Lepomis cyanellus* (62.9 km•year^{-1}), red shiner - *Cyprinella lutrensis* (54.6 km•year^{-1}), western mosquitofish - *Gambussia affinis* (37.9 km•year^{-1}), and largemouth bass - *Micropterus salmoides* (34.2 km•year^{-1}) are the fastest expanding invaders in the basin. Importantly, these species are also considered the most invasive in terms of their negative impacts on native fish communities. Next, I focused on data collected from the Upper Gila River Basin as part of the recent efforts of the Lower Colorado River Basin Aquatic Gap Program (http://www.lcrgap.org/). Based on > 10,000 fish records collected between 1989 and 2004, I show that 19 non-indigenous fish species have been observed in the Upper Gila River Basin. Of these species, red shiner, western mosquitofish, smallmouth bass (*Micropterus dolomieu*), green sunfish, and channel catfish (*Ictalurus punctatus*) are the most wide-spread in the basin.

My presentation concluded by identifying 6 key scientific needs required to support water management decisions in the Upper Gila River Basin. First, we need an understanding of the habitat requirements of non-indigenous fishes at larval, juvenile and adult life stages. Second, we require a life-history characterization of larval, juvenile and adult life stages of non-indigenous species. Third, we must be able to predict the future distributions of non-indigenous fishes as a function of local-, reach-, and watershed-scale descriptors of the environment. Fourth, knowledge of the key components of the hydrograph that discourage the spread and dominance of non-indigenous species and favor native species is critical. Fifth, we need to ask what lessons can be gleamed from past management actions in the lower basin (e.g. Upper Verde River). Sixth, we must explicitly recognize the role of invasive fish species when designing and implementing restoration activities.

Alternative Futuring In the Willamette Basin, Oregon

Dr John Bolte
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There has been considerable interest in developing and exploring alternative futures scenarios for growth, development and protection of ecosystem and ecosystem services in the Willamette Basin, Oregon. In response to this need, a software tool, Evoland (Bolte et al. 2004) was developed to allow a policy-oriented approach to creating and exploring a broad range of alternative future scenarios ranging from conservation- to development-oriented strategies. Evoland is a spatially explicit, multiagent-based modeling framework for anticipatory modeling of landscape change under alternative future scenarios. Evoland explicitly models landscape dynamics in response to coupled processes of actor-based human decision-making, landscape service provision, and autonomous landscape change, using a policy-centric approach to represent constrain decision-making.

The fundamental organizational structure used in Evoland is shown in Figure 1. Key elements in this organizational scheme are a landscape representation, actors, policies, landscape evaluators, and autonomous landscape processes. Taken together, these elements provide a basic platform for assembling actor-based models of landscape change. Because in Evoland many of these elements are "pluggable" software components, the basic Evoland platform can be fitted with application-specific actor definitions, policy sets, autonomous process descriptions, and landscape evaluators for particular biophysical and social systems of interest. Evoland provides a robust, spatially explicit representation of agents and landscape processes, and integrates agent behavior over both policy and landscape production dimensions. Landscape productions are defined by pluggable evaluative models that return information about the spatial distribution of various types of economic, environmental and social scarcities.

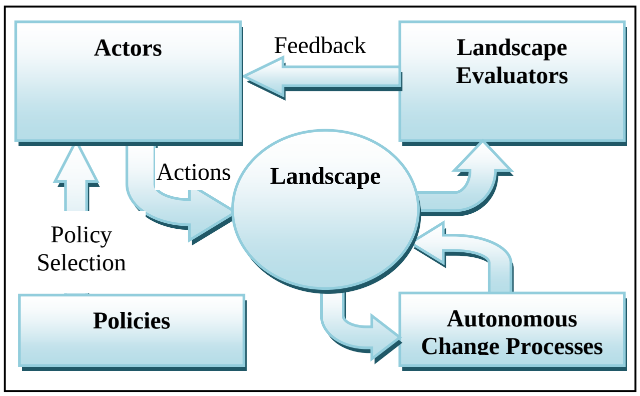

Figure1. Evoland's Conceptual Structure

Fundamental to Evoland is the concept that actors (agents) make decisions in response to these various productions as well as their internal value systems, societal pressures resulting from the emergence of scarcity, and perceptions of the utility of adoption of various policies to be responsive to their goals. Evoland models the feedbacks between the relationships of actor's values and behaviors, policy intentions and scarcity expressed through metrics of valued landscape productions. Scarcity is quantified relative to reference levels for a suite of economic and ecological processes that are key in a given study area. Taken together, Evoland provides a framework for examining and simulating the coupled interactions and cyclical feedbacks among human actions, policy effects and landscape productions.

Multiagent systems (MAS) models have, over the last several years, emerged as powerful tools to simulate the interaction of individuals, societies and their environments (Beneson and Torrens 2004, Bolte et al. 2004). The models often focus on understanding the dynamics of complex, adaptive, interacting socioeconomic and biophysical systems (Gilbert and Troitzsch 2005). While much MAS research has been aspatial, a smaller set of more recent studies have begun to couple spatially-explicit modeling of changes in land use and land cover (LULC) with models of people as agents who exert influence over LULC changes. True to their complexity science and artificial intelligence origins, these agent-based models illustrate how individuals interacting within a dynamic environment produce emergent landscape patterns that no single agent or process could produce alone. We have developed Evoland over the last five years as a robust, spatial explicit, policy-centric multiagent-based model for exploring landscape change driven by human decision-making processes and the interactions of these decisions and the production of various landscape values. Evoland provides a tool for allowing various actors to assume roles (and associated value systems) in land use decision-making, and provides feedback, in the form of trajectories of change analyses resulting from the selection of various decision drivers and policy selections at the individual actor level, to further inform decision-making and provide an educational platform to understand the consequences of various decision strategies and values on trajectories of these landscape productions at both the individual site and landscape levels.

INTEGRATING SCIENCE AND DECISION-MAKING IN THE SAN PEDRO: RESEARCH RESULTS AND LESSONS LEARNED

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Decision-makers and natural resource managers increasingly require much more sophisticated levels of expert findings and scientific results to make informed decisions. No single scientific discipline is typically capable of providing integrated solution for decision-makers and managers. Significant effort beyond the traditional scientific method is required conduct interdisciplinary science across the physical and ecological sciences. Even greater effort is required to effectively integrate this research with policy and decision makers for effective and sustainable management of natural resources. This presentation will provide an overview of the evolution of natural resources research in the San Pedro Basin into a mature integrated science and decision making program, as embodied in the Congressionally recognized Upper San Pedro Partnership. The San Pedro contains the US Army's Ft. Huachuca which houses a number of missions deemed critical for national security. In addition, the San Pedro National Riparian Conservation Area (SPRNCA) is the first Congressionally designated National Riparian Conservation Area administered by the BLM. The SPRNCA is judged one of the World's Last Great Places by The Nature Conservancy and the Audubon Society for its ecological diversity. The groundwater aquifer in the Sierra Vista sub-basin of the San Pedro supplies water for Ft. Huachuca, residents of the basin and sustains flow in the San Pedro. The presentation will highlight significant scientific finding and discuss the transition in research from a focus on science and research for understanding; through science for addressing a need; to integrated science and policy development. At each stage the research conducted became more interdisciplinary, first across abiotic disciplines (hydrology, remote sensing, atmospheric science), then by merging abiotic and biotic disciplines (adding ecology and plant physiology), and finally a further integration with the social sciences and policy and decision making for resource management. Lessons learned from this experience will be reviewed with the intent providing guidance to ensure that hydrologic and watershed research is socially and scientifically relevant and will directly address the needs of policy makers and resource managers. A key lesson learned is the need to develop trust between scientists and decision-makers and an essential element in building this trust is time. Time to sit together in numerous meetings to come to understand one another and learn the key considerations of the decisions at hand, and the science needed to support these decisions.

6. Presentations (insert following)

7. A high level summary presentation of the Upper Gila River Science Forum (insert following)

8. Science Forum Coordinators presentation of an example approach to an integrated scientific framework for the Gila River: Setting River Flow Requirements (insert following)