

Santa Cruz River Researcher's Day

March 19, 2010



Proceedings

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Tumacácori National Historic Park
Sonoran Institute
Friends of the Santa Cruz River

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Introduction

On March 19, 2010 Tumacácori National Historical Park, Sonoran Institute and Friends of the Santa Cruz River hosted the second annual “Santa Cruz River: Researcher’s Day”. This day was an opportunity for those conducting monitoring, research, or studies along the Santa Cruz River to share their work and findings through technical presentations and posters. The following is a brief proceedings of the event, including abstracts of the papers presented.

A new section has been added to this year’s proceedings. The “Additional Research” section lists abstract and summaries of current work on the Santa Cruz by researchers who were unable to present their work at this year’s mini-conference. The hope is that the inclusion of this section will provide a more comprehensive summary of the year’s current work.

This proceedings and copies of the presentations and posters can be found on the Sonoran Institute website under the page describing Santa Cruz River work. ([Link to Sonoran Institute website](#))

Program

9:30 – 9:45	Presentation loading - Coffee /Refreshments	
9:50 - 10:00	Welcome	
10:00 – 10:20	Doug Duncan	<i>Fisheries Surveys in the San Rafael Valley</i>
10:20 – 10:40	Julie Jackson	<i>Fish Surveys in the Upper Santa Cruz River: Nogales Wash to Amado</i>
10:40 – 11:00	Evan Gwilliam	<i>Ecosystem Monitoring at Tumacácori NHP 2009-2010</i>
11:00 - 11:15	BREAK	
11:15 – 11:35	Claire Zugmeyer	<i>Charting the Health of the Santa Cruz River</i>
11:35 – 11:55	Channah Rock and Jeremy Moss	<i>Characterizing the Sources of Microbial Contamination: DNA Testing of Excessive E. coli in the Santa Cruz River, Tumacácori NHP, AZ</i>
11:55 – 1:15	BREAK – Lunch on your own	
1:15 – 1:35	Emily Brott	<i>Conserve to Enhance Pilot Program</i>
1:35 – 1:55	Prescott Vandervoet	<i>Assessment of the Binational Upper Santa Cruz River Aquifer: Designing a Work Plan</i>
1:55 – 2:15	James Callegary	<i>Physical and Biological Science to Study Interactions among Water, Environmental, and Human Health in the Transboundary Upper Santa Cruz Basin</i>
2:15 – 2:30	BREAK	
2:30 – 2:50	Kristine Uhlman	<i>NEMO Watershed-Based Planning, AGWA Modeling, and Effluent Mapping of the Santa Cruz River</i>
2:50 – 3:10	Keith Nelson	<i>Risk Analysis of Pumping Impacts on Simulated Groundwater Flow in the Santa Cruz Active Management Area</i>
3:10 – 3:30	Andrea Prichard	<i>Research on Stormwater Harvesting in the Santa Cruz Tributaries of Nogales, Sonora</i>

Presentation Abstracts

(Listed in order of presentation)

10:00 am

Fisheries Surveys in the San Rafael Valley

DOUG DUNCAN, U.S. Fish and Wildlife Service

Ross Timmons, Arizona Game and Fish Department

Fisheries surveys in the lower San Rafael Valley portion of the Santa Cruz basin have occurred for decades. Before 2005 surveys were done at Sharp Spring, Sheehy Spring, Heron Spring, and the river at the Lochiel road bridge. These surveys occurred in most years from the early 1990s to 2005. Beginning in 2005 we sampled these sites and an additional three sites along the Santa Cruz River annually. The intent of the sampling has been primarily two-fold: to document the presence of any native fish species, and to document the arrival of new nonindigenous aquatic species.

We will present the results of our sampling, and compare them with earlier fish sampling. Native fishes have continued to decline in the San Rafael Valley, with the endangered Gila chub the only native fish occurring regularly. However, they have only one small population. In the last five years, two populations of the endangered Gila topminnow appear to have failed. One natural Gila topminnow site and one reestablished site have failed. We will discuss changes in the fish community, probable causes of change, and conservation implications.

10:20 am

Fish Surveys in the Upper Santa Cruz River: Nogales Wash to Amado

JULIE JACKSON, Friends of the Santa Cruz River

In November 2009, representatives from Friends of the Santa Cruz River, Arizona Game and Fish Department, U. S. Fish and Wildlife Service, and the Sonoran Institute conducted fish surveys at six sites along the Santa Cruz River (SCR) between Nogales and Tubac. These sites (upstream to downstream) included Nogales Wash at Ruby Road, Rio Rico Bridge, Palo Parado, Santa Gertrudis, Tubac Bridge, and Chavez Siding. Nogales Wash is a tributary of the mainstem Santa Cruz River and is located upstream of the Nogales International

Wastewater Treatment Plant (NIWTP). In recent years, fish surveys have been fairly dismal. In 2007 and 2008 when surveys were conducted, very few fish were observed. In 2007, two native longfin dace were collected in Nogales Wash and several others not collected were observed at this location. In 2008, results were similarly disappointing, with two native longfin dace (*Agosia chrysogaster*) collected in the mainstem SCR while none were collected in Nogales Wash. The nonnative and usually ubiquitous western mosquitofish (*Gambusia affinis*) was conspicuously absent except for one that was captured in 2007. Fish surveys conducted this year took place after improvements were made to the NIWTP in June. These improvements appear to have had a significant impact on the ability of fish and macroinvertebrates to survive in the river. Two hundred and thirty longfin dace were collected at the Nogales Wash site, and a total of 142 were collected at the five mainstem sites combined. Numerous nonnative western mosquitofish were collected at the three downstream sites that tended to have slower flows.

10:40 am

Ecosystem Monitoring at Tumacácori NHP 2009-2010

EVAN GWILLIAM, NPS Sonoran Desert Network

Perennial streams are among the most critical and impacted natural resources of the Sonoran Desert. Most species in the ecoregion utilize aquatic ecosystems for some portion of their lifecycles, yet natural surface waters have decreased by an estimated 99% since the mid-19th century due to human demands for water. The National Park Service recognizes the importance of riparian areas, and is developing, testing and implementing monitoring plans for selected ecological indicators, or “vital signs” (e.g., stream channel morphology, water quality) in perennial streams in Southern Arizona. The objective is to detect long-term changes in these “vital signs” and provide this information effectively and rapidly to Park managers. Tumacácori NHP was a focus for early research and development efforts for SODN streams monitoring, with preliminary efforts starting in 2006. Full implementation of streams monitoring at Tumacácori NHP began in 2007. Results of the monitoring efforts demonstrate recent improvements in water quality since spring 2009 with decreases in ammonia and turbidity, along with increases in dissolved oxygen. Riparian vegetation mapping has helped identify the distribution of rare or important plant communities in the park, as well as develop restoration plans. Bird monitoring during the breeding season identified 755 individuals comprising 69 species.

11:15 am

Charting the Health of the Upper Santa Cruz River

CLAIRE A. ZUGMEYER¹, Cheryl McIntyre¹, Amy L. McCoy², Emily Brott¹

¹Sonoran Institute, ²University of Arizona, Department of Arid Lands, Tucson, AZ

Riparian ecosystems constitute less than two percent of land area in the Southwest, but support the highest density and abundance of plants and animals. The Santa Cruz River, the only river to cross the U.S./Mexico border twice, is thus critical to the ecological integrity of southeastern Arizona and northwestern Sonora. Among the challenges to conserving riparian ecosystems is determining if a given riparian area is 'healthy'. To gain a better understanding of the health of the Upper Santa Cruz River in Santa Cruz County, Sonoran Institute is 1) contributing to regional knowledge by establishing a monitoring program that builds on existing data and 2) reporting the results of regional monitoring efforts in the form of the Living River report. As of May 2009, Sonoran Institute initiated monitoring efforts that expand the use of existing monitoring protocols, developed by the Sonoran Desert Network at Tumacácori National Historical Park, to supplement the regional dataset. All available monitoring data was then used to develop the Living River Report to track annual changes during the water year. Our first report tracked river health during the 2008 water year (October 1, 2007 – September 30, 2008) using 10 indicators grouped in two categories: riparian and aquatic ecosystems. We evaluated data against appropriate standards set by state agencies, federal agencies, or the scientific community. The 2008 assessment focused on the effluent dependent stretch of the Santa Cruz River flowing from Rio Rico to Amado, Arizona. Results indicate the aquatic ecosystem in this region is facing significant challenges due to poor water quality. However, data from the 2009 water year demonstrates some improvements in water quality following the recent upgrade of the Nogales International Wastewater Treatment Plant in Rio Rico. The goal of this assessment is to promote a better understanding of the health of the Upper Santa Cruz River among watershed residents. The assessment tracks river health using scientific information and establishes a baseline that we can use to compare changes in the health of the Upper Santa Cruz River over time.

11:35 am

Characterizing the Sources of Microbial Contamination: DNA Testing of Excessive E.coli in the Santa Cruz River, Tumacácori NHP, AZ

CHANNAH ROCK, PhD, Water Quality Extension Specialist, University of Arizona

JEREMY MOSS, Chief of Resource Management, Tumacácori National Historical Park

Tumacácori National Historical Park (NHP) is responsible for management of its water resources for the benefit of the park and for the health of its visitors. Understanding the origins, transport and fate of contamination is essential to effective management of water resources and protection of public health. Individuals and organizations with management responsibilities need to understand the risks to humans and to ecosystems from contact with contaminated water. They also need to understand how key contaminants vary over time and space in order to design management strategies and comprehensive policy. Currently, this project team has surveyed 4 locations monthly for the past ten months along the Santa Cruz River for the presence of microbial indicators: Total/Fecal Coliforms, male-specific and somatic bacteriophages, *Escherichia coli* (*E. coli*), and *Bacteroides*. Several rain events were sampled in August 2009 and January 2010. In addition to the above mentioned microbial constituents, these samples have also been analyzed for pH, turbidity, and residual chlorine. Initial results indicated that slight seasonal fluctuations in microbial concentrations occurred during the warmer summer months. It is also apparent that microbial levels seem to be relatively consistent throughout the park and that little die off is occurring, however, slight increases are seen after Rio Rico Bridge. After additional analysis of the molecular marker data, it became apparent that although the total concentration of *E.coli* may be increasing as water moves through the park, the human specific contribution decreased. This indicates that other non-point sources (cattle) may be contributing to the pollution problems. Additional analyses are being conducted to determine the relative concentration of bovine molecular markers in these samples as well as if microbial fluctuations coincide with extreme storm events, which might be a result of increased overland flow.

1:15 pm

Conserve to Enhance Pilot Program

EMILY M. BROTT¹, Dr. Sharon Megdal², Joanna Nadeau², Lisa Shipek³, Catlow Shipek³

¹Sonoran Institute, ²University of Arizona, Water Resources Research Center

³Watershed Management Group

Two local nonprofit organizations, the University of Arizona, and Tucson's primary water utility have developed a partnership to establish the foundation for an Environmental Water Bank driven by water conservation. The *Conserve to Enhance Pilot Program* links water conservation efforts with watershed restoration to ensure that water conservation will translate into benefits for the environment. Businesses and individuals can participate by utilizing a Water Conservation Calculator to track the amount of money saved through

water conservation practices. Participants then donate the value of their savings to the Environmental Water Bank. The Environmental Water Bank will create a mechanism for water to be purchased and designated to the environment to restore riparian areas and increase groundwater levels. Revenues generated by the program will be used to purchase water and deliver it to local environmental enhancement projects as selected by a local Advisory Board.

1:35 pm

Assessment of the Binational Upper Santa Cruz River Aquifer: Designing a Work Plan

PRESCOTT VANDERVOET, Udall Center for Studies in Public Policy, University of Arizona
The Transboundary Aquifer Assessment Program, Arizona and Sonora component (TAAP-A/S) promotes binational collaboration among stakeholders for improved assessment of the Santa Cruz and San Pedro aquifers. With emphasis on the Santa Cruz, this presentation describes TAAP-A/S collaboration as well as recent binational arrangements for assessing shared aquifer resources. Essential elements of the draft work plan developed at a stakeholder workshop in early November, 2009 are reviewed. Following discussions by workshop participants, the current version of the work plan for assessment activities of the Santa Cruz aquifer is focused on the following issues: hydrological and water quality monitoring, data analysis, environmental health, refined binational models, cross-border coordination, and diffusion of data and results.

1:55 pm

Physical and Biological Science to Study Interactions among Water, Environmental, and Human Health in the Transboundary Upper Santa Cruz Basin

JAMES CALLEGARY¹, Floyd Gray¹, Nicholas Paretti¹, Laura Norman¹, Kyle Withers², Prescott Vandervoet², Rose McAndrew², Christopher Scott², Charles Van Riper¹, Sharon Megdal², Andrea Prichard²

¹US Geological Survey, ²University of Arizona

The Border Environmental Health Initiative (BEHI) and the US-Mexico Transboundary Aquifer Assessment Program (TAAP), both of which have components focused on the Upper Santa Cruz Basin, are USGS multidisciplinary research and outreach initiatives with complementary goals. The BEHI mission is to “investigate linkages between the condition of the physical environment and environmental and health issues”, while the TAAP aims to “...develop and implement an integrated scientific approach to...assess priority transboundary aquifers...” and to “...provide the scientific information needed by water managers and natural resource

agencies on both sides of the United States-Mexico border....”. Our overarching objective is to combine the different elements of the two investigations to provide a better understanding of the hydrogeologic, environmental, and human components and their spatial and temporal interactions in the Santa Cruz Basin. Current physical science activities are focused on filling in the highest priority gaps in information identified through consultation with stakeholders. Of particular relevance are activities to update the hydrogeologic framework of the basin and to understand the role of emerging contaminants in the environment and human health. Recent work includes baseline sampling for emerging contaminants and other parameters in water, sediment, plants, fish, and aquatic insects at five sites: three in the Santa Cruz River and two in tributaries. Several tasks are in process to improve the hydrogeologic understanding of the basin. Ground-based transient electromagnetic (TEM) geophysical surveys were done on the Santa Cruz River east of Nogales to determine the geometry of the small, highly-utilized aquifers or “microbasins” found there. Paper records from over 1000 wells have been converted to digital format logs, and inverse modeling of airborne TEM data has begun. Finally, we are collaborating with researchers from the College of Public Health to integrate our hydrologic and geographic science with human health in the Nogales area.

2:30 pm

NEMO Watershed-Based Planning, AGWA Modeling, and Effluent Mapping of the Santa Cruz River

KRISTINE UHLMAN, RG, and D. Phillip Guertin, C. Rock, S. Eden, L. Levick, T. Sprouse, E. Westfall, C. Deatherage

Funding provided by the Arizona Department of Environmental Quality (ADEQ) and the Arizona Water Institute (AWI) has generated some important documents of interest to researchers of the Santa Cruz River. The NEMO (Nonpoint Education for Municipal Officials) Program is a state-wide effort to support Clean Water Act 319 programs to improve water quality. The NEMO Santa Cruz Watershed-Based Plan compiles mapped data available for the watershed, identifies areas that are susceptible to nonpoint source pollution, and models the response of the watershed to precipitation. Hydrologic modeling to predict sediment load and water yield is conducted using AGWA, the Automated Geospatial Watershed Assessment Tool. In addition to identifying and mapping important natural resources, 10-digit HUC (hydrologic unit codes) subwatersheds are ranked based on the risk of nonpoint source pollutant contribution to stream water quality degradation. The plan includes general discussions of recommended nonpoint source Best Management Practices

(BMP) that may be implemented to achieve pollutant load reductions and other watershed restoration goals. Results of Arizona NEMO's watershed classification show that the Upper Santa Cruz River contains two stream reaches that are at very high risk of nonpoint source pollution, including: Sonoita Creek for metals and Portero Creek for contamination by organics. Mapping the extent of treated wastewater effluent flow originating from treatment facilities across the state was a component of a larger AWI project: Generation, Reuse and Recharge of Treated Wastewater. On this project, the NEMO program trained volunteers to map the end points of effluent flow. In the Upper Santa Cruz River Watershed, NEMO mapped the Ina Road, Marana, Nogales International, and the Roger Road effluent flows originating from the wastewater treatment plants. Maps and reports are available on the NEMO web site: www.ArizonaNEMO.org.

2:50 pm

Risk Analysis of Pumping Impacts on Simulated Groundwater Flow in the Santa Cruz Active Management Area

KEITH NELSON, Arizona Department of Water Resources

Due to the unique hydrology of the Upper Santa Cruz watershed and regional groundwater development pressures, the Arizona Legislature created the Santa Cruz Active Management Area in 1994. The Arizona Department of Water Resources (ADWR) has been tasked with managing the AMA's dual goals, which include maintaining safe yield conditions and preventing long-term declines in local water levels. Towards that end the ADWR has been developing modeling tools that will enable different water management strategies to be evaluated in a risk-based context. In 1997 a monitoring program was established to better understand the hydrologic system and to provide calibration targets for the development of groundwater flow models. Using available hydrologic information, alternative conceptual groundwater flow models were evaluated using inverse modeling techniques as well as trail-and-error calibration techniques. The groundwater flow models simulate flood recharge and seasonality, and were calibrated over diverse environmental conditions. To address future streamflow recharge uncertainty, the ADWR contracted the development of a stochastic streamflow model. Streamflow realizations associated with the stochastic model were combined with plausible groundwater flow models to provide projected groundwater flow along reaches of the Santa Cruz River that experience intermittent baseflow (groundwater discharge). The modeling process has been automated, enabling hydrologic impacts to be statistically evaluated as functions of stress including groundwater pumpage. Accordingly, model output distributions can be used to provide risk-based information about projected

groundwater levels and baseflow for water management purposes. This talk briefly describes the hydrologic system, the hydrologic models, the simulation process, and provides statistical information and quantifies risks associated with groundwater discharge patterns projected over a 100-year simulation period based on hypothetical pumping scenarios.

3:10 pm

Research on Stormwater Harvesting in the Santa Cruz Tributaries of Nogales, Sonora

ANDREA PRICHARD, University of Arizona MA candidate

Christopher Scott, University of Arizona Assistant Professor

Flooding of the Nogales Wash and its tributary arroyos is a perennial danger as heavy monsoonal rains damage homes and infrastructure, spread garbage and disease agents, overload the wastewater treatment plant, and take lives. Recently the city of Nogales, Sonora has completed the construction of a first round of detention features in separate arroyos with the intention to reduce stormwater flows and subsequent flooding. Models suggest that these features may also serve in recharging groundwater. During the 2010 summer monsoon season, field work will be conducted in collaboration with the U.S. Geological Survey that contributes to the evaluation of the efficacy of these detention features both in terms of flood reduction and groundwater recharge. Results will be used to calibrate hydrological models for further iteration and emergency flood response planning. The presenter will outline the proposed research and invites feedback from participants.

Additional Research

Not everyone conducting research and monitoring on the Santa Cruz River were able to attend this year's conference. Therefore we have included the following additional abstracts to provide a more comprehensive record of current research and monitoring efforts.

Public Values Related to the Santa Cruz River

Matt Weber, US EPA weber.matthew@epa.gov

The Santa Cruz Basin is a focus geography for EPA Southwestern ecosystem services research, and a focal resource is water. The goal of this component of the Santa Cruz effort is to characterize the ways in which basin residents value the river, and environmental resources related to the river. This will help inform tradeoffs in river management. Focus groups and individual interviews will assist development of a survey that will collect public value data via choice experiment methodology. A parallel study in the Willamette Basin, OR may follow, in order to gain broader perspective of what features of rivers are important to stakeholders and the public. The Sonoran Institute's 'health assessment' based on aquatic and riparian conditions forms a starting hypothesis for Santa Cruz River attributes important for public welfare. This work is also one part of a USGS/EPA collaboration in developing a Santa Cruz Watershed Ecosystem Portfolio Model. The intent of the combined research is to evaluate ecosystem service issues including environmental justice in an interactive online multicriteria scenario-evaluation framework, see <http://geography.wr.usgs.gov/science/ecoSevicesSCWatershed.html>.

If you represent a Santa Cruz River stakeholder group and might be available for an interview or focus group to document river attributes important to your group, please contact Matt Weber at weber.matthew@epa.gov, or (541) 754-4315.

Emerging Contaminants in the Upper Santa Cruz River: Preliminary results from 2009

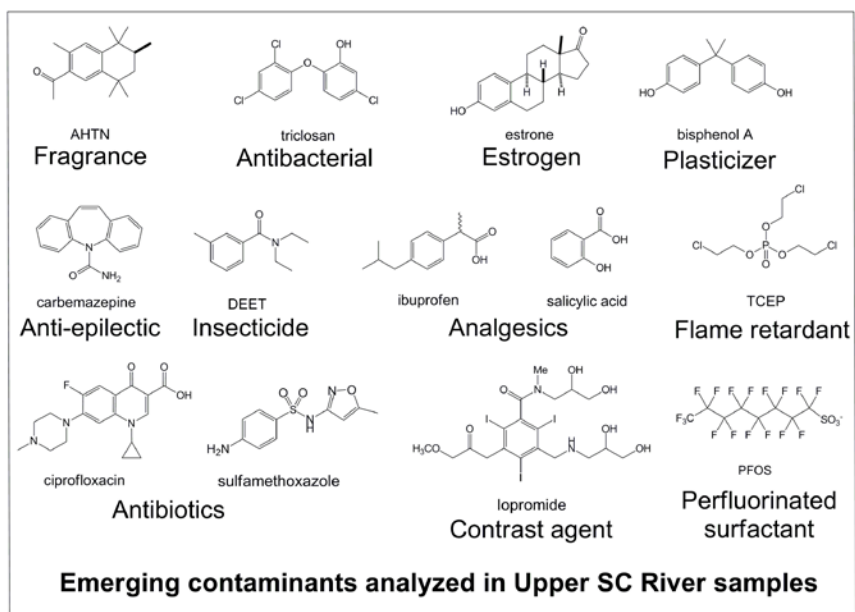
Leif Abrell, Arizona Laboratory for Emerging Contaminants, University of Arizona, abrell@u.arizona.edu

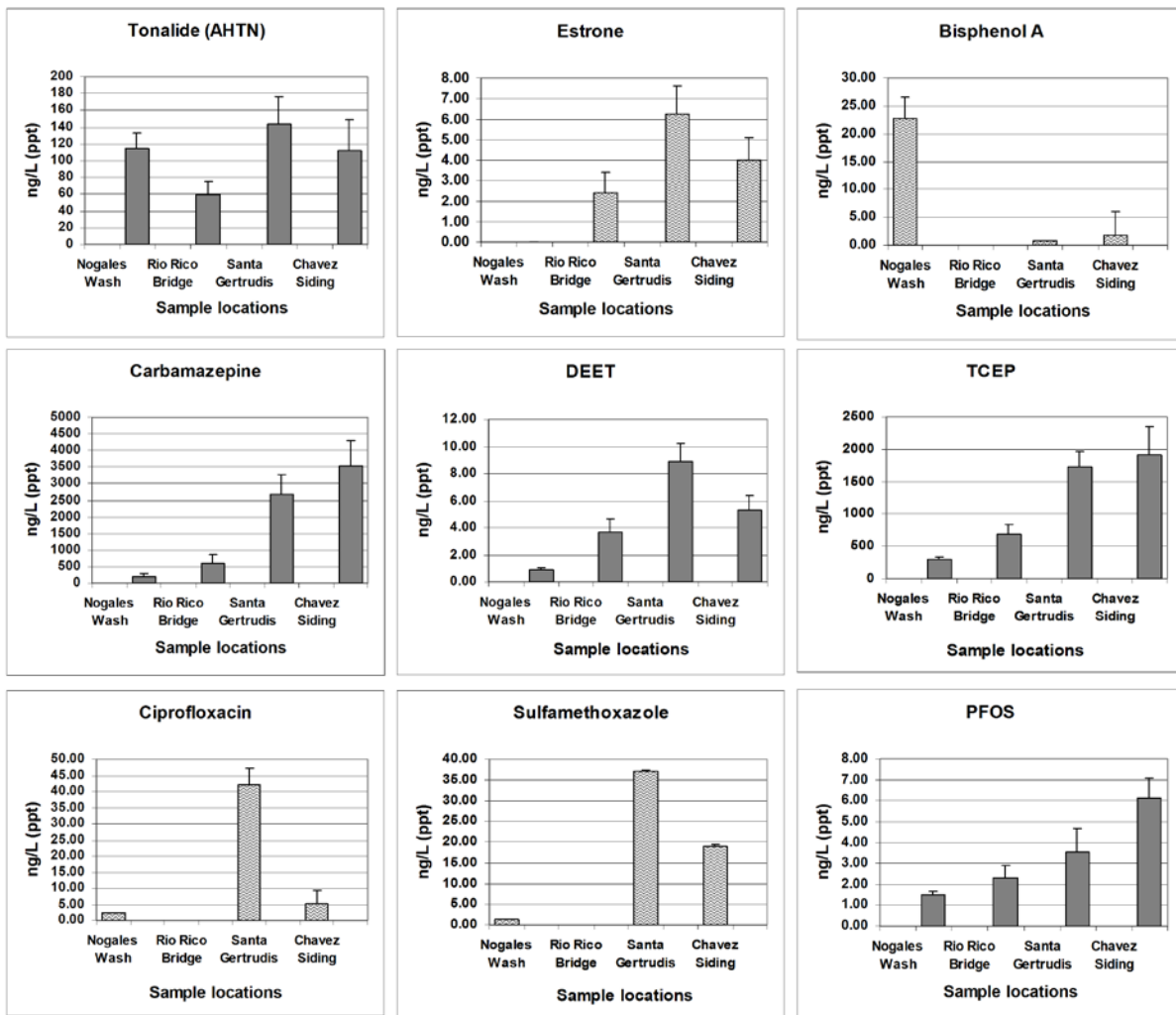
Samanthi Wickramasekara, Arizona Laboratory for Emerging Contaminants, Univ. of Arizona

Sherry Sass, Friends of the Santa Cruz River

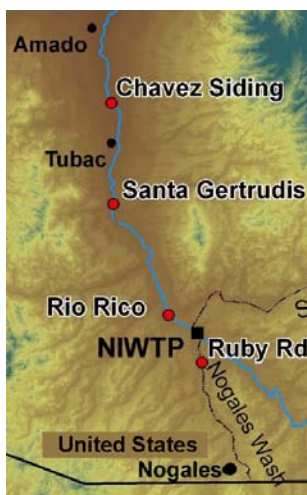
Methods Water samples were collected into 1 L amber glass bottles directly from the Upper Santa Cruz River on December 13, 2009 (see collection sites map). Before solid phase extraction (SPE; using C18 and HLB sorbents) samples were filtered through PALL 0.7 μm glass fiber filters. SPE eluents were evaporated to dryness and re-dissolved in 1 ml 50% aqueous methanol for injection on to a Waters Acquity UPLC system with a BEH C18 column (1.7 μm , 2.1 x 50 mm) and a gradient mobile phase of water and acetonitrile for 30 min. Chromatographed samples were delivered to a Waters Quattro Premier XE tandem mass spectrometer where electrospray ionization (ESI) and detection of each contaminant was optimized for multiple reaction monitoring (MRM). Each analyte response was calculated with respect to a corresponding deuterated internal standard, except for TCEP and PFOS.

Results Upper Santa Cruz River (USCR) samples were measured to obtain a preliminary understanding of river contaminant levels. Results (shown in ng L^{-1}) indicate USCR water mostly contains lower EDC/PPCP concentrations than the WWTP effluent-dependent Lower SCR (not shown). Ten of twelve target analytes were observed in excess of method detection limits. Triclosan and iopromide were not detected. Salicylic acid and ibuprofen levels were below 3.5 and 1.5 ppt, respectively. Carbamazepine has a recognized stability and persistence in the aqueous environment, so its appearance at high concentrations is not surprising.





Contaminant levels shown by hashed bars were obtained by HLB-SPE; contaminant levels shown by grey bars were obtained by C18-SPE.



Water sample collection sites

The influence of water quality on the health of riparian bird communities in Arizona

Chris Kirkpatrick, School of Natural Resources, University of Arizona

Courtney J. Conway, USGS Arizona Cooperative Fish and Wildlife Research Unit, University of Arizona

Dominic LaRoche, School of Natural Resources, University of Arizona dlaroche@email.arizona.edu

Gabrielle Robinson, School of Natural Resources, University of Arizona

Riparian woodlands bordering the Santa Cruz River in southern Arizona provide habitat for numerous breeding, wintering, and migratory birds. However, a recent increase in the number of riparian birds exhibiting physical abnormalities (e.g., lesions, tumors, abnormal bills) along the Santa Cruz River has raised concerns about the quality of the water in the river, the potential for infectious avian diseases in the region, and the overall health of the riparian bird community. Surface water in the Santa Cruz River originates primarily as treated effluent from Nogales, Arizona/Mexico and unregulated storm water runoff from Nogales, Mexico. Poor water quality in the Santa Cruz River, infectious avian diseases, or an interaction between these two factors may be responsible for the observed physical abnormalities within the breeding bird population along the Santa Cruz River, but to date, no effort has been made to assess the prevalence or diagnose the cause of these deformities. We conducted this research in low-elevation (<1,150 m) riparian woodlands along the Santa Cruz River at Tumacacori NHP and at a control study site (no effluent) located within the Cienega Creek Preserve in 2008. In 2009, we conducted research at our Tumacacori NHP study site only. We sampled sediment and soil for heavy metal contamination from both study sites. We captured adult birds with the use of mist nets and conducted physical examinations, sampled tissue from any lesions, pulled feathers from Bewick's Wrens, Bell's Vireos, Lucy's Warblers, Yellow-breasted Chats, Northern Cardinals, and Abert's Towhees and took blood samples from Yellow-breasted Chats and Abert's Towhees. We located and monitored nests of all riparian bird species at Tumacacori NHP (2008-2009) and at our control site at Cienega Creek (2008 only).

We found significantly greater ($P < 0.05$) concentrations of Cd, Cr, Pb, and Zn in river sediment and significantly greater concentrations of Cd, Cr, Hg, Pb, and Zn in floodplain soils at Tumacacori NHP compared to Cienega Creek Preserve. We were unable to detect a difference in metal levels in avian blood or feather samples between our two study sites, except for Se blood levels which were over 2x greater in yellow-breasted chats at Cienega Creek compared to Tumacacori NHP ($t = 7.0$, $P = 0.010$). Moreover, we found that metal levels in avian blood and feather samples at both sites were generally comparable to reference levels reported for birds from uncontaminated sites. We identified a total of 16 adult birds with deformities, all which were located at Tumacacori NHP. We found a total of 3 nestlings with deformities in 2008, all of which were on yellow-breasted chats at Tumacacori NHP. In 2009 we found 1 nestling with a deformity at Tumacacori NHP. We did not detect avian pox in any of our samples. We were unable to detect a difference ($t < 1.6$, $P > 0.13$) in average clutch size for Abert's towhees and Yellow-breasted Chats between our two study sites. We were unable to detect a

difference ($t < 0.6$, $P > 0.55$) in average egg volume for any of our three focal species between our two study sites. We were unable to detect a difference in hatching success for Abert's towhees between our two study sites ($t = 1.0$, $P = 0.338$; Fig. 5b). However, we detected a marginally significant trend ($t = 1.8$, $P = 0.083$) toward increased hatching success of Yellow-breasted Chats at Tumacacori NHP compared to Cienega Creek. We detected a significant increase ($Z = 2.6$, $P = 0.009$) in daily nest survival of Yellow-breasted Chats at Tumacacori NHP compared to Cienega Creek.

Our analysis of the presence and extent of contaminants in the environment revealed significantly greater concentrations of metals in river sediments at Tumacacori NHP compared to Cienega Creek. Despite increased levels of several contaminants throughout the floodplain at Tumacacori NHP, we did not detect elevated levels of any metals in blood or feather samples collected from yellow-breasted chats or Abert's towhees. Overall, our results suggest that metal contamination is not currently a major health risk for terrestrial songbirds that forage within riparian woodlands adjacent to contaminated effluent flows in the Santa Cruz River.

Riparian Dynamics: The Ebb and Flow of Ecological Function - final dissertation abstract

Amy L. McCoy, University of Arizona, amccoy@email.arizona.edu

Competition over freshwater resources is increasing at local and global scales. Growing urban and suburban centers utilize surface and groundwater resources to meet municipal, industrial, and agricultural demands, often at the expense of riparian ecosystems. Paradoxically, those same urban centers produce a significant volume of treated effluent that can be reused to restore and sustain riparian systems. Use of effluent as a source of water for the environment raises important questions about the benefits and impacts of effluent on riparian functions and ecosystem services, particularly in the context of climate change and drought conditions. This research addresses knowledge gaps surrounding riparian change and resilience along the effluent-dominated Upper Santa Cruz River in southern Arizona. Section A investigates whether the Nettlehackberry (*Celtis laevigata* var. *reticulata*) tree can provide accurate information on historic changes in climatic and hydrological conditions. Results indicate that hackberry trees do record climate-related stress in annual ring-width patterns and can therefore provide a historic frame of reference against which to compare current and future changes in riparian conditions. Section B documents spatial and temporal patterns of effluent uptake by Fremont cottonwood trees (*Populus fremontii*) through development of a new application for dendrochronology, specifically dendrochemistry. Results show that annual tree rings contain temporally variable concentrations of a micropollutant found only in effluent and may have the potential to record spatial and temporal patterns of effluent dispersion in riparian ecosystems. Section C investigates the complex interactions of ecohydrological conditions that led to a riparian mortality event along the Upper Santa Cruz River in 2005. Effluent is shown to contribute to riparian vegetation

expansion, but also, due to its consistent delivery of nutrients and water, homogenize the system and ultimately diminish its resilience to perturbations and stress. Results highlight the paradoxical nature of effluent as both a contributor to riparian growth and a potential impediment to riparian function. This paradox can be resolved through a well-defined effluent impact monitoring and assessment program that incorporates historic information as well as current trends to detect significant changes in ecosystem functions and services.

Climate and Population Change as Drivers of Hydrologic Change in Semi-arid River Systems – *working proposal*

Tom Meixner, University of Arizona, tmeixner@hwr.arizona.edu

Julie Stromberg, Arizona State University

David Brookshire, University of New Mexico

Enrique Vivoni, Arizona State University

David Plane, University of Arizona

Jennifer Duan, University of Arizona

Francina Dominguez, University of Arizona

Perennial river reaches in semiarid climates are under increasing pressure as a water source due to population growth and susceptibility to climate changes. An integrated assessment is required to quantify and predict the space and time scales of impacts on semiarid riparian areas that may alter their hydrology, ecology and social value. Hydroclimatic changes in these systems can have significant effects on the provided ecosystem services, including habitats, aesthetics and flood protection, while other changes may have more limited impacts. We will test the differentiation of these impacts using the theory of “Peak Ecological Water” defined as the breakpoint between *limited* and *significant* impacts on riparian ecosystem services. The interconnected nature of social, ecologic and hydrologic systems requires place-based research using a suite of models integrated across disciplines. Here, we propose to work on the adjacent (but distinct) San Pedro and Santa Cruz river basins, in southern Arizona, that span a gradient in water demands, streamflow regimes and ecosystem services. Additionally while riparian areas provide a wide span of ecosystem services we will focus on already quantified ecosystem services in the areas of birds, species diversity and infrastructure protection that can be quantified.

To quantify and predict how ecosystems services in semiarid river basins will vary in the face of a changing climate and a changing population, we test three hypotheses:

1. The value of ecosystem services declines as hydrologic conditions in dryland rivers become more xeric.

2. Climate change may decrease the water withdrawal level at which ecosystem services reach a threshold meaning that the same population increase would have greater adverse effects on ecosystem services.

3. The *trajectories* of changes in ecosystem value are reversible given restoration of flows to rivers via effluent recharge or groundwater recharge, but the absolute *magnitude* of ecosystem service recovery will vary depending on the historical degree of dewatering and the timeframe for recovery.

Existing datasets from both river systems will be integrated using a suite of process-based models to assess under what hydroclimatic conditions change enough to induce changes in socioecological values. We will combine the suite of process-based models with climate and population forecasts from dynamically downscaled climate scenarios and demographic model scenarios of population change. Throughout the process, we will address the risk associated for the different scenarios by propagating input, structural, parametric and outcome uncertainty to estimate the confidence with which thresholds may or may not be reached. These uncertainties will be compounded so there is the opportunity to use a risk-based approach to understand the probability that changes in ecosystem valuation and services will occur. This risk-based approach can then be used to assess ecosystem sustainability in the face of population and climate change. We will present these results to a group of stakeholders and resource managers in each of the studied basins to understand how they could use this information in their decision-making process.

The PIs, postdoctoral researchers and graduate and undergraduate students involved in this research will collaborate with a variety of federal agencies and scientists. This interaction will keep our research relevant, introduce junior scientists to the community of scientists working on the challenge of managing ecosystem resources in the Southwest United States and benefit agency scientists and managers by keeping them current on how our research might impact their decision making.

Attendees and Contact Information

Name	Affiliation	email
Abrell, Leif	University of Arizona	abrell@u.arizona.edu
Anderson, Marie Gabrielle	Pima County Regional Wastewater Reclamation Dept	marie.anderson@wwm.pima.gov
Arendt, Nicole	National Park Service - Tumacácori National Historical Park	nicole_arendt@nps.gov
Barcenas, Alejandro	Arizona Department of Water Resources	arbarcenas@azwater.gov
Bremer, Lah-May	Friends of the Santa Cruz River, Global Community Communications Alliance	lahmay.bremer@gmail.com
Brott, Emily	Sonoran Institute	ebrott@sonoraninstitute.org
Callegary, James	United States Geological Survey	jcallega@usgs.gov
Case, Natalie	Arizona State University	ncase@asu.edu
Duncan, Doug	Fish and Wildlife Service	Doug_Duncan@fws.gov
Fonseca, Julia	Pima County	
Gwilliam, Evan	National Park Service - Sonoran Desert Network	evan_gwilliam@nps.gov
Hallpenny, Philip		phalpenny@cox.net
Jackson Meyers, Julie	Friends of the Santa Cruz River	jajjulia@yahoo.com
LaRoche, Dominic	University of Arizona/USGS Cooperative Research Unit	dlaroche@email.arizona.edu
McDonough, Lisa	University of Arizona	brookem@email.arizona.edu
Moss, Jeremy	National Park Service - Tumacácori National Historical Park	jeremy_moss@nps.gov
Nadeau, Joanna	University of Arizona, Water Resources Research Center	jnadeau@cals.arizona.edu

Name	Affiliation	email
Nelson, Keith	Arizona Department of Water Resources	kmnelson@azwater.gov
Norman, Laura	United States Geological Survey	lnorman@usgs.gov
Norris, Larry	National Park Service - Desert Southwest CESU	lnorris@ag.arizona.edu
Parks, Jennifer	Arizona State Parks	jparks@azstateparks.gov
Prichard, Andrea	University of Arizona	aprichar@email.arizona.edu
Quanrud, David	University of Arizona	quanrud@email.arizona.edu
Redmann, Ionia	Global Community Communications Alliance	ionia@gccalliance.org
Riley, Kelley	University of Arizona	kriley@ag.arizona.edu
Rock, Channah	University of Arizona	channah@ag.arizona.edu
Sass, Sherry	Friends of the Santa Cruz River	sushi4334@gmail.com
Sprouse, Terry	AZ NEMO	tsprouse@ag.arizona.edu
Uhlman, Kristine	University of Arizona, Water Resources Research Center	kuhlman@ag.arizona.edu
Vandervoet, Prescott	University of Arizona, Udall	plv@email.arizona.edu
Vieo, Jessica	University of Arizona	jmegan_2@yahoo.com
Villarreal, Miguel	University of Arizona	miguel@email.arizona.edu
White, Meg	Arizona State University	meg.white@asu.edu
Zugmeyer, Claire	Sonoran Institute	czugmeyer@sonoraninstitute.org