Science on the Sonoita Plain Symposium

Audubon-Whittell Research Ranch – Elgin, AZ
June 3, 2017

Oral presentations

1) **Using Isotopes and Solute Tracers to Infer Groundwater Recharge and Flow in the Cienega Creek Watershed, SE Arizona, Rachel Tucci and Jennifer McIntosh, University of Arizona; Andrew Salyon and Ron Tiller, Desert Botanical Gardens; Jeanmarie Haney and Gita Bodner, The Nature Conservancy**

Reaches of Cienega Creek and Davidson Canyon in the Cienega Creek Watershed (CCW) are registered "Outstanding Arizona Waters" and wetlands in the Las Cienegas National Conservation Area support several threatened and endangered species. The lack of baseline hydrologic and water quality studies in the CCW leave important land management questions unanswered, such as how might increases in urbanization, ranching, agriculture, or possible mining impact groundwater resources? To help address this question, this study investigates the hydrologic connection between recharge in the surrounding mountain blocks and basin groundwater, which is contained in alluvial and Cretaceous aquifers and wetlands (cienegas) in the central portion of the basin. Specifically, we aim to determine: (1) What are the flow paths, seasonality and elevation of groundwater recharge? (2) What is the residence time of groundwater across the basin? And (3) What is the source of water in the cienegas, and possible influence of monsoon floodwater recharge?

Groundwater samples from domestic water supply and previous mining exploration wells, springs, and alluvial aquifers were collected along a broad transect from the Santa Rita Mountains eastward across the basin to Cienega Creek. Samples were analyzed for major ion chemistry, stable isotopes ($\delta^{18}O$, δD, $\delta^{13}C$, $\delta^{34}S$) and radioactive isotopes (^{3}H, ^{14}C). Initial results indicate springs and alluvial aquifers are dominantly sourced year-round from basin groundwater and $\delta^{18}O$ values and sulfur to chloride ratio values indicate little infiltration of summer monsoon floodwaters. Most of the basin groundwater samples analyzed for tritium are below detection limit or lower than modern precipitation values for the region, and ^{14}C values were low (3.33-77.09 pMC), which indicates recharge occurred prior to the 1950's. The low sulfate concentrations and $\delta^{34}S$ of basin groundwater, springs, and alluvial aquifers are typical of local rain water values consistent with the lack of sulfate sources in basin sediments. The lack of recent recharge even in shallow alluvial aquifers beneath the washes and near Cienega Creek suggests that groundwater throughout the basin is a fossil resource, and that future increases in groundwater pumping may impact the cienegas.

Rachel Tucci received her undergraduate degree in Hydrology and Water Resources in 2015 from the University of Arizona in the Hydrology and Atmospheric Science department. She is currently a master's student at the UofA and advised by Dr. Jennifer McIntosh. Her initial introduction to the Cienega Creek Watershed was when she attended the 2014 Science on the Sonoita Plains symposium. She has been conducting hydrological and geochemical research with a team of collaborators in the Las Cienegas National Conservation Area and surroundings since.

2) Creating an Environmental Flows Water Budget for the Upper Santa Cruz River, Ashley Hullinger (University of Arizona Water Resources Research Center), Claire Zugmeyer (Sonoran Institute), Kelly Mott Lacroix (U.S. Forest Service), and Bailey Kennett (WRRC)

In development of a community vision for the Upper Santa Cruz River (USCR), the Sonoran Institute partnered with the University of Arizona Water Resources Research Center (WRRC) to create a conceptual water budget exploring the inflows, outflows, and seasonal variation of one of Arizona's rare perennial streams. With a focus on maintaining flow in the river to support aquatic and vegetative communities, this water budget illustrates existing or potential gaps between water supply and demand in order to understand and protect the USCR into the future. This approach emphasizes aspects of environmental flows and was aligned with ongoing work in other parts of the watershed by comparing methods with Watershed Management Group (WMG) and others. The study area stretched from the outfall of the Nogales International Wastewater Treatment Plant to the terminus of flow from the wastewater treatment plant (approximately Amado, Arizona) during wet, dry, and winter seasons in order to evaluate the riparian conditions in the USCR and inform community outreach efforts. This presentation will share lessons learned, along with relevant discussion of methods that could be applied in the Cienega Watershed.

A water budget is a key component in planning for the challenges and opportunities in keeping water in the channel and recharging groundwater supplies, while taking into account the uncertainties about continued flow from the wastewater treatment plant, along with drought, population growth and other factors. The long-term goal of this community outreach program, led by the Sonoran Institute, is to ensure adequate flows in the river in support of shared community values and environmental conditions.

Ashley Hullinger is a Research Analyst for the Water RAPIDS (Water Research and Planning Innovations for Dryland Systems) program at the University of Arizona Water Resources Research Center (WRRC). Much of Ms. Hullinger's work revolves around developing effective means of stakeholder engagement to promote resilient water management throughout Arizona. As part of the Cooperative Extension unit of the University of Arizona, she has been able to work directly with rural

communities looking at issues that span beyond physical water resources to consider the people and history that have contributed to current conditions. Originally from Kansas, Ms. Hullinger received her MS degree in Urban Planning from the University of Arizona after receiving BA degrees in Geography and History from the University of Kansas.

Claire Zugmeyer is an Ecologist leading the Santa Cruz River Initiative within the Sun Corridor Program. Joining Sonoran Institute in 2007, she has led a variety of efforts including monitoring vegetation and fish along the river, production of the Living River series that summarizes the river health, and organization of the annual Research Days, an event promoting collaboration and awareness of regional research and conservation efforts. She completed a Masters in Wildlife and Fisheries Biology at the University of Arizona, a B.S. in Ecology, Behavior, and Evolution at the University of California, Los Angeles, and has worked on a variety of research and management projects focusing on birds, mammals, fish and amphibians, including Arizona's endangered Mt. Graham red squirrel.

3) A dynamic flow budget for Lower Sabino and Tanque Verde Creeks, C. Shipek (Watershed Management Group)

Restoring seasonal and annual flow to Lower Sabino and Tanque Verde Creeks is the first targeted effort in WMG's 50 Year Program to restore Tucson's flowing springs, creeks, and rivers. Sabino and Tanque Verde creeks are in designated shallow groundwater areas, where groundwater levels can recover rapidly with reduced pumping from nearby wells and recharge with local infiltration. WMG is building a 'River Run Collective' for each streamshed for the purposes of strengthening community connections with each other and to the local river.
Each streamshed has an online-based stewardship plan to facilitate priority actions, track progress, and monitor flow and groundwater response. Analysis of seasonal and annual flow budgeting by streamshed areas has assisted towards setting meaningful conservation and stormwater recharge augmentation targets. This flow budget can be updated on an annual or seasonal basis and provides a communication tool to inform sustainable use of groundwater that maintains secure groundwater resources and creek flow for riparian and aquatic system health. To learn more about WMG's Sabino and Tanque Verde program as part of the River Run Network please visit watershedmg.org/RRN.

Catlow Shipek is a founding member of Watershed Management Group (WMG), a Tucson-based non-profit organization. He received a MSc in Watershed Management from the University of Arizona. Catlow has over ten years of experience in applied watershed management, planning and policy specializing in urban applications like water harvesting, green infrastructure, stream restoration, and eco-sanitation. Catlow has worked on several successful local policy initiatives including Tucson's residential greywater ordinance revision process, Tucson's Green Streets Active Practice Guidelines, and Tucson Water's residential rainwater

rebate program. Catlow also serves on the Citizens' Water Advisory Committee for Tucson Water including Chair of the Conservation & Education subcommittee. Catlow's passion is to link people to their local environment for improved stewardship and prosperity.

4) CWP's "Indicators Project": Assessing the Health of the Cienega Watershed, A. Zuniga Teran , L. A. Fisher, and T. Meixner (University of Arizona), and S. McFarlin (Cienega Watershed Partnership)

Over the past two years, the Cienega Watershed Partnership (CWP) has worked with partners to identify a core set of indicators that can provide an annual snapshot of watershed health. The State of the Watershed Report is part of a larger effort to provide a regular assessment of conditions and trends in the Cienega Watershed, drawing on existing data to provide a mechanism for long-term monitoring, regular evaluation, and adaptation of CWP program priorities and actions. The State of the Watershed Report will also offer a range of opportunities to engage with the public on watershed issues.

To identify these core indicators and data sources, CWP convened a series of workshops, conducted an electronic survey, and held several smaller working group sessions. This extensive input from partners helped identify the basic criteria for selecting indicators, and trim a very long list of possible indicators to a core set of 19 indicators – representing climate, water, ecological, and socio-cultural attributes – that offer a real-time assessment of watershed health.

This presentation summarizes the initial State of the Watershed Report, providing an updated synthesis of data, based on feedback received from CWP partners during the March 2017 State of the Watershed Workshop. The final Report will be made available in an online format, as well as a shorter, brochure-type hard-copy report that can be shared with the public during community presentations.

Adriana Zuniga Teran is a Senior Researcher at the Udall Center for Studies in Public Policy, University of Arizona . Larry A. Fisher is Research Professor at the School of Natural Resources and the Environment, University of Arizona, and a member of the CWP Board of Directors. Thomas Meixner is Professor in Hydrology and Atmospheric Sciences, University of Arizona, and a member of the CWP Board of Directors. Shela McFarlin is Chair of the CWP Board of Directors.

5) Tools for Interpreting Landscape History in the Cienega Watershed, by Robin Pinto, Alison Bunting, David Tuggle, Bill Gillespie and Shela McFarlin

In recent years, aspects of the Cienega Watershed Heritage and the Empire Ranch History have been revealed through efforts ranging from map interpretation to oral history stories. The most in-depth historic landscape documentation was done in

2016 for the Historic American Landscapes Survey which not only described the Empire Ranch Headquarters in architecture and history, but provided the wider context of the Empire Ranch, neighboring ranches, and the Bureau of Land Management Las Cienegas National Conservation Area.

The Cienega History Project (CHP) continues to document and explain the landscape history, addressing both specific questions and broad contextual ones such as: the acquisition of land and water and resources control; understanding the interdependencies in broad economic patterns such as ranching, water development, transportation, and markets; and what resources are available to provide a baseline for future historical analysis and interpretation.

This presentation focuses on the tools currently available and being applied for this work which include: oral histories and interviews, secondary sources and studies, archived materials, family histories especially about the Vails, Boices and Sanfords; newspaper articles; government land records and other documents, and reports on archaeology, ecology and natural resources. Especially important are comparisons between historic maps and photographic images including aerial photography from 1936 and 1970.

All presenters are members of the Cienega History Project: Robin Pinto, historian, independent researcher, PhD in Renewable Natural Resources from the University of Arizona; Alison Bunting, retired librarian and archivist for the Empire Ranch Foundation, MLS Library Science, and Wall of Honor member of the Cienega Watershed Partnership; Harold David Tuggle, retired archaeologist and GIS specialist for the Cienega History Project, PhD in Anthropology, University of Arizona; Bill Gillespie, archaeologist, Cornonado National Forest (retired,; Shela McFarlin, MA Anthropology, the Chair of the Board of Directors of the CWP.

6) Encroachment by woody plants alters demography and species richness of breeding grassland birds, Erik M. Andersen and Robert J. Steidl, School of Natural Resources and the Environment, University of Arizona

Worldwide, grasslands are transitioning from being dominated by perennial grasses to being dominated by woody plants. In semidesert grasslands of North America, mesquite (*Prosopis* sp.) has increased in density and distribution since the late 1800s, converting large areas of grasslands into shrub-savannas. This conversion has reduced the quantity and quality of habitat for many wildlife species endemic to grassland communities, including grassland birds, which have declined more rapidly than any other group of birds during the last 30 years. On 140 plots in southeastern Arizona that we established across a gradient of encroachment by *Prosopis velutina*, we studied how species richness, density, and nesting success of breeding birds changed in response to cover of woody plants. We found that species richness increased during early stages of encroachment and peaked when cover of woody plants reached ~23%, where losses of grassland-associated species

surpassed gains of shrub-associated species. Densities of all common species changed in response to variation in cover of woody plants, but the direction and magnitude of effects varied highly. Density of most grassland-obligate species decreased as cover of woody plants increased, but some species, such as Cassin's sparrow, were affected only by larger-statured woody plants. Density of many species, including some classified as grassland-obligates, such as Botteri's sparrow, increased during early stages of encroachment and peaked at intermediate values of woody plant cover. Total density of birds, as well as density of species not associated with grass-dominated systems, such as Lucy's warblers, increased as grasslands transformed into savannas. Although woody plants exerted a strong influence on density and community composition of birds, the effects on nesting success were less pronounced. Increasing cover of woody plants did not affect nesting success of a grassland-obligate species (Botteri's sparrow), a shrub-obligate species (black-throated sparrow), or all species combined, but did affect nesting success of a generalist species (mourning dove). An understanding of how bird populations and communities are affected by encroachment by woody plants can inform conservation and restoration efforts by identifying achievable targets of shrub control that would benefit imperiled grassland species.

Erik Andersen is a Research Specialist and Ph.D. candidate in the Wildlife Conservation and Management program in the School of Natural Resources and the Environment at The University of Arizona. His dissertation research focuses on understanding how grassland birds are affected by shrub encroachment and invasions of nonnative grasses Additionally, Erik is studying the habitat requirements and effects of livestock grazing on the endangered southwestern willow flycatcher. Prior to joining Bob Steidl's lab at the University of Arizona, Erik earned a M.S. from Sul Ross State University in Alpine TX, and conducted ecological and avian research for multiple federal, academic, non-profit, and tribal entities in Hawaii and throughout Alaska and the southwestern United States. Erik enjoys travel and has spent over two years abroad tracking down rare birds and exploring the world's natural areas; he is proud to report that his two-year-old's first word was "bird."

7) Where Mountain Lions Traverse: Insights from Landscape Genetics in the Southwestern United States and Northwestern Mexico, A. Naidu, University of Arizona

The projected growth in human population, rapid urbanization, and expansion of structures like highways and canals pose a major threat to the future survival of wildlife, particularly large terrestrial mammals. In many cases, wild animal populations have been restricted to fragmented habitat islands due to anthropogenic developments, endangering them to local extinction. Current and future wildlife conservation and management strategies are leading to the implementation of mitigation measures such as creation of wildlife habitat corridors. In this light, novel and interdisciplinary research methods such as

approaches in the field of landscape genetics are proving to be increasingly useful and necessary for assessing the status of wildlife populations and furthering efficacy of conservation programs and management efforts. In this 5-year research study, I use a landscape genetic approach to understand the potential impact of natural and human-made barriers in and around the northern Sonoran Desert on one of the widest-ranging mammals in the world, the mountain lion (*Puma concolor*). I employ recently developed genetic tools to assess the current population genetic status of mountain lions in this region and Geographic Information Systems (GIS) tools to relate observations to landscape features through interpretive maps. I further investigate the utility of GIS and expert-based models in connectivity conservation and suggest validating them with information on genetic relatedness and functional connectivity among mountain lions. Lastly, I emphasize the use of these methods and data sharing in conservation planning as well as wildlife management.

Ashwin Naidu is currently an Assistant Research Scientist at the University of Arizona working for the Desert Landscape Conservation Cooperative. Ashwin received his Ph.D. and M.S. Natural Resources with an emphasis in Wildlife Conservation and Management from the University of Arizona. Ashwin's interests are in applying interdisciplinary scientific and educational approaches for the conservation and management of endangered species and their habitats. Ashwin's expertise spans a variety of fields including non-invasive surveys on wildlife, forensic genetics, landscape ecology, GIS, citizen science, science communication and conservation education/outreach. Over the last decade, Ashwin completed projects on tigers, leopards and fishing cats in South India, and mountain lions and bobcats in the southwestern United States. You can read more on Ashwin's past research at https://snre.arizona.edu/people/ashwin-naidu

8) Hinge-felling: A preferred restoration method for restoring incised ciénegas, A.T. Cole, Pitchfork Ranch

Bill Zeedyk, author of *Let the Water Do the Work, Induced Meandering, an Evolving Method for Restoring Incised Channels,* designed a grade control structure using Willow trees and first experimented with it on the Pitchfork Ranch. We have continued the practice and see it as the preferred restoration method for restoring incised ciénagas. With 95% of ciénaga habitat lost, the 68 known ciénagas are commonly incised with succession Willow trees along the incised channel. We have continued using Hinge-Felling and expect to see it as the main feature in our efforts to restore the 1.5-mile reach of the Burro Ciénaga on the ranch.

Here's how it works: cut the tree half way through the trunk 6-inches above ground level, create 4 successive "notch" cuts above the main cut, bend the tree across the watercourse as close to ground level as possible. The new structure is "perpetual" in that it not only captures debris and sediment, but "grows" branches vertically and thus there is no need to stack additional "tiers" atop earlier installed structures that

have captured sufficient sediment to be "covered" and no longer capable of capturing additional sediment and further raising the watercourse bed.

A.T. Cole retired from the courtroom and classroom, and with his wife, Lucinda, retired to the Pitchfork Ranch in southwest New Mexico. For the last 14-years they have been restoring the reach of the Burro Ciénaga and surrounding habitat on the ranch. One of the treatments is a grade control structure, Hinge-Felling, a recently developed practice that is effective, inexpensive, although under-appreciated and has application to incised, willow lined channels.

9) Brush management: an ecosystem services perspective, Adam T. Naito, Steven R. Archer, Katharine I. Predick, and Greg A. Barron-Gafford, University of Arizona; Joel A. Biederman, Phil Heilman, and Russell L. Scott, Agricultural Research Service; Tyson L. Swetnam, Cy-Verse; Heather L. Throop, Nicole P. Templeton, and Enrique R. Vivoni, Arizona State University

Brush management efforts on rangelands typically rely on chemical and/or mechanical methods to reduce woody vegetation cover in order to improve forage production and reduce erosion. Yet, the true value to short- and longer-term increases in ecosystem function remain understudied. By evaluating the long-term effects of brush management on a suite of ecosystem services (ESs) (herbaceous diversity, net ecosystem exchange, erosion and runoff, carbon storage potential) at watershed-scales, we will be in a better position to enumerate its costs and benefits objectively. We are currently quantifying the effects of brush management on a suite of ESs on four instrumented watersheds on a mesquite-encroached desert grassland on the Santa Rita Experimental Range in southern Arizona. Pre-treatment herbaceous diversity and aboveground (herbaceous and woody live and litter) and belowground (soil organic C and roots to 20 cm) carbon pools were quantified prior to an aerial herbicide application in June 2016 on two of the watersheds. We re-measured these variables from September 2016 through February 2017 to determine their initial response to the treatment. Our analyses suggest that the relative abundance of both native and nonnative grasses has increased on the treated watersheds relative to controls. In addition, forage production increased by an average value of 24.7 kg/ha (22 pounds/acre), but there is significant variability in production response across the treated watersheds. Specifically, forage production generally increased under larger mesquite only (basal diameter > 25 cm (9.84 in)). These and additional ESs (related to runoff and sediment yield, net ecosystem exchange (flux towers), herbaceous diversity and soil carbon) will be quantified at regular intervals over the next three years. Initiated with USDA-AFRI funding, this will be a long-term study supported in the Agricultural Research Service LTAR (Long-Term Agricultural Research) program network. Field data, combined with remotely sensed data from an unmanned aerial vehicle, will be used to parameterize computer simulation models to predict long-term ecosystem

responses and provide for more effective cost-benefit analyses to brush management.

Dr. Adam T. Naito is a postdoctoral researcher in the School of Natural Resources and the Environment at the University of Arizona. He has expertise in landscape ecology, physical geography, Geographic Information Systems (GIS), remote sensing, and simulation modeling. Adam has conducted research in the montane forests of northern California, the Appalachians, and the Alaskan Arctic. He received his Bachelor's and Master's degrees in Geography at the Penn State University. Between his undergraduate and graduate programs, he interned in the Maps Division at the National Geographic Society in Washington, D.C., where he helped produce maps for the magazine. Adam then moved to Texas A&M University, where he received his PhD in Geography. As both a graduate student and assistant professor at Texas A&M, Adam taught courses in physical geography and GIS. He looks forward to the potential to return to a university as a professor in the next few years.

Posters

1) **Using Water Isotopes and SO_4/Cl Ratios to Investigate the Hydrology of Wetlands in the Las Cienegas National Conservation Area, Erin Gray, Jen McIntosh, and Rachel Tucci, University of Arizona; Andrew Salywon and Ron Tiller, Desert Botanical Gardens**

Wetlands are surface water systems that support diverse habitats which are frequently integral parts of regional ecosystems. Analysis of water stable isotopes and solute chemistry can reveal the nature and seasonality of the hydrologic connection between wetlands and local and regional groundwater. This research uses water stable isotopes and sulfate to chloride ratios to investigate the seasonal sources of water and degree of evaporation in wetland complexes (cienegas) and associated surface- and ground-water within the Las Cienegas National Conservation Area (LCNCA), an area of unique biodiversity within Southern Arizona. Surface water, springs, and shallow groundwater from piezometers within the multiple cienegas in the LCNCA were sampled seasonally and analyzed. Preliminary results suggest that the main source of water within shallow groundwater and wetlands in the LCNCA is basin groundwater, with little ephemeral input from direct winter or summer precipitation. There is little evidence of seasonal changes in water source, indicating that basin groundwater sustains these ecosystems year-round. Their apparent reliance on basin groundwater implies that the cienegas could be impacted by increased groundwater pumping. This insight, as well as the baseline hydrologic data that this research provides, will aid research efforts and help inform groups interested in the preservation of the LCNCA regarding future management decisions.

Erin Gray is an accelerated master's student in the Environmental Hydrology program the University of Arizona. In her first two years as a returning student, she

was involved with the student groups Engineers Without Borders and the UA Green Fund, an elected group dedicated to the advancement of sustainable practices and projects on campus though grant funding. She is currently the student assistant at Arizona Project WET, where she provides support for a team that spreads water conservation education throughout the state via direct student outreach and teacher development. In the past year, she has worked with Dr. McIntosh's research group using water chemistry to investigate wetland hydrology. Her experiences with research, outreach, and involvement will be valuable tools to she enters the workforce as a hydrologist focused on restoration and conservation after her expected graduation in December, 2018.

2) Ten Year Summary of Grassland Bird Point Counts at Appleton-Whittell Research Ranch, Vashti "Tice" Supplee, Audubon Arizona

Roadside point counts for grassland birds were established on the Appleton Whittell Research Ranch of the National Audubon Society (AWRR) in 2006. Points are located in half mile increments on the main road from the Upper Elgin Road junction to the AWRR headquarters (17 points) and on the East Mesa Road and that portion of the West Gate Road within the AWRR boundary (14 points). The main access road route includes 8 points on the Babacomari Ranch pasture that has livestock grazing. The East Mesa route includes points that are Oak Savannah and Oak – Riparian. The points are surveyed one time each year with dates varying from mid-August to early September. The protocol is a 5 minute count duration at each point and routes are begun a half hour before sunrise. Birds detected by auditory and visual methods are recorded. Singing birds are documented and when possible pairs or family groups are noted.

Apparent trends in bird species occurrence will be presented. The most commonly detected species are Botteri's sparrow (*Peucaea botterii*), eastern (Lilian race) meadowlark (*Sturnella magna lilianae*), Cassin's sparrow (*Peucaea cassinii*), and grasshopper sparrow (*Ammodramus savannarum*). Other species commonly encountered were mourning dove (*Zenaida macroura*), common nighthawk (*Chordeiles minor*), Montezuma (Mearn's) quail (*Cyrtonyx montezumae*), scaled quail (*Callipepla squamata*), western kingbird (*Tyrannus verticalis*), Say's phoebe (Sayornis saya), rufous-winged sparrow (*Peucaea carpalis*), lark sparrow (*Chondestes grammacus*), and blue grosbeak (*Passerina caerulea*).

Vashti "Tice" Supplee: Tice has been the Audubon Arizona Director of Bird Conservation since 2005, after a career with the Arizona Game and Fish Department that included experiences in research, habitat management, game management, and urban wildlife.. She Coordinate Audubon Arizona's science related activities with National Audubon Society programs and offices in other states and co-manages the Arizona Important Bird Areas program. She earned her B.S at Cornell University and M.S. at the University of Arizona, both in Wildlife Ecology. She has received

awards from the Arizona chapter of The Wildlife Society, Arizona Wildlife Federation, and National Audubon Society

3) Assessing the Conservation Effects on Cienega Creek Watershed, Haiyan Wei, D. Phillip Guertin, David Goodrich, Ken Spaeth, I. Shea Burns, Jane Barlow (University of Arizona)

Conservation Effects Assessment Project (CEAP) is a multi-agency effort to quantify the environmental effects of conservation programs. Assessments are carried out at national scale on cropland, grazing lands and wetlands. Cienega Creek Watershed was selected as a pilot watershed for the CEAP grazing lands assessment, because it has a history of over-grazing and has been the focus of a long-term conservation planning process afterwards. Numerous NRCS and USFS grazing land management and soil erosion conservation activities have been implemented.

Conservation records showed that most conservation dollars, such as the Environmental Quality Incentives Program and livestock subsidies were spent after 1996. We assigned "1990-1996" as the Pre-conservation period and "2008-2012" as the Post-conservation period. Soil and vegetation data for these two periods were extracted from the National Rangeland Inventory database. We also collected data to represent the Historical Reference Condition, characterized by the least disturbed vegetation community examples from specific locations. Using the Automated Geospatial Watershed Assessment tool and the Rangeland Hydrology and Erosion Model, Cienega Creek Watershed was broken into 974 hillslopes. Sediment yield from a 10year-1hour storm, as a watershed condition indicator, was simulated spatially across the watershed for all three conservation periods.

Results indicated that much of the watershed have improved from the Pre-conservation condition to the Post-conservation scenario. While the improvement is compromising comparing with the Historical Reference Condition, it is very encouraging given that about half of the 23 driest seasons in the 117-year (1895 to 2012) precipitation record occurred during the 16-year period from 1997 to 2012 when conservation spending was highest.

We also simulated the impact of a stock pond on a small subwatershed. ~75% of the sediment was trapped by the pond, following a 10year-1hour storm. If managed properly, stock ponds can serve as a conservation practice to improve downstream water quality in addition to supplying water for cattle and wildlife.

Haiyan Wei is an Assistant Research Scientist at the School of Natural Resources and the Environment, University of Arizona, and a support scientist at the USDA-Agriculture Research Service. Her research interests include rangeland hydrology and erosion modeling, model calibration, sensitivity and uncertainty analysis, drought, and remote sensing application.

4) The Effect of Gabion Construction on Infiltration in Ephemeral Streams, Chloe Fandel, University of Arizona

Low-tech rock structures called gabions are commonly used in dryland stream channels to reduce erosion, slow floodwaters, and increase infiltration. Gabions may also increase water availability for riparian vegetation, and increase the duration of surface flow in ephemeral stream channels. However, their effects on infiltration and recharge are not well-understood. This study tested low-cost methods for easily quantifying the total infiltration induced by gabion construction in an ephemeral stream channel, over the course of a single flow event. We used well-established methods to find point infiltration fluxes from subsurface temperature time-series. Unique to this study, we then upscaled these measurements to the gabion's entire area of influence using time-lapse photo data, which recorded the onset of flow and the duration of ponding. For a flow lasting ~5 hours, we ran 225 model scenarios, estimating that a single gabion could have increased the total infiltrated volume in the channel reach between it and the next gabion by as much as 255% or as little as 0%, but the most likely scenario is a 10.8% increase. We found the photo data to be invaluable in obtaining these estimates, and in understanding the dynamics of a remote field site. Future work would benefit from more precise measurements of point infiltration fluxes and better records of ponded surface area over time. If these improvements are made and our estimates can be replicated reliably, they would suggest that gabions are a more powerful restoration and management tool than previously understood.

Chloe Fandel is a PhD student in Hydrology & Atmospheric Sciences at the University of Arizona. She is working on understanding the effects of small-scale rock structures on infiltration in ephemeral stream channels, with Prof. Ty Ferré and Prof. Christopher Scott, and with support from the NASA SpaceGrant and the NSF GRFP. Before moving to Tucson, she received a B.A. in Geological Sciences from Brown University in 2012, and worked as a GIS technician with Tug Hill Operating, as a field hydrology assistant at the USFS, and as an environmental educator through AmeriCorps. She also has a background in scientific illustration, and is currently discovering the exciting world of animation. Finally, as an instructor for the UA SkySchool, she has lead inquiry-based, multi-day science field trips into the Sky Islands for local middle and high school students, where her goal is to share the beauty and excitement of science.

5) Using repeat aerial imagery to quantifying long term rates and patters of Prosopis Velutina across Las Cienegas National Conservation Area- quantifying long-term rates and patterns of shrub cover (velvet mesquite) across Las Cienegas National Conservation Area, Scott Jones, University of Arizona

Rangelands provide a myriad of ecosystem services (ESs) giving them substantial value to socioecological systems. Over the past 150 years, many rangelands have experienced an increase of shrubs at the expense of perennial grasses. This state change, termed woody plant encroachment (WPE) or shrub proliferation, can result in alterations to ecosystem structure and functions with recent revelations suggesting that provisions of ESs can both increase or decrease under WPE. While the proliferation process and its drivers are varied and complex (e.g. excessive livestock grazing, increases in atmospheric CO_2, altered fire regimes, and climate change) consensus is emerging that interactions among multiple factors are key. The strength of these interactions varies with local constraints imposed by landforms, soils, and topography. Thus, long-term spatial/temporal dynamics of the proliferation process or responses to brush management are a challenge to predict. Furthermore, the long-term efficacy of brush management actions is largely unknown. Understanding spatiotemporal rates/dynamics of the encroachment process across a landscape with consideration to topoedaphic variables would provide valuable insights to land managers on where encroachment is most likely to occur. Additionally, evaluating the temporal response of re-encroachment following brush management actions across different topoedaphic constraints could aid in the development of guidelines for determining when, where and under what circumstances to use brush management and plan when retreatments might be required.

The proposed presentation will provide preliminary results from my dissertation research in which I'm quantifying long-term rates and patterns of shrub cover (velvet mesquite) across Las Cienegas National Conservation Area (LCNCA) on sites with contrasting soils, topography, and management histories (e.g. brush management). I will be utilizing historical time-series aerial photography and modern satellite imagery spanning from 1936-2015 and land use records to achieve this task. Not only will these results be valuable to BLM while creating an ecological assessment for proposed brush management on LCNCA, but spatial layers created from this will serve as a foundation for other sections of my research in which I will be assessing landscape-scale temporal changes in the provision of a suite of ecosystem services on these sites and how encroachment and subsequent brush management affects the provision and restoration, respectively of those services.

Scott Jones is a PhD candidate in the Arid Lands Resource Science program at the University of Arizona. The focus of his dissertation research is looking at the long-term rates and dynamics of the shrub encroachment process and how landscape changes (such as grassland-to-shrubland shift resulting from the proliferation process) can affect the provision of ecosystem services. He is also interested in trade-offs and synergies to ecosystem services that might be present following restoration actions. His research is focused on Las Cienegas National Conservation Area located in southern Arizona which is currently undergoing woody plant encroachment from velvet mesquite and also has a long history of brush management actions to control this phenomenon. This unique landscape is not only

a working ranch but also provides numerous recreational activities as well as critical wildlife habitat truly defining what a mixed-use landscape is.

6) **Surveying Public Values and Preferences to Guide Environmental Management in the Sonoita Creek Watershed, Oliver Lysaght, Laura M. Norman, Richard Pritzlaff, David Seibert, and H. Ron Pulliam (Borderlands Restoration)**

The Sonoita Creek Watershed is bound by the Patagonia and Santa Rita Mountains, where surface water flows westerly, eventually draining into the Santa Cruz River. Over 1000 people live, work, and play in the Sonoita Creek watershed, all with varying opinions about what is important to them. Ecosystem services, including those associated with healthy, biologically diverse natural habitats such as forests, urban green spaces, wetlands (marshes and swamps), grasslands, and rivers, provide natural benefits to people. In order to better understand how ecological restoration and a restoration economy might support the ecological values of residents in, and visitors to, the Sonoita Creek Watershed, we are developing a survey to gain insight into the values placed on provisioning, regulating and cultural ecosystem services. Surveyed topics include: respondent's hydro-economic relationships; attitudes towards, and participation in, activities in the Sonoita Creek watershed; familiarity with terminology; preferences for resource management; and a spatially-explicit identification of where cultural values arise within the jurisdiction. Our end goal is to develop input for a regional decision-making tool called, "Social Values for Ecosystem Services" (SolVES), which uses GIS to assess, map, and quantify the social values assigned by stakeholders to ecosystem services. Insights from this survey will guide watershed management in the Sonoita Creek Watershed and strengthen restoration efforts via community participation.

Oliver Lysaght is a graduate of the London School of Economics, where he studied Environment and Development and became interested in the field of Ecological Restoration. He has since worked as an intern for Borderlands Restoration for a year, and in that time has been a member of the team developing the Borderlands Restoration Leadership Institute. Following his internship he will return to studies in the UK, where he wishes to advance research on which models (post-Brexit) can support agriculturalists in their production of food while too enhancing broader ecosystem service provision in the UK.

7) **Conservation Easements in the Madrean Archipelago: Random Acts of Conservation or a Landscape-scale Strategy? Damian Rawoot, University of Arizona**

Over the past three decades, conservation easements (CEs) have become a vital tool for protecting undeveloped private lands in the Madrean Archipelago in Arizona and New Mexico. Undeveloped private lands often form core portions of ranches managed in conjunction with leased federal and state trust lands, buffer existing protected areas, and support landscape connectivity, while development of these lands results in fragmentation, losses of habitat and connectivity, and isolates existing protected areas. Conservation easements represent a possible market-based solution these threats, but as a market-based mechanism, there is no explicit expectation that land protected supports landscape-scale conservation values. We assessed the spatial distribution of 95 conservation easements in the region relative to three local landscape-scale conservation priorities – connectivity with protected areas, riparian and aquatic ecosystems, and grassland ecosystems. Additionally, we conducted qualitative interviews with conservation easement "buyers" (organizations that seek, hold and finance CEs) and "sellers" (private landowners) to identify and characterize the process driving the spatial pattern of conservation easements in the region. Our results suggest that conservation easements do provide landscape-scale conservation benefits, and this is a result of deliberate selection by conservation easement "buyers" and the fact that a large supply of undeveloped private land with landscape-scale conservation values remains in the region.

Damian Rawoot is a native of Virginia's Shenandoah Valley. After graduating from Emory University with a BA in Political Science in 2008, he joined the Peace Corps. Serving in Panama's Darien Province, he worked with ranchers to improve production and reduce land degradation. Following completion of his Peace Corps service, Damian took a position with the US Forest Service's Office of International Program. In this role, he managed collaborative natural resource management and conservation projects in Israel, Oman, Malawi, Namibia and Botswana. In 2015, Damian returned to school to pursue a Master's degree in rangeland management at the University of Arizona's School of Natural resources, and serve as a Graduate Research Assistant with the Desert Landscape Conservation Cooperative. Following completion of his graduate studies, Damian is shifting into a new role as the Land and Water Protection Manager for Southern Arizona with The Nature Conservancy.