

# **Santa Cruz River Researchers' Day**

## **March 29, 2012**



Santa Cruz River and Central Arizona Project near Marana, Pima County, Arizona

## **Proceedings**

- Sponsored By –  
Tumacácori National Historic Park  
Friends of the Santa Cruz River

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## Introduction

On March 29, 2012 Tumacácori National Historical Park and Friends of the Santa Cruz River hosted the fourth 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.

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

- Sonoran Institute [www.sonoraninstitute.org](http://www.sonoraninstitute.org) - links to Researchers’ Day events and information are provided in the ‘resources’ side-bar of the page describing Santa Cruz River work (go to “WHERE WE WORK” > “Southwest” > “Santa Cruz River” or use the following [Link to Santa Cruz River Project on Sonoran Institute website](#)).

## Program

| Time                 | Schedule                                                                                                                                                         | Title                                                                                                                                                           |
|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 9:30                 | Refreshments/Poster Time                                                                                                                                         |                                                                                                                                                                 |
| 9:40                 | Welcome - Jason Welborn and Jen Parks                                                                                                                            |                                                                                                                                                                 |
| 9:50                 | Emily Brott and Claire Zugmeyer                                                                                                                                  | <a href="#">Santa Cruz River Conservation Symposium - update and invitation</a>                                                                                 |
| 10:00                | Evan Gwilliam                                                                                                                                                    | <a href="#">A River Runs Through It...Usually: Ecosystem Monitoring atTumacácori NHP 2007 to 2012</a>                                                           |
| 10:20                | Ron Pulliam                                                                                                                                                      | <a href="#">The Borderlands Habitat Restoration Initiative</a>                                                                                                  |
| 10:40                | Break/Poster Time                                                                                                                                                |                                                                                                                                                                 |
| 11:00                | David Quanrud                                                                                                                                                    | <a href="#">Fate of Emerging Contaminants along the Lower Santa Cruz River, Arizona</a>                                                                         |
| 11:20                | James Callegary                                                                                                                                                  | <a href="#">Update on surface-water-to-groundwater transport of contaminants at Tumacácori NHP</a>                                                              |
| 11:40                | Jennie MacFarland and Kendall Kroesen                                                                                                                            | <a href="#">Avian monitoring and restoration of Esperanza Ranch in the Upper Santa Cruz River Important Bird Area</a>                                           |
| 12:00                | BREAK LUNCH (on your own/bag lunch permitted)                                                                                                                    |                                                                                                                                                                 |
| 1:00                 | Mark Krieski                                                                                                                                                     | <a href="#">Coping with a String of Nasty Breakups</a>                                                                                                          |
| 1:20                 | Gaurav Arora                                                                                                                                                     | <a href="#">Effects of Environmental Amenities and Locational Disamenities on Home Values in the Santa Cruz Watershed: A Hedonic Analysis Using Census Data</a> |
| 1:40                 | Laura Norman                                                                                                                                                     | <a href="#">The Santa Cruz Watershed Ecosystem Portfolio Model (SCWEPM); Progress and Future</a>                                                                |
| 2:00                 | Akitsu Kimoto                                                                                                                                                    | <a href="#">Historical Changes in the Lower Santa Cruz River</a>                                                                                                |
| 2:20                 | Break/Poster Time                                                                                                                                                |                                                                                                                                                                 |
| 2:40                 | Evan Canfield                                                                                                                                                    | <a href="#">Modeling Changes in Infiltration in the Lower Santa Cruz River</a>                                                                                  |
| 3:00                 | Rewati Niraula                                                                                                                                                   | <a href="#">Hydrological Modeling of a Semi-arid Santa Cruz Basin</a>                                                                                           |
| 3:20                 | Jennifer Duan                                                                                                                                                    | <a href="#">Annual Total Sediment Load in Santa Cruz River</a>                                                                                                  |
| 3:40                 | Frank Postillion                                                                                                                                                 | <a href="#">Hydrologic Evaluation of the Tres Rios Del Norte Area</a>                                                                                           |
| 4:00                 | Poster Time/Networking/Wrap-up                                                                                                                                   |                                                                                                                                                                 |
| Posters              |                                                                                                                                                                  |                                                                                                                                                                 |
| Candice Rupprecht    | <a href="#">Conserve to Enhance: An Innovative Pilot Program in Tucson to Conserve Water for the Environment</a>                                                 |                                                                                                                                                                 |
| Carolyn Lipnick      | <a href="#">Composting Toilets in Nogales, Sonora: Results of a Pilot Study</a>                                                                                  |                                                                                                                                                                 |
| Leif Abrell          | <a href="#">Indicators of organic contamination in the Lower Santa Cruz River</a>                                                                                |                                                                                                                                                                 |
| Eleanor McCallum     | <a href="#">Visitor experience and anthropogenic landscapes</a>                                                                                                  |                                                                                                                                                                 |
| Miguel L. Villarreal | <a href="#">Land use matters: Private and public land stewardship efforts moderate the effects of drought and resource consumption on watershed habitat loss</a> |                                                                                                                                                                 |
| Sofia Grigera        | <a href="#">Investigating Water Quality in Private Domestic Wells in Santa Cruz County, Arizona.</a>                                                             |                                                                                                                                                                 |

## Presentation Abstracts

(Listed in alphabetical order by presenter)

### **Effects of Environmental Amenities and Locational Dissamenities on Home Values in the Santa Cruz Watershed: A Hedonic Analysis Using Census Data**

ARORA, GAURAV, Department of Agricultural and Resource Economics, University of Arizona

George Frisvold, Department of Agricultural and Resource Economics, University of Arizona

Laura Norman, U.S. Geological Survey

For this study, we used the hedonic pricing method to measure the effects of natural amenities on home prices in the U.S-side of the Santa Cruz Watershed. We employed multivariate spatial regression techniques to estimate how different factors affect median home values in 613 census block groups of the 2000 Census, accounting for spatial autocorrelation, spatial lags, and/or spatial heterogeneity in the data. Diagnostic tests suggest that failure to account for spatial effects would bias inferences made from the statistical analysis. The explanatory factors for the hedonic model can be classified as (1) physical features of the housing stock, (2) neighborhood characteristics, and (3) environmental attributes. Census data was combined with GIS data for vegetation and land cover, land administration, measures of species richness and open space, and proximity to amenities and disamenities. Census block groups having more vegetation identified as species-rich habitat, having closer access to public lands, or with relatively more undeveloped private land had higher median home values. In contrast, home values in census block groups closer to the US-Mexico border or airports/air bases were negative. Results suggest that policies to maintain biodiversity and open space provide economic benefits to homeowners, reflected in higher home values. Future research will quantify the marginal effects of regression explanatory variables on home values to assess their economic and policy significance. These marginal effects will be used as input indicators to discern potential economic impacts of various scenarios in the Santa Cruz Watershed Ecosystem Portfolio Model (SCWEPM). Future research will also expand this effort into the Mexican-portion of the watershed.

### **Santa Cruz River Conservation Symposium – update and invitation**

BROTT, EMILY M., Sonoran Institute

Claire A. Zugmeyer, Sonoran Institute

Inspired by a conservation mapping and goal-setting process Sonoran Institute helped lead in the Colorado River Delta nearly a decade ago, Sonoran Institute staff propose implementing a similar process for the Santa Cruz River Watershed. Previous Santa Cruz River Researchers' Day meetings have identified the need to expand collaboration, partnerships, and sharing of lessons learned across the watershed, including cross-border and across subwatersheds. The overarching goal of such collaboration will be expanded collective impact of conservation efforts. On May 2, 2012 a full day symposium will be held on Santa Cruz River Conservation as part of the binational Madrean Archipelago III conference held in Tucson, Arizona. The symposium will have simultaneous Spanish/English translation and will feature 1) presentations focused on work being done within the watershed in Mexico, 2) a binational mapping session to review preliminary research identifying the current knowledge of conservation, monitoring, and restoration efforts in the watershed, and 3) a discussions on

increasing collaborations with an invitation to form a binational Santa Cruz River Steering Committee. Including the Santa Cruz River Symposium as part of the larger Madrean Archipelago III conference is an important step towards increasing cross-border participation and elevating the profile of conservation efforts within the watershed. Results of the symposium will be summarized and published as part of the conference proceedings as well as in a publication in development that is tentatively titled “State of the Santa Cruz River”.

### **Update on surface-water-to-groundwater transport of contaminants at Tumacácori National Historical Park**

CALLEGARY, JAMES, US Geological Survey

Nick Paretti, U.S. Geological Survey

Kim Beisner, U.S. Geological Survey

The USGS conducted a study of surface-water-to-groundwater transport of contaminants at Tumacácori National Historical Park (TUMA). Water samples were collected from the drinking water well at TUMA, and both sediment and water were collected from the Santa Cruz River at Santa Gertrudis Lane in February, June, and September/October, 2011. Water samples were analyzed for pharmaceuticals, personal-care products, haloorganics, trace elements, and nutrients. Passive samplers, designed to detect low-level organic compounds present in the water, were installed in both the river and a monitoring well in the Park. Analytical results of that work are pending. Results from the river sampling have confirmed the presence of pharmaceuticals, personal-care products, and haloorganics that were previously detected in December 2009. TUMA groundwater samples had low level detections of flame retardants and a few other organic compounds such as benzophenone, phenol, and DEET indicating that some contaminants from the river may be reaching the drinking water well. Groundwater levels in a set of paired monitoring wells at TUMA generally indicate an upward gradient, but a comparison of the timing of changes in water levels with discharge (monitored at the USGS gaging station in Tubac, Arizona) shows that occasional reversals in gradient are closely tied to high flows in the river. Groundwater temperature data also indicate a clear correlation with high flows, and both water levels and temperature exhibit a seasonal cycle that is correlated with river discharge cycles.

### **Modeling Changes in Infiltration in the Lower Santa Cruz River**

CANFIELD, EVAN, Pima County Regional Flood Control District

Akitsu Kimoto, Pima County Regional Flood Control District

Jacob Prietto, Pima County Regional Flood Control District

The infiltration conditions in the lower Santa Cruz River may change in response to the renovation of the wastewater treatment plants that is now under way. The upgrades will significantly reduce the amount of nutrients, (especially nitrogen, which will drop from the current concentration of about 30 mg/l to about 8 mg/l), and suspended solids, which promote clogging.

Infiltration studies conducted using data from the early-to-mid 1990s showed that the effluent flow rarely passed the Pima County line. However, in recent years, a significant portion of the effluent left the County. This was in-part a function of the increase in discharge volumes from the wastewater treatment plants as population in Pima County increased, but might also be related to changes in infiltration rate. In order to evaluate this

change in infiltration, a KINEROS2 model, like the model used by Lacher 1996, was optimized for saturated hydraulic conductivity (Ks) and Manning's channel roughness (n) using 2010 USGS flow data. The results showed that Ks values from 2010 were approximately half of those determined by Lacher using data from 1994 and 1995. (0.7 in/hr in 1994-1995 to about 0.35 in/hr in 2010). However, like the previous study, this study found that following a flow event that scoured the bed, Ks increased. Some possible reasons for the observed decline may relate to physical changes, such as less frequent scour events and avulsion of the low flow channel. With less avulsion the biological clogging associated with nutrient loading to become more pervasive. However, the lower Ks values might also be attributed to chemical changes such as the increasing salt content of the influent associated with the transition from groundwater to a blend of Colorado River water and groundwater.

### **Annual Total Sediment Load in Santa Cruz River**

DUAN, JENNIFER, Department of Civil Engineering, University of Arizona

Among over 40 sediment transport equations (Laursen 1958; Toffaleti 1966; Engelund and Hansen 1972; Yang 1973), the equations of Laursen (1958) and Yang (1973) are applicable to fine grain sized sediment with  $d < 0.0625\text{mm}$ . All of the equations have limited accuracy when applying to field sites, especially for dry-land rivers in the semi-arid region. Because only daily averaged flow and water depth are available, this study chose the daily suspended sediment discharge to determine which sediment transport equation is applicable to the Santa Cruz River. Both Laursen (1958) and Yang (1973) equations were used to estimate the daily suspended load. The calculated results are compared with measurements obtained at Cortaro and Laveen gauges, which shows both equations under-predict the suspended sediment load, but Yang (1973)'s equation gives closer matches to the measurements, especially when the daily sediment load is greater than 10 tons/day. The averaged relative errors for Yang (1973) and Laursen (1958)'s equations are 20.5% and 281%, respectively. This result attributes to the very large transport rates predicted by the Laursen (1958)'s equation at discharges greater than  $28\text{ m}^3\text{ s}^{-1}$  (1000 cfs). Based on the Yang (1973)'s equation, annual sediment load in Santa Cruz River is calculated at Laveen gage from 1993-2008. Santa Cruz River has contributed considerable sediment load to the Gila River in 1999, 2000, and 2003. This demonstrates the hydrologic connectivity between the Santa Cruz River and the Gila River.

### **A River Runs Through It...Usually: Ecosystem Monitoring at Tumacácori NHP 2007 to 2012**

GWILLIAM, EVAN, NPS Sonoran Desert Network

In this presentation we will briefly review the NPS Inventory and Monitoring program, and then discuss results from monitoring at the park including water flow, water quality, channel morphology, macroinvertebrates, riparian vegetation and birds. We will highlight connections with management issues, regional land use and climate change.

## **Historical Changes in the Lower Santa Cruz River**

KIMOTO, AKITSU, Pima County Regional Flood Control District  
Evan Canfield, Pima County Regional Flood Control District

The Lower Santa Cruz River is an effluent-dependent river. To evaluate best management of the Lower Santa Cruz River, Pima County Regional Flood Control District (RFCD) launched “Lower Santa Cruz River Management Plan”. As part of efforts, this study assessed historical changes in the effluent-dependent low flow channel geometry in the Santa Cruz River from Sweetwater Dr. to Trico Rd. Low flow channels were digitized using aerial photos taken in 1998, 2002, 2005, 2008, and 2010. Lateral changes including alignment, area and length of reaches were compared throughout the study period. Vertical changes were assessed by comparing elevation differences between periods using 20’ DEM data from the 1998, 2005 and 2008. Throughout the study period, substantial changes in low flow channel location occurred in the reaches from Sanders Rd. to Cement Plant Rd., from Cortaro Rd. to Ina Rd. and from Ina Rd. to Sunset Rd. The comparison of the length, area and location of low flows showed that flow splits, meandering and merging occurred throughout the study reaches. The comparison of elevation changes showed that severe scour was found at locations where a low flow channel shifted and a new flow path developed. Scour was dominant during the study period though a few reaches had more deposition than erosion. The data also showed that more scour occurred during the period between 2005 and 2008 than between 1998 and 2005. This may be related to the fact that larger floods occurred in 2005, 2006 and 2007. This study showed that there was significant movement of the low flow channel within the floodplain of the Lower Santa Cruz River. This movement has implications on the ability of the effluent flow to support a stand of riparian trees for an extended period of time.

## **Coping with a String of Nasty Breakups**

KRIESKI, MARK, Pima County Regional Flood Control District

A compound high-flow/low-flow channel bank protection system was constructed by developers in 1986 along the Santa Cruz River for the Continental Ranch housing project. The low-flow channel, three miles long and 400 feet wide, is bordered by 12-foot high soil cement banks. During the last twenty-five years, daily effluent flows from upstream wastewater treatment plants and stormwater flows have significantly incised the channel bed and undermined sediment from beneath the bank structures. In contrast to local channel incision by sediment-deficient effluent flow, the overall low-flow channel is characterized by aggradation of approximately 500,000 cubic yards of sediment. After monsoon flooding in 2006 RFCD observed two soil cement bank failures, both 100 to 150 feet long, located across the low-flow channel from each other. In January, 2007 RFCD identified a third soil cement bank protection collapse some 2000 feet upstream. Disaster relief applications were submitted to FEMA for funding of each collapse areas. In August 2007, two additional bank protection failures were observed. The cost to reconstruct the soil cement banks exceeded \$1,000,000. RFCD prepared an Alternatives Analysis in 2008 for remediation of the entire low-flow channel; the recommended alternative, including four grade control structures spanning the channel, soft stabilization of the soil cement banks, and removal of substantial aggraded sediment was estimated to cost \$14,000,000. In 2010, RFCD completed a \$200,000 pilot stabilization project of critical undermined bank areas. Stabilization techniques included a soil cement toe trench, filling of undermined voids and placement of gabion jetties to divert flow from banks and promote vegetation growth. A new soil cement bank collapse occurred in September, 2011; repair is imminent.

RFCD intends to analyze additional bank stabilization techniques, implications for existing high-value riparian areas, and the pros and cons of not repairing future bank failures.

### **Avian monitoring and restoration of Esperanza Ranch in the Upper Santa Cruz River Important Bird Area**

MACFARLAND, JENNIE, Tucson Audubon Society

KROESEN, KENDALL, Tucson Audubon Society

Esperanza Ranch is an 800-acre parcel located along the upper Santa Cruz River east of Interstate 19 between Amado and Tubac. The “Esperanza Ranch Conservation Easement” (Easement) is a 300-acre area within Esperanza Ranch that is controlled and managed by Tucson Audubon Society (TAS). Staff members of TAS have been involved in both restoration work and bird monitoring on the Esperanza property since 2005. Long-term stewardship consists of monitoring physical and ecological conditions as well as maintaining existing desirable ecology and infrastructure. Ecological restoration involves changing physical and biological resources at the Easement to enhance the diversity, stability and functionality of the ecology. Work completed at Esperanza Ranch to date includes the establishment of the legal easement; funding an endowment; publication of a site assessment, visitation plan, and numerous work plans associated with an Arizona Water Protection Fund grant; fencing of the site; restoration work carried out under the grant (planting, seeding, initial site monitoring and outreach); and other basic reconnaissance and maintenance.

A large range of stewardship issues confront Tucson Audubon at the Easement. These range from fence maintenance and access control to ongoing monitoring, and from continued ecological enhancement and restoration to long-range budgeting. TAS has conducted nearly 50 bird survey efforts on Esperanza with 217 species of birds detected. There are several nesting pairs of Grey Hawks and unusual species such as Tropical Kingbirds, Black-bellied Whistling-Ducks, White-faced Ibises, Crested Caracara, Yellow-billed Cuckoo, Louisiana Waterthrush, Dickcissel, Lawrence’s Goldfinch and Painted Bunting have been detected on Esperanza. It is potentially important to several special status bird species. The Esperanza property is included in the larger Upper Santa Cruz Important Bird Area (IBA) which was identified in 2007 by the IBA science committee after being proposed as an IBA by Tucson Audubon.

### **Hydrological Modeling of a Semi-arid Santa Cruz Basin**

NIRAULA, REWATI, Hydrology and Water Resources, University of Arizona

Thomas Meixner, Hydrology and Water Resources, University of Arizona

Laura M. Norman, U.S. Geological Survey

The objective of this research is to develop a reliable model to analyze hydrology of a semi-arid 9,100 km<sup>2</sup> Santa Cruz watershed located on the Arizona-Mexico Border. In most watershed-modeling studies, flow is calibrated at one monitoring site. Since streamflow in the Santa Cruz watershed—like many arid and semi-arid watersheds, is discontinuous except in a few large flood events, the flow characteristics at the outlet do not represent the entire watershed. Therefore, calibration is required in multiple locations to best portray watershed conditions. In this study, the Soil and Water Assessment Tool (SWAT) was used for modelling the Santa Cruz watershed. The developed model was calibrated and validated at seven monitoring stations inside the watershed to improve model performance and reliability in this arid-land watershed. The Nogales International Waste Water Treatment Plant (NIWTP) at Nogales, which discharges approximately 15 million gallons per day (MGD) of

treated effluent, is responsible for keeping the downstream section (~26 miles downstream of the IWWTP) perennial. However, the new Los Alisos plant; under construction about 20 miles south of Nogales will allow Mexico to treat waste water originating (~10 MGD) and discharge back into the Los Alisos basin. This change could have significant implications for the Santa Cruz River. Thus, we are analysing the impact of reductions in daily discharge from 15 MGD to 5 MGD on the currently perennial reaches of the Santa Cruz River. These preliminary simulations show that the river will be perennial for ~10 miles downstream of IWWTP instead of the current 26 miles. At Tubac, which is 16 miles downstream, the river will be dry for approximately 37% of the time (136 days/year). The river will be dry for about 60% of the time (217 days/year) at the 26 miles location at which the river is perennial under current conditions. Considering that the treatment plant is currently being built to treat 5 MGD but will be soon expanded to treat 7.5 MGD, we are analysing those scenarios too.

### **The Santa Cruz Watershed Ecosystem Portfolio Model (SCWEPM); Progress and Future**

NORMAN, LAURA, U.S. Geological Survey

William B. Labiosa, U.S. Geological Survey

The Santa Cruz Watershed Ecosystem Portfolio Model (SCWEPM) is an online-decision-support system used to analyze various scenarios of land use change, climate change and effluent from wastewater treatment plants for their independent and cumulative effects on ecosystem services. Scenario development efforts to date focus on a series of land-use maps characterizing the watershed in 1979, 1989, 1999, and 2009 and—using the SLEUTH urban growth model—simulated future land-use patterns through 2050. Predicted climate change information will be incorporated to simulate impacts on the landscape. Submodels represent the three “pillars” of sustainability in the SCWEPM— Ecological-Value Submodel (EVM), Human Well-Being (HWB) and Market Land-Price Submodel (MLP) — portrayed for exploring spatially-explicit changes within various scenarios. Modeling efforts to date orient on the EVM, including the calibration of the Soil and Water Assessment Tool (SWAT) to portray surface water hydrology and the development of a vegetation map and related terrestrial vertebrate species richness summary. Also to date, a Modified Socio-Environmental Vulnerability Index (M-SEVI) has been developed using binational census and neighborhood data for the HWB and an econometric, hedonic model of property values has been initiated for the MLP. Future modeling efforts will include developing hydrology scenarios (e.g. potential changes in wastewater, water quality analysis, tracking contaminants, quantifying surface to groundwater relationships), biodiversity scenarios (creating a link between water availability and vegetation response), and the completion of binational hedonics models (to obtain monetary estimates of non-market goods based on characteristics of location). The SCWEPM web-interface prototype is available to display some data described and to run the SWAT model in real time. Further development of the website will allow the user to explore value maps or, after applying user-chosen multi-criteria weights, as an aggregated value map to compare and contrast existing and potential land-use patterns and metrics with climate change predictions.

### **Hydrologic Evaluation of the Tres Rios Del Norte Area**

POSTILLION, FRANK, Pima County Regional Flood Control District

David Scalero, Pima County Regional Flood Control District

The Corazon de Tres Rios Del Norte (CTRDN) includes the area surrounding the confluence of the Rillito and Canada del Oro Wash (CDO) with the Santa Cruz River (SCR) in Pima County, Arizona and is a significant regional location for water resource management, flood control and public recreation. Pima County has positioned the CTRDN as a focal point for future flood control, environmental enhancement/restoration, recreational

development and recharge activities. The study extended from Roger Road to Avra Valley Road. An understanding of the sub-surface water levels and flow dynamics and what influences them is essential to future planning efforts for this area. The purpose of this paper is to summarize the findings of the hydrologic evaluation of current and historic water-level conditions, river flow changes and monitoring opportunities in the vicinity of the CTRDN area. Flows on the Santa Cruz River are perennial in this area from discharge of treated effluent at the Roger Road and the Ina Road Wastewater Treatment facilities. Effluent recharge rates from Roger Road to Ina Road have varied from 0.50 to 5.9 AF/mi/day since 2000, with an average rate of 3.33 AF/mi/day. Recharge rates from Ina Road to Trico Road have varied from 2.83 to 4.06 AF/mi/dy since 2004, with an average rate of 3.15 AF/mi/dy. Water levels are shallowest at the confluences of the Santa Cruz River, Rillito and CDO Wash with a narrow band of contours 110 feet bls and less along the Santa Cruz River corridor from Sunset Road to Ina Road. The presence of cottonwoods and willows in an area just north of the alignment of Orange Grove Road west of the SCR and east of Silverbell Road suggests the possibility of perched water. Monitor wells will be drilled to confirm perched water and review additional data in the area.

### **The Borderlands Habitat Restoration Initiative**

PULLIAM, RON, University of Georgia

The Borderlands Habitat Restoration Initiative is a collaborative conservation movement seeking to restore ecological resiliency to ecosystems along both sides of the U.S.-Mexico border. Our goals are

1. to empower local citizens to restore ecosystem services in their own communities, and
2. to have a measurable impact on regional wildlife populations and ecosystem services, with an initial emphasis on pollinators and pollination services.

We view restoration as a multi-step process that begins with restoring physical processes (principally stream flow and groundwater recharge) and then restoring vegetation and food chains that support biological diversity. The essential final step is reconnecting humans and their ecosystems by engaging local citizens in the restoration of local ecosystem services. The initiative began in 2010 as a collaboration between Cuenca Los Ojos and the Biophilia Foundation, and since has grown to include many other partners. The initial emphasis of the initiative was the documentation of the impact of the 30 years of hydrologic and vegetation restoration work conducted by Cuenca Los Ojos on ranches in southeastern Arizona and northern Sonora. The presentation will focus on our current restoration work in the Sonoita Creek watershed, a tributary of the Santa Cruz River. We began with a series of workshops, public meeting, and presentations in Patagonia. We engaged local citizens in the propagation of large numbers of native plants that support hummingbirds and other pollinators and established three community pollinator gardens in Patagonia. We are currently working with The Nature Conservancy, Friends of Sonoita Creek, and the Hummingbird Monitoring Network, to restore pollinator habitat in the watershed. Finally, we are training citizen scientists to assist in monitoring the survival of the transplants, their flower and fruit production, and the visitation rates of bees, butterflies, and hummingbirds.

## **Fate of Emerging Contaminants along the Lower Santa Cruz River, Arizona**

QUANRUD, DAVID, University of Arizona

Darryl Jones, University of Arizona

Bingfeng Dong, University of Arizona

Alandra Kahl, University of Arizona

Leif Abrell, University of Arizona

Shane Snyder, University of Arizona

Robert Arnold, University of Arizona

Eduardo Saez, University of Arizona

Many chemical substances used in domestic households are persistent and pass through conventional wastewater treatment. Among these, emerging trace organic contaminants (TOrcs), including endocrine disrupting compounds (EDCs), are of concern. TOrc loadings to the effluent-dependent lower Santa Cruz River (SCR) near Tucson are largely unknown. The occurrence and fate of a suite of 12 representative TOrcs, including pharmaceuticals, steroid hormones, surfactants, personal care products, and flame retardants, was evaluated along a 22-mile reach of the Lower SCR during 1) in-stream transport of wastewater effluent and 2) subsurface transport of infiltrate through ~37m of unconsolidated sediment to the water table. Subsurface fate of TOrcs was established by comparing river data to data from a series of 11 proximate monitor wells owned by the Pima County Regional Wastewater Reclamation Department. Sample analyses were performed at the Arizona Laboratory for Emerging Contaminants. All 12 TOrcs were detected in all SCR samples. TOrcs found at the highest concentrations in the river were sucralose, sulfamethoxazole, trimethoprim, and DEET. Some TOrcs (DEET, tonalide, fluoxetine, trimethoprim, and iopromide) were attenuated during surface transport along the 22-mile reach of the SCR. Possible removal mechanisms include photo-oxidation, biodegradation, and/or sorption to particles that may have then settled onto the riverbed. Eight of the twelve TOrcs were detected in the ground water along the SCR and there were substantial differences in TOrc concentrations in the different monitor wells. Groundwater TOrc concentrations were generally at least one order of magnitude lower than in the SCR, which may have resulted from a combination of biodegradation, sorption and/or dilution. Exceptions included PFOS, PFOA, sucralose, and carbamazepine; these were present at similar or sometimes even greater concentrations in ground water.

## Poster Abstracts

(Listed in Alphabetical order by author)

### **Indicators of organic contamination in the Lower Santa Cruz River**

ABRELL, LEIF, University of Arizona  
Alandra Kahl, University of Arizona  
David Quanrud, University of Arizona  
Bob Arnold, University of Arizona  
Samanthi Wickramasekara, University of Arizona  
Selene Hernandez-Ruiz, University of Arizona  
Jon Chorover, University of Arizona

Emerging contaminants of many types are understood to occur in many of the United States' populated watersheds, including Tucson and the Lower Santa Cruz River Basin. Accurate measurement of each chemical species is costly and technically challenging. A calibrated appreciation of indicator species and a strategically implemented sampling plan may inform us about the relevancy of new measurements and help us interpret analytical results. Recent organic contaminant measurements in the Lower Santa Cruz River Basin will be interpreted and presented with an eye towards optimal designs for future research projects that can answer remaining questions about the origin and fate emerging organic contaminants.

### **Alluvial Processes and Human Population Dynamics along the Santa Cruz River: Evidence from Recent Investigations near the Terminus of the A-Mountain Reach**

CRAIG, DOUGLAS B., Northland Research, Inc.

The past two decades have seen archaeologists make great strides in their understanding of prehistoric settlement and land-use practices in southern Arizona. Excavations along the former floodplain of the Santa Cruz River in Tucson have figured prominently in these research efforts. This paper reviews the results of recent work conducted by Northland Research as part of Pima County's Plant Interconnect Project. Unlike other recent projects, which have looked mainly at individual sites, Northland's investigations provided an opportunity to examine portions of seven sites located along a continuous five-mile stretch of the Santa Cruz floodplain. In addition to identifying the earliest known irrigation canals originating from the Rillito Creek, dating to about 1000–600 B.C., a large 15<sup>th</sup> century Hohokam settlement was documented in the same location that Father Kino identified an O'odham village in the late 17<sup>th</sup> century. Current models of human land-use along the Santa Cruz are reviewed in light of these findings, with special attention paid to the complex relationship between alluvial processes and population aggregation and dispersion.

## **Investigating Water Quality in Private Domestic Wells in Santa Cruz County, Arizona**

GRIGERA, SOFIA, University of Arizona

Jen Parks<sup>2</sup>, Friends of the Santa Cruz River

Mary Kay O'Rourke, University of Arizona

Laura Norman, US Geological Survey

Water sampling efforts in the Upper Santa Cruz Watershed (USCW), located in Southeast Arizona and Northern Sonora, Mexico have revealed a number of contaminants in both surface and monitoring-well water. Many wells in the Santa Cruz County portion of the USCW are exempt from water-quality monitoring. There is concern that the local populace may be exposed to known water-borne contaminants in surface waters. Collaborating with the U.S. Geological Survey, and the Mel and Enid Zuckerman College of Public Health, Friends of the Santa Cruz River (FOSCR) will investigate water quality at private wells. Specifically, FOSCR will sample wells for metals, nitrates, E.coli, and emergent contaminants, at 40 homes located within a ½ mile of the Nogales Wash and the Santa Cruz River, during wet and dry seasons. The Southeastern Arizona Area Health Education Center is collaborating on the project to integrate local high school student clubs from Nogales and Rio Rico. Using the results of this research we hope to improve scientific knowledge on the relationship between surface and groundwater, the condition of well water quality, and water consumption practices. We will develop exposure factors for the tested contaminants for infants and children. We also hope to build community awareness.

## **Composting Toilets in Nogales, Sonora: Results of a Pilot Study**

LIPNICK, CAROLYN, University of Arizona

PEDRO ROBLES, University of Arizona

Diane Austin, University of Arizona

Francisco Trujillo, Frente Cívico Nogalense, A.C.

Many homes in Nogales, Sonora lack connections to potable water supplies and wastewater collection systems and are forced to rely on homemade latrines situated in dense, rocky soil with poor drainage characteristics. Following heavy rains, it is not uncommon for the human waste in these latrines to flow down streets and drainages, ultimately reaching the Santa Cruz River. In May 2008, with funds from the U.S. Environmental Protection Agency Border 2012 program, students and faculty from the UA's Bureau of Applied Research in Anthropology; leaders of Frente Cívico Nogalense, a Mexican non-governmental organization; and leaders and residents of Colinas del Sol, a Nogales neighborhood lacking piped water and sewer services, came together to initiate a composting toilet demonstration program. A year later, with funds from the Mexican government's program to support unemployed workers, engineers from Nogales municipal government supervised construction of a second round of toilets. The project also received support from Friends of the Santa Cruz River, the Arizona Department of Environmental Quality, and schools in Nogales, Sonora. This poster provides background on the project and describes the results of a recent three-year project assessment.

## **Visitor experience and anthropogenic landscapes**

MCCALLUM, ELEANOR, University of Arizona

The Santa Cruz river valley experiences many different dimensions of human impacts. Its water table has dropped dramatically due to high water demand and the river is now effluent fed, its climate may be getting hotter and drier, exotic and invasive species are present and visible, and plastic waste is washed downstream from the border city region of Ambos Nogales. In the center of this complex landscape is Tumacacori National Historic Park, which attempts to negotiate the many different human impacts and preserve a space for visitors to come and experience a historic Spanish Mission and a section of the Santa Cruz river itself. Given the many dimension of human impacts, the landscape that visitors experience is not one that reflects a hybrid of interactions among human and non-human actors. In this poster presentation, I wish to propose a study that would investigate the way the visitors and land managers interact with the many different human and non-human factors that are visible at Tumacacori National Park and the surrounding area. Does the mixed nature of the landscape complicate the way people perceive it? Do visitors see the landscape as natural, as human, or something in between? What features of the landscape appear more or less human-influenced? Put simply, I wish to investigate the way people interact with hybrid landscape that is the Santa Cruz river riparian area. This understanding of visitor experience could be useful for the park and for academics wishing to understand how human negotiate an increasing hybrid world.

## **Conserve to Enhance: An Innovative Pilot Program in Tucson to Conserve Water for the Environment**

RUPPRECHT, CANDICE, University of Arizona

Aaron Lien, University of Arizona

Brittany Choate, University of Arizona

Sharon Megdal, University of Arizona

Emily Brott, Sonoran Institute

Claire Zugmeyer, Sonoran Institute

The University of Arizona Water Resources Research Center (WRRRC) is exploring ways to meet the challenge of water for the environment in Arizona. Conserve to Enhance (C2E) is an innovative financial mechanism that links voluntary water conservation actions to environmental enhancement projects and the first pilot of this concept has been underway in Tucson, Arizona since January 2011. The Sonoran Institute, Tucson Water, Watershed Management Group, and WRRRC have partnered to engage Tucson Water customers as pilot program participants that will conserve water and contribute the value of their savings to the C2E fund; this fund will support restoration work at Atturbury Wash (southeast Tucson), as well as smaller scale neighborhood projects. C2E has gained local support and a voluntary check box on the Tucson Water utility bill was approved by City of Tucson Mayor and Council that provides additional C2E funding for local projects. Forty-five of the 60 participants are receiving subsidies provided by the US EPA to implement rainwater harvesting practices, designed to increase household water savings and improve backyard environments. Monthly water use is tracked by Tucson Water and provided to participants on a quarterly basis, along with a suggested donation for the value of water conserved. In the first year of the C2E pilot, program participants saved over 1.1 million gallons of water and donated \$1,074 to the C2E fund. This poster details outcomes from the first year of the

Tucson pilot and explores the idea that programs like C2E that connect water conservation to environmental enhancement, provide a new, unique motivation for water conservation and raises awareness about water resources-related environmental benefits. Lessons learned during program development in Tucson will help inform implementation of C2E in other communities.

### **Land use matters: Private and public land stewardship efforts moderate the effects of drought and resource consumption on watershed habitat loss**

VILLARREAL, MIGUEL L., U.S. Geological Survey

Laura M. Norman, U.S. Geological Survey

Cynthia S.A. Wallace, U.S. Geological Survey

Kenneth G. Boykin, New Mexico State University

In the arid southwestern United States, vegetation types that support high biodiversity are being impacted by variable and extreme climate patterns and intensive land use. Examination of watershed-scale habitat dynamics across a heterogeneous land use mosaic can illustrate the role of land management in mitigating the impacts of climate change on biodiversity. Using satellite imagery, land-ownership data, and long-term climate and vegetation monitoring data, we quantified changing spatial and temporal distributions of potential terrestrial vertebrates in the Santa Cruz River watershed. Vegetation and land cover maps (1979, 1989, 1999, and 2009) were developed using combinations of satellite imagery and field data for application with SWReGAP species-habitat models. The resulting species-richness maps indicate that vegetation types with the highest mammal and avian richness, primarily desert grasslands (mammal) and riparian (avian) types, were most affected through time, yet change patterns were neither temporally directional nor spatially uniform over the landscape. While historical data from the study area describe 20<sup>th</sup> century shrub invasion of grasslands and late century growth of woody riparian plants, the land cover data show a 15% increase in grassland cover and 19% decline in riparian from 1979-2009. Cover change fluctuated over time with climate patterns; for example, the development and decline of riparian cover coincided with an El Niño wet period followed by extended drought. Impacted lands showed diverging patterns of resilience and sensitivity based on land-use management: Urban and agricultural land uses contributed to the decline of riparian cover on private lands, while private and publicly managed grasslands and riparian habitat, where efforts in restoration and conservation were employed, demonstrate stability and increased potential for biodiversity. Habitat restoration and stewardship efforts in the watershed appear to have minimized impacts from climate variability and drought, showing real potential to mitigate the effects of future climate change in arid lands.

## 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.

### **The Plants of Tumacácori National Historical Park**

BUCKLEY, STEVE, National Park Service

The Plants of Tumacácori National Historical Park is a product of the vegetation mapping program at the National Park Service's Sonoran Desert Network. The Plants of Tumacácori NHP is the first volume to be released by The Flora Project, a network wide effort to produce field guides for all eleven parks, coincident with vegetation mapping products. The field guide is a 600+ page full color product that treats 383 taxa. The field guide is designed as an educational resource for field researchers, managers, and the public. The guides are designed to be tools for broader public education in botany, communicating the basics of plant systematics and morphology, and serving as an interpretive tool for the vegetation mapping effort. My talk will introduce the field guides and provide a broader floristic context for the Santa Cruz Valley as a whole by discussing the Tumacácori flora and its regional implications.

### **Recent Geological Dating of Santa Cruz River Prehistoric Canal and Alluvial Deposits: Insights into ~ 5000 Years of Floodplain Dynamics**

HUCKLEBERRY, GARY, Geoarchaeological Consultant

Three archaeological projects conducted 2009-2010 within the Santa Cruz River (SCR) floodplain in the Tucson-Marana area provide new information regarding prehistoric floods, channel dynamics, and irrigation agriculture over the past 5000 years. Excavations associated with the Pima County Pipeline Interconnect Project, the Pima County Wastewater Reclamation Campus, and the Interstate 10 Traffic Interchange at Twin Peaks-Linda Vista Road provided multiple exposures of SCR floodplain deposits that were subject to geological dating. Thirty-six radiocarbon ( $^{14}\text{C}$ ) and six single-grain optically stimulated luminescence (OSL) ages provide a temporal framework for reconstructing floodplain dynamics and prehistoric irrigation. As previously documented, the SCR floodplain contains several meters of fine-grained deposits (sands, silts, and clays) overlying higher energy gravels and cobbles at depth. The finer textured deposits date to the past ~ 5000 years and contain wetland soils and buried channels, the latter indicative of prehistoric arroyo-cutting events. However, rates of deposition have not been uniform in space or time. Overall rates of floodplain deposition along this reach of the SCR decreased after ~ 500 BC which may relate to increased frequency of arroyo cutting as evidenced by previously dated paleochannels. Increased frequency of channel incision and backfilling since ~ 500 BC is probably related to changes in flood regime but may have been exacerbated by increasing agricultural activity within the SCR floodplain. The ecological impact of more frequent disturbances to the SCR floodplain after 500 BC is unclear and warrants further study. Geological dating of floodplain deposits and canals helps us to understand the dynamic history of the SCR and provides a frame of reference for evaluating current changes. Future work should focus on improving the spatial and temporal resolution of past floods and arroyo-cutting in relation to climate and ancient agricultural activities.

## **Building Community Capacity in Rainwater Harvesting in the Border Region**

SILINS, JOSEPH, Watershed Management Group

Catlow Shipek, Watershed Management Group

Urbanization and development cause substantial hydrologic impacts on watersheds leading to increased runoff, erosion, and desertification, which are presently seen in the rapidly-growing Arizona-Sonora border region. Water harvesting and green infrastructure practices are increasingly being used to improve watershed health by realizing benefits such as reduced stormwater volumes and improved quality, conservation of extractive water resources used for irrigation, and providing native wildlife habitat. Since 2003, Tucson-based nonprofit Watershed Management Group (WMG) has developed several model, community-based programs that utilize water harvesting and green infrastructure practices to improve watershed health in Tucson and beyond. Since February 2011, WMG has been working in three communities in the Arizona-Sonora border region along the Santa Cruz River and tributaries to facilitate community adoption of water harvesting and green infrastructure techniques. Working in partnership with local organizations in each of the three communities, WMG is creating public water harvesting demonstration sites to show the promise and potential of water harvesting, and providing hands-on training to members of each community. These demonstration sites showcase a variety of water harvesting and green infrastructure practices at the following locations: the Instituto Tecnológico de Nogales, a technical college in Nogales, Sonora; the Guy Tobin Memorial Anza Trailhead in Rio Rico, Arizona; and Summit View Elementary School in the Summit View area of unincorporated Pima County, Arizona. With the help of established partners in these three communities, WMG has been able to engage diverse local audiences in creating these demonstration projects. Furthermore, this broad-based involvement in the project has resulted in building capacity of local community leaders to advocate for and implement green infrastructure practices. Hands-on training opportunities offered through these projects range from half-day, introductory workshops to WMG's intensive, 10-day Water Harvesting Certification course.