7th Annual

Science on the Sonoita Plain

June 6, 2015

Sponsored by:

Cienega Watershed Partnership

Sonoita Valley Planning Partnership

National Audubon Society

At the

Appleton-Whittell Research Ranch of the

National Audubon Society

Elgin, AZ

The Sonoita Valley Planning Partnership (SVPP) is a voluntary ad hoc association of agencies, user groups, conservation organizations, and individuals working together to achieve community-oriented solutions to local and national issues affecting public lands within the Sonoita Valley. The SVPP was created in 1995 in response to BLM's initiation of a collaborative planning process for Las Cienegas National Conservation Area. The SVPP provides a forum for participants to share information and work together to perpetuate naturally functioning ecosystems while perpetuate naturally functioning ecosystems while preserving the rural, grassland character of the Sonoita Valley for future generations. The SVPP is now administered and supported by the Cienega Watershed Partnership (CWP), a 501c(3) non-profit organization that was founded in 2007 to facilitate cooperative actions that steward the natural and cultural resources of the Sonoita Valley while enabling sustainable human use.

The Science on the Sonoita Plain symposium was established to bring together and share the results of scientific investigations that are occurring within and informing us about the unique and diverse resources of the Sonoita Plain in the upper watersheds of Cienega Creek, Sonoita Creek, and the Babocomari River.

This year, our primary focus was on water, and included a series of morning presentations and a panel discussion on surface and groundwater issues. The afternoon session was open to a broad range of scientific presentations and project updates. Posters were on display throughout the event. We hope you enjoy this recap of the 7th annual Science on the Sonoita Plain Symposium.

Proceedings compiled by Amanda D. Webb

Planning committee: Gita Bodner (The Nature Conservancy), Larry Fisher (CWP, University of Arizona), Julia Fonseca (Pima County Office of Sustainability and Conservation), Linda Kennedy (Audubon), Shela McFarlin (CWP), Annamarie Schaecher (CWP), Amanda D, Webb (University of Arizona)

Thanks also to:
David Murray, who provided technical support.

Funding to compile these proceedings was provided by The Nature Conservancy, the Bureau of Land Management, and the Cienega Watershed Partnership.

Cover photo of Research Ranch and conference photos were provided by Tahnee Robertson.

A Certified Professional in Rangeland Management
Continuing Education Workshop, 6 CEU

Agenda and Table of Contents

8:00 Registration & light breakfast (courtesy of Cienega Watershed Partnership and Audubon)

8:30 Welcome and introductions – Linda Kennedy (Audubon) & Shela McFarlin (Cienega Watershed Partnership)

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- Introduction to water management on the Sonoita Plain: Julia Fonseca (Pima County)
- What lies below: groundwater controls on surface water in the Cienega Creek Basin: Jeanmarie Haney….. p.5
- Harnessing runoff on the Sonoita Plains; a primer for watershed resilience: Laura Norman
- Private water wells and their place in future plans: Gary Hix….. p.6
- Legal and policy considerations: Linda Stitzer
- Panel discussion, Q and A – all speakers
- Pupfish monitoring: Doug Duncan….. p.7

12:00 Lunch

1:00 – 4:30 Presentations (with break, midafternoon) – moderated by Tom Meixner and Gita Bodner

- Shrub encroachment and brush management: research priorities for competing land-use objectives: Steve Archer….. p.8
- The 2015 Soil Moisture Active Passive Validation Experiment (SMAPVEX15) in the Sonoita Plain: Phil Heilman ….. p.9
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- The evolution of hummingbird visual signals: Richard Simpson
- Las Cienegas National Conservation Area program update: Amy Markstein and Karen Simms
- The shared history of the Watershed Curriculum Project: Annamarie Schaecher

4:30-5:00 Summary wrap-up and evaluations – Tahnee Robertson

Scientific Posters (displayed all day)

- Preliminary results from an investigation of pollination and floral form change in the Genus *Dalea*: Justin Zweck, Peter Bernhardt….. p.14
  The Evolution of Hummingbird Visual Signals: Richard Simpson……p.15

Meeting participants gathered at the Appleton-Whittell Research Ranch of the National Audubon Society and took part in a panel discussion of water management on the Sonoita Plain. Attendees included citizens of the Sonoita Plain, researchers, land managers, and conservation practioners.

What Lies Below: Groundwater Controls on Surface Water in the Cienega Creek Basin

Jeanmarie A. Haney
The Nature Conservancy in Arizona

In the arid southwest, the presence of year-round surface water is a reflection of the intersection between land surface and the groundwater table. The discharge of groundwater maintains flow at springs, streams and creeks, cienegas, and wetlands. The location of the start of perennial flow on a stream reach, for example, may migrate upstream or downstream according to fluctuation in water table elevation. Whether a stream reach maintains water through drought times is a reflection of the size of the groundwater reservoir supplying flow to that location. Groundwater recharged to the floodplain and stream banks during high flows will discharge back to the stream during the days or months following the high flow, but generally be depleted in a relatively short time period if additional high flows do not occur. Storm runoff along washes may recharge shallow perched aquifers that then provide discharge to streams and wetlands for months or years, but may be depleted in times of drought or heavy pumping by wells. Runoff from snow melt and rain in the high elevation mountain blocks and along mountain fronts recharges the deeper regional aquifer, with often long travel times to discharge areas - streams, springs, and wetlands - in lower elevation areas. These regional aquifers have large storage volume and slower response time to climate and human perturbations, and thus may continue to provide discharge to surface water features during drought times. The different sources and pathways of water in the subsurface can be deduced through careful study and multiple lines of evidence. Understanding the source of water to surface water features is key to understanding trends and making management decisions to support continued function of streams, wetlands, and riparian areas. Multiple lines of evidence are being complied in the Cienega Creek basin to develop a picture - or conceptual hydrogeologic model - of how the groundwater system works to support surface water resources. This information will help land managers with decision making for adaptive management.

Jeanmarie Haney

Private Water Wells and Their Place In Future Plans For Arizona

Gary L. Hix, R.G., CWD/PI
In2Wells, LLC; owner and water well consultant

Water wells played a significant part in the history and growth of the State of Arizona that isn't often remembered, or fully appreciated. The first domestic wells were shallow hand dug wells, and only a few of these remain in use today. Many of the first drilled wells were only 100 to 200 feet deep. Today the average depth of drilled wells is more like 300 to 500 feet deep and in some cases as much as 1,000 feet deep. As weather patterns change, bringing drier winters and hotter summers, the amount of water remaining in the bottom of these wells has been decreasing, causing great concern for their future.

Private well owners, especially those in rural communities, know the true value of water more so than people on metered public supplies. Their homes, their animals and their pets depend upon the water their wells can produce. In addition to declining water levels, many private wells are being impacted by declining water quality. Reaching out to private well owners to inform them that their wells and their health may be peril is an ongoing effort for many of us.

The public at large does not know or appreciate the fact that there are no water quality standards in place for private and shared water wells. This means that are no drinking water standards to be met for roughly 15% of the state's population. Likewise, there are no water quantity or quality standards to be met for private water wells at the time of sale and transfer of homes served by private water wells. Private water well owners are exempt from reporting the amount of water they pump annually, or the results of any water quality testing. Buyers are left to their own when purchasing a home on a well.

Shallow water wells, typically located near ephemeral washes and rivers, respond more quickly to periodic recharge events and periods of extended drought. They are in more direct contact with recently stored surface water while the deeper wells are drawing groundwater out of storage that may be millions of years old. Shallow wells are subject to human caused contaminates while deeper wells are subject to naturally occurring or leached from the formation contaminates. Both shallow and deep well owners could be at risk for the future of their only source of drinking water.

Trip notes on endangered pupfish effort at the research ranch

Date: 6 JUNE 2015
Purpose: desert pupfish monitoring @ Science on the Sonoita Plain
Location: Appleton-Whittell Research Ranch
Personnel: Doug Duncan, US Fish and Wildlife Service; Jeff Simms, BLM

This was the fourth year of monitoring desert pupfish *Cyprinodon macularius* at this Safe Harbor site. We set four baited Gee metal minnow traps in the pond at ~1030 hrs. Traps were set for two hours each: checked at ~1230 hrs. Size class break for adult and juvenile was 15mm. Most fish captured were greater than 15mm. Just before pulling traps, an estimated minimum of 50 pupfish, mostly adults, were still swimming free outside the traps. There were 166 fish captured in the traps; 143 adults and 23 juveniles. Many adult males were in breeding color, though no very young fish were captured or seen in the pond. The smaller proportion of the population that is made up of juveniles may be due to a cooler than normal June. All fish appeared healthy. The catch per unit effort (fish/trap hour) was 20 (11 last year). Minimum number in traps and swimming free was 216. About 50% of the water is covered by *Eleocharis*. The larger number of fish captured this year may be a reflection of the greater amount of open water, when compared to previous years. Flat rocks placed in the pond by Audubon staff were observed being heavily used by juvenile pupfish. Two or three more flat rocks in the pond will reduce the area covered by vegetation, and create more warm, shallow areas that pupfish, especially juveniles, prefer. This pupfish population should be augmented with pupfish from other sources this year.

Desert pupfish *Cyprinodon macularius* monitoring history at Appleton-Whittell Research Ranch, Arizona.

Date	Event	Adults trapped[2]	Juveniles trapped[2]	Catch per unit effort (fish/trap hour)	Number pupfish observed outside of traps	Minimum number pupfish present
4 June 2011	fish released	-	-	-	-	229
9 June 2012	Monitoring[1]	146	148	37	48	342
8 June 2013	monitoring	13	0	2	17	30
7 June 2014	monitoring	55	27	11	40	122
6 June 2014	Monitoring	143	23	21	50	216

[1] Four baited Gee metal minnow traps deployed two hours each.
[2] Number of fish.

Shrub encroachment and brush management: research priorities for competing land-use objectives

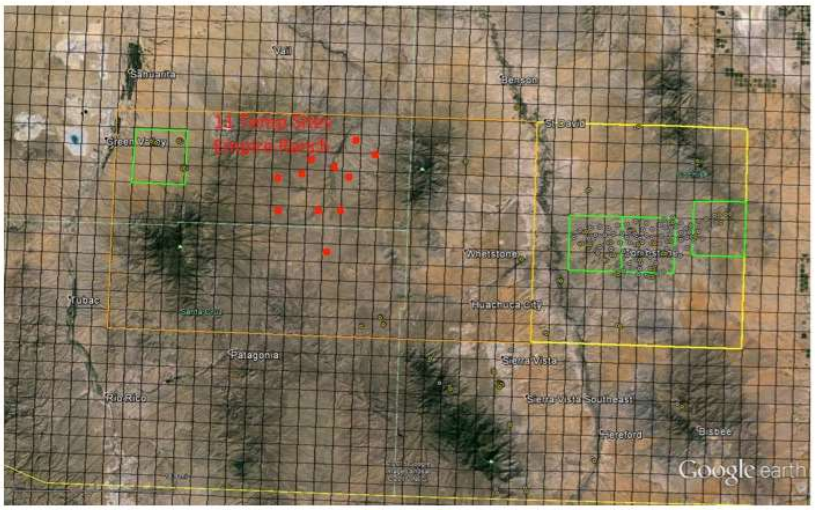
Steve Archer
University of Arizona, School of Natural Resources and the Environment

The vegetation of drylands is typically comprised of mixtures of herbaceous and woody plants. Shifts from grass to shrub or tree dominance have occurred in drylands world-wide since the early 1900s. This has presented challenges to grassland and savanna ecosystem conservation and to animal production in commercial ranching and pastoral societies. Management focused on cattle and sheep grazing has historically sought to reduce the cover of woody vegetation ('brush management') with the intent of reversing declines in forage production, stream flow or groundwater recharge. This presentation will overview the known and potential consequences of brush management actions on a broader suite of ecosystem services, the scientific challenges to quantifying those services and the trade-offs among them. Despite considerable investments in brush management, the recovery of key ecosystem services may be short-lived or absent. However, in the absence of intervention, these and other services may be compromised, and the persistence of grassland and savanna ecosystem types and their endemic plants and animals threatened. Addressing challenges posed by woody plant encroachment will require integrated management systems using theoretical principles to design the type, timing and spatial arrangement of initial actions and follow-up management. Management activities will also need to balance cultural traditions and preferences, socioeconomic constraints and potentially competing land-use objectives. Research scientists are challenged with generating robust information about the response of ecosystem services if we are to position managers and policymakers to make objective decisions that reconcile trade-offs and competing objectives for dynamic grassland management and conservation.

The 2015 Soil Moisture Active Passive Validation Experiment (SMAPVEX15) in the Sonoita Plain

Phil Heilman
USDA Agricultural Research Service

On January 31, 2015 NASA launched the Soil Moisture Active Passive (SMAP) satellite with the goal of estimating global soil moisture at a shallow depth (2 inches) every 2 to 3 days. The sensor is "active" in the sense that it emits a radar signal that is reflected off the earth's surface and captured by the satellite. The "passive" capability in the name refers to capturing radio waves emitted by the earth's surface that indicate temperature. NASA will estimate the average soil moisture in an area covering 36 square miles by combining both the active and passive observations. The Sonoita Plain is in the center of the core validation site that stretches from the Santa Rita Experimental Range in the west across to the Walnut Gulch Experimental Watershed in the east. This area was selected both because of the density of existing rainfall and soil moisture measurements and because the very localized summer storms will help test the sensor's capabilities. Aircraft with the same sensors will fly over the area coincident with the satellite overpass to get estimates with greater spatial resolution. At the same time, ground measurements will be taken with both electronic sensors and direct measurement throughout the month of August to ensure that the satellite's soil moisture measurements are as accurate as possible. Ultimately, the SMAP sensor will help monitor drought, assess crop production, improve flood and weather forecasting. Along with the SMAP validation experiment, ground based radars will also look upward to improve rainfall estimates from the satellite-based Global Precipitation Measurement (GPM) mission.



Recovery Effort of Native Aquatic Species in the Cienega Creek Basin, AZ

Doug Duncan, Dennis Caldwell, Jeff Simms
US Fish and Wildlife Service, FROG project, BLM

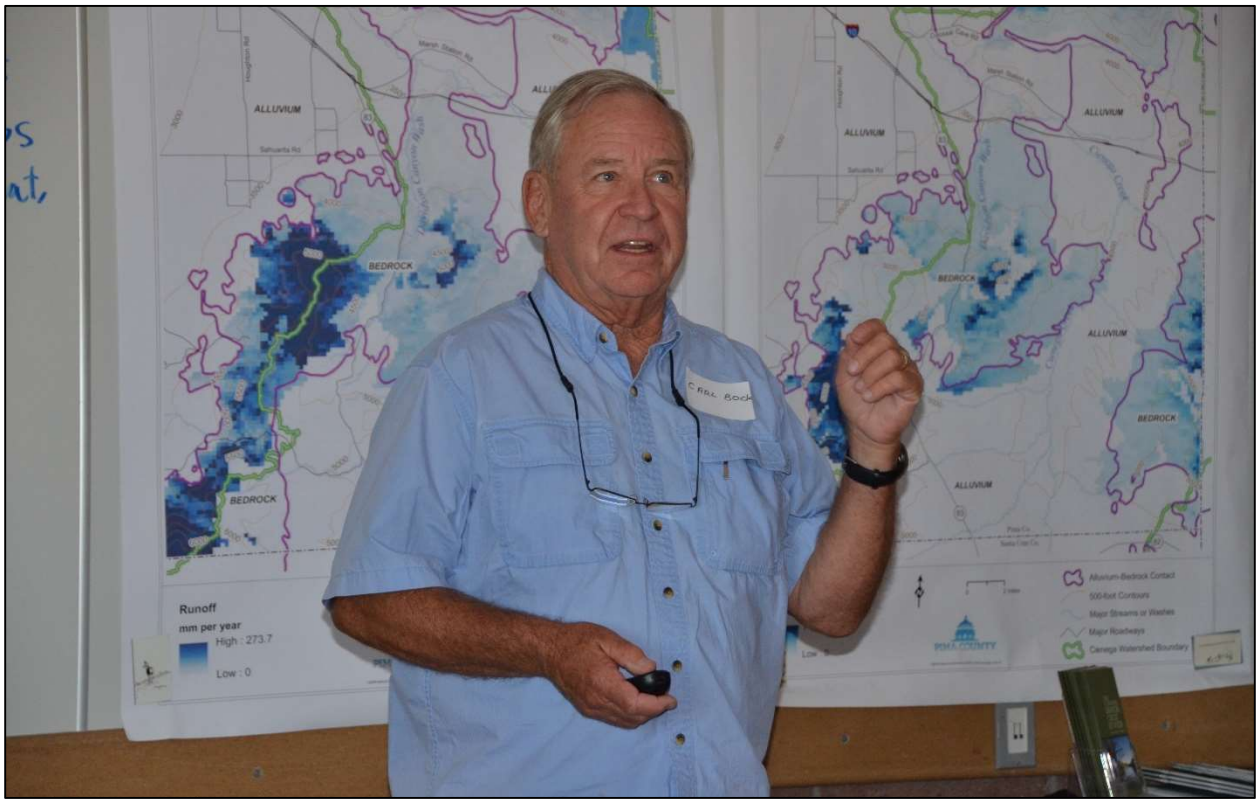
The Upper Cienega watershed and its aquatic ecosystems support a rich diversity of native aquatic species, many of which are federally listed as either threatened or endangered with extinction. While a variety of threats loom over aquatic habitat and species in the Santa Cruz River basin, great progress has been made by a diverse group biologists and land managers to restore and create new aquatic habitats to recover declining populations of threatened species on a landscape level. Here we present a brief overview of the many threats and ongoing efforts and successes.

Pictured from right to left: Doug Duncan, Jeff Simms, Dennis Caldwell

Effects of Wildfire on Riparian Trees in Southeastern Arizona

Carl E. Bock and Jane H. Bock
University of Colorado (Ret.)

We measured fire damage to 250 riparian trees in 2003-2004 and again in 2012-2013, in three drainages on the Research Ranch burned by wildfires in 2002, or 2009, or both. The sample included 41 desert willow (*Chilopsis linearis*), 44 Arizona walnut (*Juglans major*), 90 velvet ash (*Fraxinus velutina)*, 28 Wright's sycamore (*Platanus wrightii*), and 47 Fremont cottonwood (*Populus fremontii*). Following a single fire, combined mortality or survival only by ground-level resprout was highest for desert willows (64%) and Fremont cottonwoods (57%), lowest for Wright's sycamore (25%) and velvet ash (32%), and intermediate for Arizona walnuts (48%). Fire damage was inversely correlated with trunk diameter for all trees combined and for Arizona walnut, Fremont cottonwood, and desert willow separately. Production of ground-level resprouts was most likely for desert willows (86%) and least likely for Fremont cottonwoods (25%). A second fire burned 120 of the trees that happened to have been less damaged by the first fire. Distinctions among species in overall fire damage persisted after the second fire, but to a lesser degree. By the conclusion of our study, 26% of the 250 trees had died completely, while another 32% survived only as relatively small resprouts. We conclude that the impact of the burns on the abundance and crown volume of mature trees in the study area was substantial.



Carl E. Bock

Tracking Wetland Conditions of an Effluent-Dependent River: the Lower Santa Cruz Living River Project

Claire Zugmeyer
Sonoran Institute

Throughout Arizona the release of effluent is maintaining flows of many river reaches. Along the Lower Santa Cruz River in Pima County, two major regional facilities release effluent into the river. These two facilities underwent significant upgrades in 2013. The release of higher-quality water is a key ingredient in supporting wetland health along the river, but how can we gauge conditions of this valuable ecosystem and community amenity? Pima County and Sonoran Institute have partnered to develop an annual report series to track and communicate wetland conditions. The *Living River* annual reports chart the status of the Lower Santa Cruz River by presenting data on 16 indicators of wetland health with easy to follow text and engaging graphics. The first report on the 2013 water year, prior to the completion of upgrades, was released in October 2014 and documented baseline conditions in flow extent, water clarity, water quality, aquatic wildlife, riparian vegetation, and social impacts. The second report, focused on the 2014 water year, will be released in June 2015 and will highlight immediate changes since the facility upgrades. Notable findings included the following: improved water clarity and quality, reductions in nutrient pollution, contraction of flow extent with higher infiltration rates, and improvements in aquatic wildlife. To learn more about the Living River project – go to www.tiny.cc/lscr.

Claire Zugmeyer

Flora of the Cienega Creek Natural Preserve

Julia Fonseca
Pima County Office of Sustainability and Conservation

This project involves characterizing the distribution of plant diversity at the Cienega Creek Natural Preserve relative to substrates and past land use history. The study area is located east of Tucson in Pima County at an elevation of around 3500 feet. The Preserve is located in the Cienega "gap", between the Rincon Mountains and Agua Verde Hills on the north (see photo), and the northern Santa Rita and Empire Mountains to the south. The study area includes around 4000 acres of land managed by Pima County for protection of vegetation and stream flows. Previously collected specimens are biased toward riparian herbs collected along main channels of Davidson Canyon and Cienega Creek. Previous collections primarily occurred March, April, September and October, and most collecting effort has been since 2000, a time period that has been characterized by reduced extent of surface flows. The author has made 450 collections so far. Special effort is made to sample geomorphic diversity and disturbed areas. The effort so far has documented two species not collected in over 100 years: Encelia farinosa and Croton pottsi. This study has confirmed new exotic species, Brassica tournefortii, Matthiola parviflora, and Pennisetum setaceum, in the Preserve. The author gratefully acknowledges the assistance of the University of Arizona Herbarium and its volunteers.

Pictured from left to right: Julia Fonseca, Jeanmarie Haney, Linda Stitzer, Laura Norman, Gary Hix

Preliminary Results from an Investigation of Pollination and Floral Form Change in the Genus Dalea

Justin Zweck, Peter Bernhardt
Saint Louis University and the Missouri Botanical Garden

Dalea is a fascinating plant genus in the legume (Fabaceae) family due to its striking variation in floral form. While some species possess the papilionoid floral form typical of most legumes in which the sexual organs are enclosed by the petals, others have lost this form, having their anthers and stigma exposed and exerted beyond the petals. We tested the hypothesis that this shift in floral form has been accompanied by a shift in pollination system, and also recorded natural rates of pollination of species with each floral form at the Appleton-Whittell Research Ranch from August-September 2014. Specifically, we investigated whether papilionoid *Dalea* feature a more specialized pollination system than non-papilionoid *Dalea*. Insects found pollinating non-papilionoid species D. albiflora and *D. candida* represented a broad range of taxa, including beetles, wasps, flies, and bees. In contrast, only bees were found pollinating papilionoid *D. formosa*, and only 3 insects were captured over ~33 hours of observation on the three papilionoid species studied. Natural rates of pollination varied between floral forms as well. While unbagged flowers had significantly more pollen grains on their stigmas than those covered with a bag to prevent insect visitation in non-papilionoid *D. albiflora*, there was no significant difference in pollen deposition on bagged vs. unbagged flowers of papilionoid *D. formosa*, *D. nana*, and *D. pogonathera*. Together, these preliminary data are consistent with a shift from bee pollination in papilionoid *Dalea* towards a more generalized pollination system in non-papilionoid *Dalea*. Additionally, differences in natural rates of pollination during the study period suggest that the generalized strategy can be beneficial when bee abundance is low. Although further research is required, this preliminary study may shed light on the selective pressure promoting loss of the papilionoid floral form in *Dalea*.

The Evolution of Hummingbird Visual Signals

Richard Simpson
Arizona State University, Animal Behavior Ph.D. Candidate

Animals possess a diversity of ornamental traits (e.g. deer antlers, bird coloration), and often these traits are used to communicate. Many animals use more than one trait to communicate, and this raises the questions: why do animals use multiple signals to communicate and why is there so much diversity in these signals? Many studies have been conducted on multiple signals within a single animal, but few have tracked the evolution of multiple signals across many species and none have considered how multiple signals can interact during use or presentation, which can greatly influence the perception of these signals. My study will test how interactions between multiple signals (coloration and display behavior) influence the evolution of these signals in North American hummingbirds. Hummingbirds are ideal for this type of study, because they possess gaudy iridescent plumage coloration and exaggerated courtship displays (e.g. dives, shuttles) that vary among species. Because iridescent coloration is angle dependent (e.g. the observed color changes depending on viewing and lighting angle), it can be greatly influenced by behavioral displays that incorporate this coloration. Hummingbird males court females through rapid side-to-side horizontal movements in front of them (i.e. shuttle display), while displaying their iridescent throat/crown plumage. I will assess how the display behavior of each species of breeding North American hummingbird is specifically shaped to match the plumage color characteristics of that species. Further, I will test how the perceived coloration during a courtship display changes when I model one species plumage color using a different species' display pattern. These results will illustrate how the interactions between iridescent coloration and display behavior in hummingbirds led to the diversity of these traits. Further, this study will demonstrate the need to consider signal interactions when assessing how and why multiple signals evolved.

Quantifying rates and patterns of mesquite cover in Las Cienegas National Conservation Area using repeat aerial imagery and land use records from 1936 to 2014

Scott Jones and Steve Archer
University of Arizona, School of Natural Resources and the Environment

Arid and semi-arid grass-dominated landscapes provide a myriad of ecosystem services giving them substantial multidimensional value to both ecological and social systems. Over the past 150 years many of these areas have experienced the proliferation of woody trees and shrubs replacing perennial grasses. A transition from grassland to shrublands has significant effects on ecosystem functions, goods, and services. Despite the ramifications of encroachment, knowledge is lacking on the long-term spatial and temporal dynamics of the proliferation process. Available evidence indicates encroachment is locally constrained by soils and topography and influenced by interactions of multiple broad-scale drivers.

The proposed research will utilize land use records and repeat aerial imagery from 1936 to 2014 to quantify rates and patterns of velvet mesquite cover across the Las Cienegas National Conservation Area (LCNCA) on sites with contrasting soils, topography, and management histories. Changes in the provision of ecosystem services (e.g., primary production, critical habitat, forage production, and recreational opportunity) accompanying shrub encroachment and following brush management will be assessed. This project seeks to provide managers with information needed to ascertain where shrub encroachment is most likely to occur, where encroachment will have the greatest impact on conservations objectives, when, where and under what circumstances should brush management activities be conducted and when and where follow up actions will be required. The proposed project will seek to generate a quantitative, objective assessment of trade-offs among competing land use and land management approaches and objectives.

Sources of recharge to groundwater in Davidson Canyon, SE Arizona: an isotopic tracer study

Rachel Tucci and Jennifer McIntosh
University of Arizona, Department of Hydrology and Water Resources

Davidson Canyon is the largest channel draining the proposed controversial Rosemont Copper Mine, and is a tributary to Cienega Creek. Portions of Davidson Canyon are classified as Outstanding Arizona Waters (OAWs). Questions have been raised about the potential impacts of future mining activities on surface water and groundwater resources in the area. Background studies are needed of the natural hydrogeochemical conditions in order to evaluate the potential of contamination if it were to occur, as well as understand potential impacts of other land use changes and climate change to water resources in the region. This preliminary study utilizes natural isotopic tracers (^{18}O, ^{2}H, ^{3}H) to investigate the source of recharge as affected by seasonality and elevation, relative ages of groundwater and groundwater-surface water interactions in the Davidson Canyon watershed. Water samples were collected from 15 domestic water supply wells and 4 surface water sites; additional data from 4 surface water sites, 3 groundwater well sites and 2 precipitation collectors were obtained from Hudbay Minerals Inc., Pima County Regional Flood Control and Pima Association of Governments. Initial results show distinct $\delta^{18}O$ and δD values for average winter versus summer precipitation in the study area, similar to values for low-elevation Tucson Basin precipitation, although there is wide overlap in the range of winter and summer precipitation values. The elevation difference between the two precipitation collectors in the study area is too small to determine the effects of altitude on the isotopic composition of precipitation, and thus recharge. Longer-term records of precipitation and collectors at a wider range of altitudes are likely needed to better constrain the seasonality and elevation of recharge. Most of the groundwater, surface water and springs have $\delta^{18}O$ and δD values that plot between winter and summer precipitation average values, with values closer to average winter precipitation. This suggests a mix of seasonality of recharge, with a majority of recharge coming from winter precipitation, as shown in adjacent basins. Tritium levels in groundwater and spring samples ranged from <0.6 tritium units (TU) to 3.6 TU, indicating some of the groundwater samples were recharged prior to 1952, while others are a mixture of pre-1952 waters and more recent (<10 years) recharge. Analyses of other age tracers (e.g. Carbon-14) are needed to determine the relative age of older (pre-1952) groundwater.

Flow regimes and infiltration potential of streams in southern Arizona

Tomas Meixner[1], Erika L. Gallo[1,2] and Kathleen A. Lohse[2]
1 University of Arizona, Department of Hydrology and Water Resources
2 Idaho State University, Department of Biological Sciences

Streamflow in arid and semi-arid regions is predominantly temporary, an integral part of mountain front hydrology and of significant importance for groundwater recharge and biogeochemical processes. However, streamflow regimes in ephemeral and intermittent channel systems are not well characterized. We used electrical resistance sensors and USGS stream gauge data to quantify streamflow intermittency as streamflow presence and water presence in 16 southern Arizona streams spanning a climate gradient (mean annual precipitation from 160 to 750 mm). We use stream channel sediment data to estimate saturated hydraulic conductivity and potential annual infiltration. Annual streamflow ranged 0.6 to 82.4 % or 2 to 301 days; while water presence ranged from 2.6 to 82.4%, or 10 to over 301 days. We identified 5 statistically distinct flow regimes based on the annual percent streamflow and water presence: 1) pulse- ephemeral, 2) phreatic-ephemeral, 3) dry intermittent, 4) wet intermittent and 5) semi-perennial. Responses to the magnitude and temporal distribution of rainfall were highly variable. The pulse-ephemeral and phreatic-ephemeral flow regimes vary with seasonal precipitation while the dry- intermittent, wet intermittent and semi-perennial flow regimes do not. These results coupled with potential infiltration estimates suggest that streamflow at the driest sites occurs in response to rainfall and overland flow; while groundwater discharge and vadose zone contributions enhance streamflow at the wetter sites. We suggests that on a short temporal scale, and with respect to water presence, wetter sites might be overall better buffered against shifts in the timing and distribution of precipitation in response to climate change.

Predicting Treatment Windows for Invasive Buffelgrass in Southern Arizona using MODIS and Climate Data

Cynthia S.A. Wallace[1], Susan M. Skirvin[2], Caroline Patrick-Birdwell[3], Jake F. Weltzin[4], Helen Raichle[5]
1 USGS Western Geographic Science Center; 2 Contract Geostatistician, Tucson, AZ; 3 Southern Arizona Buffelgrass Coordination Center; 4 National Phenology Network; 5 USGS Arizona Water Science Center

The increasing spread and abundance of an invasive perennial grass, buffelgrass (*Pennisetum ciliare*), represents an important shift in the vegetation composition of the Sonoran Desert in southern Arizona. Buffelgrass out-competes native species and alters fire regimes, and its control and management is a high-priority issue for resource managers who seek to preserve the unique and iconic Sonoran Desert flora. Herbicidal treatment of buffelgrass is most effective when the vegetation is actively growing; however, the erratic timing and length of active buffelgrass growth periods in southern Arizona confound effective management decision-making. The goal of our research is to enable the strategic application of buffelgrass herbicide by using remote sensing data to detect when and where buffelgrass is photosynthetically active. We integrated ground-based observations of buffelgrass phenology (green-up and senescence) in the Tucson, Arizona area with climate information and Moderate-resolution Imaging Spectroradiometer (MODIS) satellite imagery at 250m spatial and both 8-day and 16-day composite temporal resolution to understand dynamics, relationships and resonance between these disparate datasets during 2011 to 2013. Regression analyses and statistical tests were used to identify correlations between temporal patterns of the data sets. Our results reveal strong correlations between the observed greenness of in-situ buffelgrass and satellite LSP metrics, confirming that MODIS-EVI data can be a useful indicator of active buffelgrass growth at multiple scales. The analysis also reveals strong harmonics between precipitation and greenness, but with a lagged response, suggesting that precipitation can be a predictor of the location and intensity of buffelgrass green-up at landscape scales. This information can be used by resource managers to treat buffelgrass during optimal conditions.

Outreach Diagram for Resilience of Shallow Groundwater in Arid Environments

Mead Mier
Watershed Planning Lead, Pima Association of Governments (PAG)

In contrast to deeper aquifers with lower water tables, within the Cienega Watershed shallow bedrock brings groundwater close to the surface, expressing itself as a perennial creek. This diagram illustrates how although the groundwater may be cloaked by sediments, it is divulged by the presence of riparian ecosystems. PAG and CWP partners are considering localized drought planning needs for the urban periphery of the Tucson metro area where individual private wells do not receive imported supplies. The diagram is part of a concept to engage with people living in the watershed to encourage strategies for resilience such as water conservation, water harvesting, and landscape restoration practices.

Tracking Drought Impacts along the Lower Cienega Creek, Pima County

Mead Mier
Pima Association of Governments

PAG drought reporting uniquely depicts the localized drought impacts on a shallow groundwater dependent system, important for habitat and rural residents dependent on this water source. With long term support and interest from its member jurisdictions, PAG has consistently monitored the shallow groundwater-dependent riparian area of Cienega Creek Preserve on a monthly basis since 1989, allowing evaluations of seasonal, annual and cumulative impacts of drought. In 2014, PAG's analysis determined several record-breaking water level trends that indicate a heightened level of risk to the ecosystem due to drought, especially during the driest times of the year.

Recent results include the lowest flow length in our historical record at 0.86 mile in June 2014 (9% of the full 9.5 miles of flow extent observed in June of the mid-1980s). Other findings include the lowest levels of average annual streamflow on historical record and a five-foot drop in average well levels with some wells dropping as much as 12 feet in one year. The relationship of surface baseflows to groundwater in this system is strongly correlated as these trends parallel each other. Resulting mortality of cottonwood galleries and mesquite bosques have been observed. PAG has tracked a major erosion headcut as its progression followed not just major flood events, but were preceded by especially dry periods.

Increased coordination with land use planners and well owners to encourage conservation strategies near vulnerable riparian area is recommended. Monitoring is recommended where groundwater restoration methods are applied to increase stormwater infiltration.