

Santa Cruz River Researchers' Day

March 29, 2011



Santa Cruz River near Green Valley, Pima County, Arizona

Proceedings

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

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Introduction

On March 29, 2011 Tumacácori National Historical Park, Sonoran Institute, and Friends of the Santa Cruz River hosted the third annual “Santa Cruz River: Researchers’ Day”. This day was an opportunity for those conducting monitoring, research, restoration or other conservation efforts along the Santa Cruz River to share their work and findings through presentations and posters. The following is a brief proceedings of the event, including abstracts of the papers and posters presented.

This year a special session entitled “Forming a Santa Cruz Watershed Steering Committee” discussed the idea of forming a group to coordinate and communicate conservation efforts in the binational watershed. See the summary for a brief overview of this discussion.

The “Additional Research” section lists abstracts 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.

Proceedings and pdf copies of the presentations and posters from all three Researchers’ Day events can be found on two websites:

- Sonoran Institute www.sonoraninstitute.org - links to Researchers’ Day provided in the ‘resources’ section of the page describing Santa Cruz River work ([Link to Santa Cruz River Initiative project on Sonoran Institute website](#)).
- Southwest Learning Center www.southwestlearning.org - links to Researchers’ Day information located as a subtopic on the Santa Cruz River page ([Link to Santa Cruz River on the Southwest Learning Center](#)).

Program

Time	Schedule	Title
9:30	Welcome	
9:40	Benton Leitner – BirdWorks	A new network of banding stations on the Santa Cruz River in Southern Arizona
9:55	Lisa McDonough – University of Arizona	Resurgence of a River: A Report on Fish in the Santa Cruz River
10:10	Julia Fonseca – Pima County	History and Prospects for Fish in the Santa Cruz River, Pima County, Arizona
10:25	James Callegary – USGS	Linking hydrology, geology, chemistry, and biology in the Upper Santa Cruz River Basin
10:40	Berenise Rivera – University of Arizona	Characterization of Fecal Contamination Targeting 16S rRNA Bacteroides Molecular Markers in the Santa Cruz River, Arizona
10:55	BREAK*	
11:15	Felipe Caldeira – University of Arizona/USGS	Nogales, Sonora, Mexico: Is there something in the Water?
11:30	Sofia Grigera – University of Arizona/USGS	Health and Lifestyle of Children Living in the Santa Cruz River Watershed
11:45	Gladys Amaya – University of Arizona/USGS	Measuring the Impacts of Natural Amenities and the US-Mexico Border, on Housing Values in the Santa Cruz Watershed, using Spatially-Weighted Hedonic Modeling
12:00	SPECIAL SESSION	Forming a Santa Cruz Watershed Steering Committee
12:30	BREAK LUNCH * - on your own/bag lunch permitted	
1:45	Margaret White – Arizona State University	Nutrients and nitrophiles: effects of treated wastewater discharge on dryland riparian plant communities
2:00	Natalie Case – Arizona State University	Causes and Consequences of Clogging in the Santa Cruz River
2:15	Leif Abrel – University of Arizona	Emerging Contaminants in the Upper Santa Cruz River: 2010-2011
2:30	Tom Meixner – University of Arizona	Climate and Population Change Impacts on Dryland Rivers - Integrated Synthesis
2:45	Cynthia Wallace and Miguel Villarreal – USGS	Development of landscape-scale geospatial data sets describing the vegetation and land use of the binational Santa Cruz watershed
3:00	Andy Hubbard – NPS Sonoran Desert Network	Ecosystem Monitoring at Tumacácori National Historical Park
3:15	BREAK*	
3:30	Jason Welborn – NPS Tumacácori NHP	Tumacácori National Historical Park: Its Resources and Role in Research
3:45	Neva Connolly – Pima County	Santa Cruz River at Canoa Ranch Photo Monitoring
4:00	Ken Lamberton	Dry River: Stories of Life, Death and Redemption on the Santa Cruz
4:15	Amy McCoy – Ecosystem Economics	Market-based Responses to Arizona's Water Sustainability Challenges: The Cornerstones Report
4:30	Josh Gormally	The Vegetation of the Middle Effluent Dominated Santa Cruz
4:45	Emily Brott and Claire Zugmeyer – Sonoran Institute	Science-based outreach and water for the environment: Sonoran Institute's updates on Santa Cruz River Work
*Poster	Rose McAndrew – University of Arizona	Groundwater Contaminant Transport Modeling In the Upper Santa Cruz Basin

Special Session: Forming a Santa Cruz River Watershed Steering Committee

Santa Cruz River Researchers' Day 2011 included a special session whose goal was to get feedback on the potential formation of a Santa Cruz River Watershed Steering Committee. Inspired by a conservation mapping and goal-setting process Sonoran Institute helped implement in the Colorado River Delta nearly a decade ago, Sonoran Institute staff proposed implementing a similar process for the Santa Cruz River Watershed to coincide with next year's Researchers' Day. The conservation mapping and goal-setting process could be called the "2012 Santa Cruz River Watershed Conservation Summit" and would potentially address the following:

- Who is doing what on the Santa Cruz River and its major tributaries?
- What are the priority natural and cultural resources along the River and its major tributaries?
- What are the priority conservation and restoration areas?
- What are short, medium, and long-term goals for conservation and restoration of the River and its tributaries?
- What are the most important opportunities and threats to the resources?
- How can stakeholders coordinate our efforts to have the greatest impact? Partnerships? Niches? Funding opportunities?
- How can we track progress towards our goals ?

The overarching goal for this work would be to increase our collective impact on conservation efforts within the Santa Cruz Watershed and ultimately form a Santa Cruz River Watershed Steering Committee to promote increased collaboration and awareness of the work being done.

Sonoran Institute proposes to start the process of forming a Santa Cruz River Steering Committee by leading the efforts of preparing for the Santa Cruz River Watershed Conservation Summit to coincide with next year's regularly scheduled Researchers' Day. Sonoran Institute would conduct necessary preparatory research and stakeholder interviews in order to develop draft ideas to present at the 2012 Conservation Summit. Sonoran Institute proposes formation of a short-term advisory group comprised of 12-15 members that would meet quarterly to guide and review the research being prepared for this Conservation Summit. At the interactive 2012 Conservation Summit, participants would give feedback on the initial research and draft ideas; the broad-based input from the Conservation Summit would be included in the Santa Cruz River Researchers' Day proceedings and would contribute to a publication produced by the Sonoran Institute tentatively entitled "State of the Santa Cruz River Watershed". At this point, organizations, researchers, and community members, who "buy in" to the priority conservation/restoration areas and goals mapped out at the Conservation Summit would be invited to

form a longer-term Santa Cruz River Watershed Steering Committee. The Steering Committee could potentially meet annually during the Santa Cruz River Researchers Day to discuss progress on meeting common goals.

Feedback and General Discussion

The following comments and feedback were made during the ensuing discussion (listed in no particular order):

- Overall there was support for this idea.
- As Santa Cruz River Watershed is a binational watershed, it was noted that partners south of the border should be included.
 - One way to do this would be to host research meetings in conjunction with EPA taskforce meetings that already occur in Nogales, Arizona and Nogales, Sonora.
 - Simply having meetings closer to the border will likely increase participation due to ease of crossing the border.
- There was discussion on the geographic scope of the committee.
 - Would the focus be only on the main stem of the river? Main stem and major tributaries?
 - Including San Rafael Valley may help attract interest from Mexico, as impacts to this region will be felt downstream in Mexico.
 - There may be a need to break the watershed into two regions, Upper (Santa Cruz County and Mexico) and Lower (Pima County) as the hydrology and water resources are so different between these two.
- In addition to geographic scope, the scope of committee membership was also discussed.
 - Would all members of the committee be from the conservation community? For example, would public officials, industry, and agricultural representatives be included?
 - One collaborative model that could be emulated is ASU's Decision Center for a Desert City, and potentially some groups in the Bay area of California.
 - In general, there was support for diverse participation as this would bring together many different perspectives.
 - One weakness of the conservation mapping process implemented in the Colorado River Delta is that although stakeholders hail from the government, nonprofit, and academic sectors, they are

mostly coming from natural resource conservation perspectives; organizers could have had more impact by involving the business, agriculture, and industrial community from the start.

- Steering Committee name – there seemed to be confusion between the short-term advisory group that would review Sonoran Institute’s research progress (approximately one year, quarterly time commitment) and the final, longer-term Steering Committee (time commitment = attend annual meeting to report on progress).
 - Perhaps Steering Committee is not the best name for the final group to be formed. This will likely evolve as the research is completed.
 - There was also concern that using the terms “Steering Committee” imparts some form of power that will likely be difficult to define/acquire. Thus perhaps a better word would be partnership?
- There was some discussion regarding whether the annual Researchers' Day would change from the current effort to provide an opportunity for collaboration and sharing of work being done along the Santa Cruz River?
 - There was concern that we would lose a valuable opportunity/tool for researchers to interact and discuss current work if we broaden the focus too much and invite many diverse stakeholders and community members
 - One solution to this concern:
 - Perhaps one day would focus on research and allow for technical presentations and discussion among researchers (mirroring the traditional Researchers’ Day)
 - Perhaps a second day could have less technical presentations on the research, as well as invite presentations from other stakeholders. This could be the annual venue for the broader meeting of the Steering Committee that will have diverse perspectives.

Next Steps:

- Sonoran Institute will be inviting a diverse group of people from across the Santa Cruz River Watershed to serve on the initial short-term advisory group to flesh out a strategy.

Presentation Abstracts

(Listed in alphabetical order by presenter)

Emerging Contaminants in the Upper Santa Cruz River: 2010-2011

ABRELL, LEIF Arizona Laboratory for Emerging Contaminants, University of Arizona

Samanthi Wickramasekara, Arizona Laboratory for Emerging Contaminants, University of Arizona

Sherry Sass, Friends of the Santa Cruz River

Water samples were collected over the past year directly from the Upper Santa Cruz River by UA and FOSCR. Emerging contaminants were extracted and concentrated by solid phase extraction in preparation for LCMSMS analysis in the Arizona Laboratory for Emerging Contaminants using a Waters Acquity UPLC system and a Waters Quattro Premier XE tandem mass spectrometer with electrospray ionization (ESI). Detection of each contaminant (ca. 17) was optimized for multiple reaction monitoring (MRM) at ppt levels in the environment. Upper Santa Cruz River samples were measured to obtain an understanding of river contaminant levels. Preliminary results will be provided and compared with historical measurements.

Measuring the Impacts of Natural Amenities and the US-Mexico Border, on Housing Values in the Santa Cruz Watershed, using Spatially-Weighted Hedonic Modeling

AMAYA, GLADYS, University of Arizona, NASA Space Grant, Department of Systems and Industrial Engineering

Laura M. Norman, U.S. Geological Survey, Western Geographic Science Center

George R. Frisvold, University of Arizona, Department of Agricultural and Resource Economics Tucson, AZ

Assessing the sustainability of International policy or urban development requires consideration of the impacts of these decisions on Ecosystem Services, or the values that humans receive from the ecosystem, including market-land price, environmental, and human well-being values. Hedonic modeling helps to identify the market land price, considering the price is determined by multiple factors affecting it. In U.S. portions of the bi-national Santa Cruz Watershed (SCW), situated at the Arizona-Sonora International border, natural amenities like the riparian corridor and green space have been documented as positive amenities that boost local real estate.

The goal of this research is to isolate the effects of the US-Mexico border and known environmental or natural amenities or disamenities on housing prices in the binational watershed, while controlling for

housing stock characteristics and social-environmental vulnerability. In the ultimate analysis, the mean house values within census blocks will be used to represent local housing stock. A human well-being index that measures people's socio-environmental vulnerability for the entire SCW is in publication that is based on access to infrastructure, number of bedrooms per house and other social data from the binational census and local *colonias* database will also be compared. The hedonic pricing method will be applied to statistically estimate a function that relates property values to the variables described.

This presentation will provide a synopsis of the quality of life and hedonics literature review used to develop this research agenda. Variables relevant for local environmental management, having significant effects on property values, will be discussed. The final results obtained from this study can be used determine the benefits of preserving or developing land binationally and will be uploaded to the Santa Cruz Watershed Ecosystem Portfolio Model (SCWEPM), an online Ecosystem Services tool, being created to promote sustainable development in the Borderlands.

Nogales, Sonora, Mexico: Is There Something in the Water?

CALDEIRA , FELIPE, Udall Center for Public Policy; Mel and Enid Zuckerman College of Public Health, University of Arizona

Laura M. Norman, US Geological Survey, Border Environmental Health Initiative (BEHI), Tucson, AZ

James Callegary, US Geological Survey, Border Environmental Health Initiative (BEHI), Tucson, AZ

Floyd Gray, US Geological Survey, Border Environmental Health Initiative (BEHI), Tucson, AZ

In Nogales, Sonora, Mexico, some neighborhoods have intermittent delivery of water through pipes while other areas lack piped water and rely on water delivered by truck. Multiple sources could potentially contaminate the quality of this water at point of use including contact with water storage containers and delivery trucks tanks, in addition to the preexisting conditions of the water loaded into the trucks. Little information is available on water quality and its impact on human health in this area. Adding complexity to the problem are monsoonal rains that increase surface runoff in the city during the summer months that could both dilute some contaminants and/or contribute to others. We collected 21 water samples from point of use in households both in August (rainy season) and in January (dry season) to analyze potential contaminants including microbes, metals, and anions. Fourteen households in Colonia Luis Donaldo Colosio, a neighborhood recognized as marginalized and highly vulnerable, were sampled and 7 households in Colonia Lomas de Fatima, a more affluent neighborhood recognized for having low vulnerability, were sampled. This presentation will report on the quantities found of total fecal coliforms, *E.coli*, arsenic, lead, mercury, chlorine and sulfate in both neighborhoods and discuss potential cause and effects.

Science-based outreach and water for the environment: Sonoran Institute's updates on Santa Cruz River work

BROTT, EMILY, Sonoran Institute

CLAIRE A. ZUGMEYER, Sonoran Institute

Cheryl McIntyre, Sonoran Institute

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 is thus critical to the ecological integrity of southeastern Arizona and northwestern Sonora. Sonoran Institute is working to increase riparian conservation efforts on the Santa Cruz River by 1) conducting science-based outreach and 2) piloting a unique mechanism to acquire water for the environment.

To better understand the health of the Upper Santa Cruz River, Sonoran Institute developed the Living River report that tracks ten indicators of riparian health on an annual basis. The third report in this series, the 2010 water year, continues to demonstrate improved water quality since the baseline report (2008 water year). Stay tuned for the report, available in summer of 2011. The first Santa Cruz River Researchers' Day identified a need for a centralized database and web tool with which to organize and learn about research conducted on the Santa Cruz River. In 2010, Sonoran Institute created a Santa Cruz River page on the Southwest Learning Center at www.southwestlearning.org/santacruz. Resources listed include regional monitoring, research, and restoration projects with links to summary documents, contacts, and other related websites. This page can also be easily found by going to www.santacruzriver.org, which is redirected to the Southwest Learning Center's Santa Cruz page.

Along with Watershed Management Group and the University of Arizona's Water Resources Research Center (WRRC), Sonoran Institute is launching the nation's first pilot program testing an innovative idea that links personal water conservation and local river restoration. The idea, developed by the WRRC and known as Conserve to Enhance, proposes that dollars saved through water conservation can purchase water for the environment. Currently 60 residents are signed up in Tucson's Conserve to Enhance pilot, installing water harvesting features at their homes and donating savings to local river restoration projects. Revenues generated by the program will be used to purchase water and deliver it to local environmental enhancement projects as selected by the program's Advisory Board. This year's first project is the Atturbury Wash Restoration Site. Results from the pilot will inform an effort to bring the program to other communities.

Linking hydrology, geology, chemistry, and biology in the Upper Santa Cruz River Basin

CALLEGARY, JAMES, US Geological Survey

Nick Paretti, Floyd Gray, Laura Norman, Kim Beisner, Katie Eddelman, Logan Matti, Diana Papoulias, Charles van Riper, JR Bell, Rose McAndrew, Alexis Lincicome, Mark Brusseau, Dave Alvarez, Chris Scott, Prescott Vandervoet, and Sharon Megdal

This presentation will provide an update on interrelated USGS investigations in the Upper Santa Cruz River Basin. These include abandoned mine-land studies, updating geologic maps of the river valley, the Transboundary Aquifer Assessment Program (TAAP), the Border Environmental Health Initiative (BEHI), and contaminant transport between surface water and groundwater at Tumacácori National Historical Park. The technical portion of the TAAP has focused on contaminant transport modeling, aquifer vulnerability to contamination, development of a hydrogeologic framework, and work with Sonoran counterparts on hydrology of the Mexican portion of aquifers. Recognizing the potential for bioaccumulation of contaminants in the food chain, BEHI researchers have collected fish, macroinvertebrates, plants, water, and sediment samples in order to identify presence of emerging contaminants and metals at five sites on the US-side of the basin, each with different contaminant sources. Surface-water models are being calibrated to track the flow and identify sources and sinks of contaminants. The study focusing on Tumacácori began in mid-February 2011 with sampling of both groundwater and surface water, as well as installation of passive chemical samplers and temperature sensors. Results of the BEHI study indicate that a number of contaminant classes are present, including pharmaceuticals, personal care products, pesticides, and metals. Surface-water modeling results indicate that land use changes are increasing water and sediment yield through time. Trends in groundwater levels and temperatures at Tumacácori appear to correlate with streamflow patterns, indicating a hydraulic connection between the Santa Cruz River and the alluvial aquifer. These data support the conclusions of earlier studies, both geochemical and hydrological, which point toward the potential for substantial groundwater-surface water interactions at Tumacácori, though there may be significant interannual variability. Next steps include re-sampling groundwater and surface water at Tumacácori during pre-monsoon and monsoon conditions to assess seasonal variations in contaminant transport. Field work to revise existing geologic maps is also ongoing.

Causes and Consequences of Clogging in the Santa Cruz River

CASE, NATALIE, Arizona State University School of Life Sciences

Julie Stromberg, Arizona State University School of Life Sciences

There is evidence of reduced infiltration of water from the channel to the aquifer in the Santa Cruz River. However, the causal agents that impede infiltration, and the environmental factors that regulate their dynamics, remain virtually unknown in rivers. Reduced infiltration may be a result of biotic processes (growth of microbial biofilms or algae), abiotic processes (siltation or colmation of interstitial spaces), or both acting to clog the sediments of the riverbed. We propose that where steady flows of nutrient-enriched waters occur, such as downstream of wastewater treatment facilities, biofilms may become sufficiently abundant to reduce infiltration rates. This disruption of hydrologic connectivity is of concern because it can reduce survivorship of floodplain riparian vegetation, reduce local recharge of groundwater, and induce surface flow where it is not desired. This study seeks to understand the spatial distribution, identity, and environmental controls of clogging in an effluent-dependent river. To address these questions we established sites at varying distances from municipal effluent discharge points (near Nogales and Tucson) as well as in non-effluent control reaches of the San Pedro River, and are currently collecting data through the seasons. At these sites we quantify streambed infiltration rates by measuring hydraulic conductivity, and analyze sediment samples for physical (particle size), chemical (pH, dissolved oxygen, total organic carbon, ammonium and other nutrients) and biological (bacterial plate counts) parameters. Preliminary results indicate that reduced hydraulic conductivity is associated with fine sediment particles and higher abundance of bacteria. Bacteria are also more abundant in areas with high levels of organic carbon and ammonia. Distinct trends in nutrients and conductivity can be seen between the Nogales (upgraded treatment facility) and Tucson (not yet upgraded) reaches. Additional analyses are underway to tease apart these interactions, and to identify possible thresholds for reduced conductivity.

Santa Cruz River at Canoa Ranch Photo Monitoring

CONNOLLY, NEVA, Pima County Office of Conservation Science

Julia Fonseca, Pima County Office of Conservation Science

Frank Postillion, Pima County Regional Flood Control District

Pima County purchased Canoa Ranch in 2001 for historical and cultural preservation, as well as for open-space protection. Canoa Ranch totals 4,800 acres. Pima County Regional Flood Control District

took ownership of the portions most susceptible to flooding. Roughly, 1,300 acres are within the floodway. The Santa Cruz River at Canoa Ranch is primarily ephemeral, though in most years effluent flow from the Nogales Wastewater Facility reaches Canoa Ranch during the winter. Historic straightening, berming and removal of vegetation due to ranching and flood control activities have compromised floodplain functions along this reach. Groundwater pumping in the area has reduced the availability of surface water, though groundwater is generally less than 50 feet below the surface at the south edge of the ranch. In this area, riparian plant species such as Fremont cottonwood, Goodding willow, and seep willow are present along the Santa Cruz River.

In 2002, photo points were established for baseline conditions for Canoa Ranch along the Santa Cruz River. In June 2004, 2006, and 2008, Pima County Water Resources staff repeated the photo monitoring effort to document any changes that had occurred between each two-year period.

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.

History and Prospects for Fish in the Santa Cruz River, Pima County, Arizona

FONSECA, JULIA, Pima County Office of Conservation Science

The disappearance of the streamflow along the Santa Cruz River at Tucson contributed to the endangerment of six species of native fish. Today, an average of 46 million gallons of treated effluent is discharged to the river daily, sustaining the longest and largest flowing stream in Pima County. The diversity of aquatic macroinvertebrate life in the Santa Cruz River downstream of Tucson has been documented to be lower than nearly every other effluent-dominated stream studied in the southwestern U.S. Repeated surveys in the late 20th century detected few fish of any kind. There are no upwellings of groundwater in this reach, thus there is no water quality refugium for aquatic life, as exists in the upper Santa Cruz River in Santa Cruz County and in Mexico. The physical substrate also presents challenging conditions for fish and invertebrates.

Recent improvements to the wastewater process at the Ina Road treatment facility have decreased nitrogen and carbon in the effluent. Today, mosquitofish (*Gambusia affinis*) have been found at a number of locations along the effluent-dominated reach downstream of the Ina facility. Future improvements to the Roger Road facility will further reduce nitrogen and carbon loads to the river. Improved water quality presents an opportunity for an expanded diversity of aquatic and terrestrial fauna in the area, including the potential for natural colonization of the river by native fish, to the extent that effluent continues to be discharged and substrate proves not to be a limiting factor.

The Vegetation of the Middle Effluent dominated Santa Cruz

GORMALLY, JOSH

The lower effluent dependent Santa Cruz River of Southern Arizona represents a unique partially rehabilitated riparian ecosystem. Effluent release begun in the late 1970's has led to the emergence of a verdant and diverse plant ecosystem. Presented will be the results of original scientific study looking at the effects of effluent release on the vegetation in this unique river ecosystem. Discussed will be study methodology, study findings including measures of species diversity, density, richness, evenness, nativity, and plant type composition, as well as statistical analysis of the results. Also discussed will be the various predominant and unique plant species which occur in the area as a result of effluent release as well as the relatively new and complex vegetative mosaic. Striking photographic evidence from 2002 coupled with current images will visually describe rapid changes in vegetation growth rates and developing complexity. In addition an attempt will be made to describe the original ecosystem prior to European settlement and briefly discuss water treatment. Available will be a comprehensive and current plant list of over 100 species identified as effluent dependent in the area developed by the author.

Health and Lifestyle of Children Living in the Santa Cruz River Watershed

GRIGERA, SOFIA, U.S. Geological Survey, Western Geographic Science Center

Laura Norman, U.S. Geological Survey, Western Geographic Science Center

Health issues are common among children living in the U.S. portion of the Santa Cruz Watershed (SCW), located at the border of Arizona and Sonora. Arizona Department of Health Services (ADHS) reports provide disease incidence rates affecting children 0-19 years of age (yoa) within Pima and Santa Cruz Counties, which include the majority of the SCW in Arizona. Potential health disparities observed among infants and children may result from environmental exposures that occur in the SCW.

Surface waters near Nogales, Rio Rico, and Tubac, Arizona contain detectable levels of metals, pharmaceuticals, personal care products, pesticides, flame retardants etc. Exposure to environmental contaminants may influence the incidence of mortality and morbidity.

Compared with other Arizona counties, Pima and Santa Cruz Counties show higher rates for low-birth weight, spontaneous fetal death, infant mortality, specific birth defect, infant and pre-puberty death from congenital anomalies/malformations, childhood leukemia, and reportable cases of infectious disease caused by waterborne contaminants. Specific causes of these rate increases are unknown. Future investigations of whether low birth weight or small for gestational age births are related to environmental contaminant exposure, and whether exposure to contaminants at an early age influences the onset of later diseases like diabetes and asthma are needed.

USGS Border Environmental Health Initiative researchers are documenting water quality in the SCW. Issues associated with environmental exposures, and health equity are of great concern. Health equity is the study of differences in the quality of health or access to health care across different socioeconomic groups. An online Ecosystem Portfolio Model is being developed by the USGS to help decision-makers consider the impacts of land use and climate change to socio-environmentally vulnerable communities. Future proposals will address environmental justice issues relevant to the inability to pay for private well monitoring, and the potential risk of exposure to waterborne contaminants in the SCW. 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 trial-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.

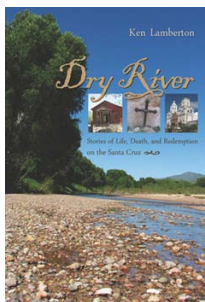
Ecosystem Monitoring at Tumacácori National Historical Park

HUBBARD, ANDY, NPS Sonoran Desert Network

Set aside to preserve unique cultural resources, Tumacácori National Historical Park also contains important natural resources associated with the Santa Cruz River. To better understand and manage critical park ecosystems, the National Park Service initiated long-term monitoring of key physical and ecological resources in 2005. Results of this multi-disciplinary effort illustrate a complex system in which park resources reflect external influences from the upper Santa Cruz watershed to regional and even continental scales.

Dry River: Stories of Life, Death and Redemption on the Santa Cruz

LAMBERTON, KEN (University of Arizona Press, 2011)



The poet and writer Alison Deming says, "In the desert, one finds the way by tracing the aftermath of water..."

Southern Arizona's Santa Cruz River has been a mystery to author Ken Lamberton since the day he moved into its watershed at the age of nine. River of still and silent sand in one moment; river of thundering mud the next. But mostly a strange and twisting gash. The desert is an extreme place. So maybe this dry river that runs through it has to be the desert's reflection. What does water mean to the Santa Cruz? It certainly doesn't define it, since over most of its course water is an abstraction, or at best only wishful thinking. The Santa Cruz River *is* the aftermath of water.

In his new book, *Dry River: Stories of Life, Death, and Redemption on the Santa Cruz*, Lamberton takes his readers on a trek through three nations, the US, Mexico, and Tohono O'odham, as he hikes the river's 200-mile course from source to cessation. While tracing the river, he discusses the region's human and natural history, sometimes talking with scientists and researchers he meets along the way, but always weaving in stories of ordinary people, past and present (including stories of his own family), who have drawn and still draw life from the Santa Cruz. *Dry River* is a book with a new perspective, one

of possibility and hope, rather than abandonment and despair, two themes already adequately addressed concerning the Santa Cruz River. It relates stories of hope because hope, unlike despair, leads to action. It means a better world might be possible. *Dry River* celebrates not only the place but the people who have spent their lives scratching an existence out of the very desert the river bisects.

A new network of banding stations on the Santa Cruz River in Southern Arizona

LEITNER, BENTON, BirdWorks

Larry Norris, National Park Service

Wade Leitner, BirdWorks

Tumacácori National Historical Monument has hosted a single banding station for 14 years. This station has produced extensive data concerning species richness, abundance distributions, species accounts and molt migration. However, basic data on recruitment and dispersal requires the establishment of a set of sister stations. According to data drawn from stations both within and outside of the TUMA MAPS network, recapture of a hatch year bird is far less likely than recapture of birds first banded later in life for most of the abundant species. Notably, the non-migratory species have much greater probabilities of recapture. The three most obvious hypotheses to explain this difference are:

1. Migration for hatch year birds is far more risky than for second year or older birds;
2. Hatch year birds of migrant species are less likely to survive either before migration or on the wintering grounds;
3. Hatch year birds do not return to their natal sites long enough to be re-captured.

It might be possible to do discriminate between these three hypotheses for multiple species by measuring distance dispersed in terms of home range or territory size. To that end, the TUMA MAPS network was established and has recorded its first data on between, and it turns out, within station dispersal.

Groundwater Contaminant Transport Modeling In the Upper Santa Cruz Basin

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The Upper Santa Cruz Basin has experienced population growth and industrial development that has resulted in increasing water demand and greater risk of groundwater contamination. This demand and

subsequent pumping that began in the late 1800s have led to ephemeral flow in portions of the river, while effluent discharge from the Nogales International Wastewater Treatment Plant (NIWTP) now sustains perennial flow in the downstream reach. In combination, these factors have altered the natural groundwater flow patterns in the basin. The objective of this study is to examine the potential for contaminant transport in the subsurface and associated human-health risks by using a groundwater flow model previously developed for the portion of the aquifer downgradient of the NIWTP. Water-quality data from numerous sources (federal, state, consultant, and academic) have been collected and compiled into a database of sampling events for the area and was then aggregated to identify major contaminants and their distribution. Using a numerical model (MT3D), simulations have been conducted for specific contaminants, including nutrients and trace metals, to evaluate their movement in the aquifer. The results of this study will be used to evaluate the potential for groundwater contamination and transport to drinking water wells.

Market-based Responses to Arizona's Water Sustainability Challenges: The Cornerstones Report

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In 1986, the Ford Foundation touted the Arizona Groundwater Management Act for its innovative approach to water management. Thirty-one years after the Act's passage, Arizona continues to cope with familiar challenges, such as groundwater overdraft, drought, and surface water shortages. In addition, population growth and competition for freshwater supplies have strained the health of Arizona's rivers and shallow groundwater tables. The decline of rivers not only affects sensitive riparian habitat but also impacts local water supplies, aquifer recharge, and flood control and highlights the need for sustainable water management efforts to balance human and ecosystem water requirements. The Cornerstones Report explores how market-based tools can contribute to water sustainability efforts and the protection and restoration of ecosystem water needs. This report emerges from a series of workshops in May and July of 2010. During these workshops, a range of representatives from conservation groups, municipal water utilities and federal water projects came together to discuss sustainability within Arizona generally, with specific focus on how market-based responses might contribute to sustainability and the protection and restoration of ecosystem water needs. This effort identifies the cornerstones, or foundational elements, required for market-based reallocation to contribute to water sustainability and ecological needs and offers recommendations for moving forward.

The Resurgence of a River: A Report on Fish in the Santa Cruz

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Fish abundance in the Santa Cruz River has increased dramatically since 2008. Water quality of this river, which receives effluent discharge, has improved with recent upgrades to the Nogales International Wastewater Treatment Plant (NIWTP). In addition to escalation in fish numbers, ammonia and total nitrogen levels have decreased, dissolved oxygen levels have increased, and the diversity of aquatic invertebrates has increased, indicating healthier river conditions. Researchers found increased numbers of fish but no increase in fish diversity. Fish species consisted solely of longfin dace (*Agosia chrysogaster*) and mosquitofish (*Gambusia affinis*). This presentation will provide an overview of an ongoing, collaborative effort among the Friends of the Santa Cruz River (FOSCR), the Sonoran Institute, US Fish and Wildlife Service, Arizona Game and Fish Department, and the University of Arizona to monitor water quality and fish populations in this living river.

Climate and Population Change Impacts on Dryland Rivers - Integrated Synthesis

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Recent research has revealed the strong dependence of ecosystem services on the physical and biological conditions of riparian areas in the Southwest United States. Nevertheless, it is unclear how ecosystems services change in response to exogenous forcing on the physical and biological state of ecosystems. To address this effectively, an integrated modeling and synthesis approach is being conducted needed to quantify how ecosystem services might vary in response to future climate change and population growth. Changes in the water extracted from to ecosystems can have large impacts on the value of ecosystem services provided to society. The differentiation of these impacts will be studied by investigating breakpoints between *limited* and *significant* impacts on riparian ecosystem services and their valuation. The interconnected nature of social, ecologic and hydrologic systems

requires this place-based research using a suite of models integrated across disciplines. We are working on the adjacent (but distinct) San Pedro and Santa Cruz river basins, in southern Arizona. These basins span a gradient in water demand, streamflow regime and ecosystem services and have been studied through multiple projects, including studies on the value of ecosystem services provided by vegetation, birds and species diversity.

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

1. The value of ecosystem services declines (increases) in non-linear and stepwise fashion as water is extracted (restored) from (to) dryland rivers
2. Hysteretic effects characterize stream re-watering: the *trajectories* of changes in ecosystem value are reversible, but the absolute *magnitude* of ecosystem service recovery varies depending on the degree of historic dewatering.
3. Climate change and population growth act together in a synergistic way to decrease the water withdrawal levels at which ecosystem services cross thresholds.

Characterization of Fecal Contamination Targeting 16S rRNA *Bacteroides* Molecular Markers in the Santa Cruz River, Arizona

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Fecal contamination of ground and/or surface water can result from several sources ranging from human sewage (septic tank leakage), agricultural or livestock operations runoff, and local wildlife. Bacteria belonging to the genus *Bacteroides* have been suggested as alternative fecal indicators to *E. coli* or fecal coliforms because they make up a significant portion of the fecal bacterial population, have little potential for re-growth in the environment, and have a high degree of host specificity that likely reflects differences in host animal digestive systems. In this study our team used microbial source tracking (MST) techniques designed to target specific diagnostic sequences within a *Bacteroides* gene present in feces from different animals; coupled with conventional microbial methods to determine the dominant sources of fecal contamination in the Santa Cruz River. The existence of microbial contaminants in the Tumacacori National Historic Park (NHP), Tubac, Arizona, poses risks that must be considered in park planning and operations. The objective was to differentiate between human, ruminant and other animal sources of fecal contamination by

targeting 16S rRNA *Bacteroides* molecular markers found in the literature. In this study we evaluated 8 *Bacteroides* based assays; human, bovine, avian and pig sources. Results indicate that 73% of total samples assayed (n=58) show high levels of total coliforms and *Escherichia coli*, 33% show contributions of Human molecular markers, and 29% show bovine and pig molecular markers. Our data suggests that seasonal changes contribute to the microbial load present in water within the region due to storm events in which increased overland flow is bringing additional pollution into the watershed. This data will be used for the development of techniques and tools to characterize, control, and manage sources of water quality impairment.

Development of landscape-scale geospatial data sets describing the vegetation and land use of the binational Santa Cruz watershed

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Trends derived from vegetation maps and multi-temporal land-cover data can be used to inform land-management decisions and model future-change scenarios. The U.S. Geological Survey is currently developing geospatial data to support ecosystem services modeling of the bi-national Santa Cruz watershed of southern Arizona, USA, and northern Sonora, Mexico, which are available for public use. Using Landsat TM data and a Classification and Regression Tree (CART) modeling environment, we developed 1) a vegetation classification of the Santa Cruz River riparian habitat and watershed vegetation and 2) a multi-decadal Land Use/Land Cover (LULC) dataset (1979 to 2009). The vegetation classification was based on NatureServe's Terrestrial Ecological Systems and is thematically commensurate with the Southwest Regional Gap Analysis Project (SWReGAP) of the USGS Gap Analysis Program (GAP) and the LULC dataset was based on USGS National Land Cover Database (NLCD) classification scheme. Environmental layers used as independent, predictor data were derived from a seasonal set of Landsat TM images (spring, summer, and fall) and from a 30-meter digital-elevation model. Because both sources of environmental data are seamless across the international border, they are particularly suited to this binational modeling effort. Training data were compiled from field data collected: (a) for recent vegetation map produced for the Santa Cruz River riparian corridor and (b) by the New Mexico-GAP team for the original SWReGAP modeling effort. With these data, we examine the current distribution of vegetation communities in the watershed, historical trends, and changes in land use and land cover, and we discuss future research and applications within the Santa Cruz River watershed.

Tumacácori National Historical Park: Its Resources and Role in Research

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Tumacácori National Historical Park is situated 30 kilometers north of the US-Mexico border in the Santa Cruz River Valley of southern Arizona. In 2002, the park acquired lands adjacent to the ruins of the Spanish colonial mission for which the park was designated nearly one century earlier. The new lands have changed the character of the park to some degree by adding a substantial natural resource component to its existing emphasis on cultural resources. The recent acquisition also increased the size of the park nearly ten-fold to over 350 acres and introduced a host of new research opportunities in natural resource conservation with the addition of a mile-long reach of the Santa Cruz River channel. The park provides habitat for some 600 plant and animal species, with over 150 bird species, native fish, amphibians, reptiles and mammals. Mesquite bosques, grasslands and riparian corridor create a nexus of suitable habitat for these taxa and recreational opportunities for over 50,000 annual visitors. Trespass cattle and effects from over three centuries of grazing mark the landscape along with impacts related to human migration. With these resource management challenges in mind, the park coordinates closely with outside researchers in topical areas such as water quality, public health, bird conservation and vegetation change while conducting research of its own in riparian site restoration and wildlife monitoring. The size and accessibility of the park, coupled with its geographic site and situation, make it a desirable venue for a variety of research interests. It is the objective of the resource program at Tumacácori NHP to encourage scientific research as part of the regional effort to build knowledge of this bi-national waterway and its environs.

Nutrients and nitrophiles: effects of treated wastewater on dryland riparian plant communities

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During the twentieth century, nutrient inputs to aquatic and riparian ecosystems worldwide increased dramatically leading to changes in community composition and ecosystem function. For riparian ecosystems of the southwestern United States, declines in surface water flows coupled with the release of treated municipal wastewater have resulted in the emergence of effluent-dominated waterways. However, little is known about the riparian plant communities that are created and sustained by treated wastewater. We conducted a greenhouse experiment and gathered field data to determine how elevated nutrient levels in treated municipal wastewater influence riparian plant community response in three different hydrologic settings. Plants from soil seed banks collected from

ephemeral, perennial, and effluent-dominated rivers were monitored in a greenhouse to address how varying concentrations of nitrogen and phosphorus would influence richness, biomass, density and composition. Streamside herbaceous vegetation was sampled for two years at twelve sites along the effluent-dominated Santa Cruz River and at nine sites along the San Pedro River, our control. We used a modified Ellenberg index to further assess composition and found that effluent-dominated systems had greater abundance of nitrophilic species, those with higher nitrogen affinity, such as *Conium maculatum* and *Polygonum lapathifolium*, in both the experiment and field settings. In all settings, biomass and plant height increased while stem density and richness decreased with increasing nutrient concentrations. Hydrologic setting is also an important factor on community response, as biomass and density were significantly higher in the perennial and effluent-dominated seedbanks. As anthropogenic nitrogen inputs currently equal or exceed natural N inputs in many ecosystems and as larger scale restoration is planned for entire landscapes, this study revealed that water quality and hydrologic setting are important ecological variables influencing herbaceous plant community development and population-level processes in waterways receiving treated wastewater.

Additional Research

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

Using Qualitative Research to Understand Riverine Ecosystem Services

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This research relies on a series of focus groups and interviews to gain a broader perspective of how people perceive riparian resources in southern Arizona, and the Santa Cruz River in particular. While much ecosystem services research makes use of quantitative tools, this research aims to deepen context by harnessing social science qualitative research methods such as moderating individual interviews and small group interactions, coding transcribed text, and noting participants' apparent emotions. The goal of these interactions is to help scientists understand what is important to people about waterways. This might then sharpen the focus of riparian ecosystem services research to be most meaningful for public welfare, in foundational applications such as monitoring, mapping, or modeling. Qualitative analysis can also be used to inform follow-up quantitative social science research. For example, ecosystem service valuation surveys are often based on qualitative pre-testing to help define the most salient questions. This project is a pilot, with subsequent work planned in other regions of the U.S., where different sociodemographic and riparian conditions apply.

In the fall of 2010, twenty in-depth interviews were conducted with a sample of Santa Cruz River stakeholder representatives, including neighborhood contacts for areas near the river in Tucson. The next phase scheduled for the spring of 2011 aims to broaden the sample, with an emphasis on capturing the views of typical citizens rather than those of known stakeholders. Over one hundred people will be engaged through a combination of focus groups and individual interviews. Meetings will be stratified by sociodemographic data, predominantly in the Tucson area, with two meetings planned in the upper basin. Participants will be compensated, and meetings will have Spanish translation services where needed. Recruitment will be via random-digit-dialing to facilitate broad representation, rather than an open meeting format inviting self-selection.

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