California Institute for Water Resources
Annual Technical Report
FY 2015

Introduction

The California Institute for Water Resources (CIWR) is a special program within the University of California's (UC) Division of Agriculture and Natural Resources (ANR). The Institute is enabled by the federal Water Resources Research Act (WRRA), with the mission of supporting research and extension activities that contribute to the efficient management of California's water resources, in water quality, quantity, and reliability.

Headquartered at ANR's offices within the UC Office of the President, CIWR is well positioned to coordinate research, education, and extension activities across the 10 campuses of the UC system, as well as academic institutions across the state. Throughout California, ANR is an engine for problem solving. Serving as the bridge between local issues and the power of UC research, ANR has more than 300 campus-based specialists and county-based advisors working to bring practical, science-based answers to Californians.

CIWR brings together federal, state, and local communities to identify issues and builds support for water-related research. The CIWR mission is to provide leadership that links stakeholders with UC resources to carry out statewide water planning, research, and outreach.

Given the WRRA statutory mission of education and outreach, CIWR is best suited to linking water research to the needs of water managers and users throughout California. The CIWR serves an important linkage niche: science to public policy, science to education and outreach, researchers to State agencies and the public, ANR initiatives to each other, UC water centers to each other, and UC water centers to other academic institutions.

The Institute's Director is housed within ANR to facilitate a statewide focus. The Institute also has affiliate faculty from ANR, the different UC and California State University campuses and other universities as appropriate. The CIWR Director serves as a key spokesperson on California water issues; working with federal, state, regional, nonprofit, and campus stakeholders to improve the understanding of water issues through advocacy and outreach programs.

The Director also serves as Leader for ANR's Strategic Initiative on Water Quality, Quantity and Security. Thus, part of CIWRs mission is to assist ANR in the management of this Strategic Initiative. As part of that Initiative, CIWR helps to manage ANR's competitive grants portfolio. Through this partnership, CIWR is developing such strategic themes of importance as irrigation efficiency, ecosystem services, source water production and protection, water policy, drinking water, food safety, and water quality.

Research Program Introduction

The California Institute for Water Resources (CIWR) is involved in two competitive grants programs. We manage a Request for Proposals to allocate funds from our USGS 104b program. We also assist, through the University of California Agriculture and Natural Resources (ANR) Water Strategic Initiative, with the ANR competitive grants program.

USGS 104b: The CIWR receives funds from USGS that are used to support the operations of the Institute, our Information Transfer and our Competitive Grants Program. Information on outcomes from our 104b competitive grants program is provided elsewhere in this report.

ANR Grants Programs: ANR invests in research, education and outreach projects that meet the goals of its mission by conducting a competitive grants program aimed to support high priority issues, encourage collaboration among ANR representatives and key players from throughout the state, support short-term high-impact projects, continue to strengthen the research-extension network, yield policy relevant outcomes, and achieve significant statewide economic, environmental and social impacts in California. To address some of these challenges, ANR developed the Strategic Vision 2025 to identify and meet the statewide scientific, technological, social, and economic demands facing California. As an initial implementation strategy, ANR identified five Strategic Initiatives that are favorably positioned within the Division to achieve maximum results. To attest to the importance of California water research, one of the five grant categories is specifically dedicated to “Water Quality, Quantity, and Security.”

2015 Highlights

Advisory committee: We continue to work with our advisory committee to administer the junior investigator competitive grants program. The committee is also involved in strategic planning for the Institute.

Competitive grants program: CIWR continued its competitive grants program in 2015. Working with our advisory committee, we solicited proposals for California water related research, education, and extension projects from academics at qualified institutions statewide to be funded under the 2015 WRRA (contingent on funding). We supported several new projects on topics ranging from salmon incubation temperatures to nitrates to debris flows – all topics of concern in the state.

Drought: Much of our effort this year continues to be related to the historic drought in California. We grew an already strong web presence, leveraging additional funds from the California Department of Water Resources and gathering academic drought information, providing information on drought related events held by the UC system, and providing media contacts and information. Our Twitter following has exploded with our drought coverage and this year we surpassed 5000 followers.

Nitrates in groundwater: Building on our 2013-14 work, we held additional training for over 100 California Certified Crop Advisors on nitrogen and water management, leveraging support through a project with the California Department of Food and Agriculture. These trainings were very well received. Our annotated nutrient and water management curriculum is now also available on the web for access beyond the in-person training opportunities.

Additional highlights: We continue to work to communicate University based science to our stakeholders, with a renewed focus on highlighting the work of a diversity of researchers across the system.

Rosenberg International Water Policy Forum: The Forum brings water scholars from the around the world together on a biannual basis to collaborate on water related conflict.

Minimizing Hexavalent Chromium in Californian Water: Understanding Hiding Reaction Pathways in Drinking Water and Reinventing Treatment Process

Basic Information

Title:	Minimizing Hexavalent Chromium in Californian Water: Understanding Hiding Reaction Pathways in Drinking Water and Reinventing Treatment Process
Project Number:	2014CA322B
Start Date:	3/1/2014
End Date:	11/30/2015
Funding Source:	104B
Congressional District:	44
Research Category:	Water Quality
Focus Category:	Toxic Substances, None, None
Descriptors:	None
Principal Investigators:	Haizhou Liu

Publications

1. Chebeir, M.; Liu, H. Oxidation of Cr(III) Solid Phases by Chlorine in Drinking Water and Implications on Cr(VI) Formation. In preparation. To be submitted to Environmental Science and Technology.
2. Chen, G.; Chen, M.; Yin, Y; Liu, H. Photocatalytic reductive treatment of hexavalent chromium using barium doped TiO2. 249th American Chemical Society National Meeting and Exposition. Denver, CO. March 22-26, 2015.
3. Chebeir, M.; Liu, H. Transformation of hexavalent chromium via redox pathways in drinking water: Implications on Cr(VI) control and treatment. 249th American Chemical Society National Meeting and Exposition. Denver, CO. March 22-26, 2015.
4. Liu, H.; Chen, M.; Sohn, H.; Alkhamis, L.; Wang, W.; Yin, Y. Application of sulfur-containing radical treatment for water reuse and recycling. AIChE Annual Meeting. Atlanta, GA. November 17-20, 2014.
5. Liu, H.; Chebeir, M.; Sohn, H.; Chen, M.; Wang, W.; Yin, Y. Transformation and reoccurrence of hexavalent chromium via redox pathways in drinking water: implications on Cr(VI) control and treatment. California-Nevada Sectional Conference of American Water Works Association Annual Fall Conference. Reno, NV. October 22-24, 2014.
6. Liu, H.; Chebeir, M.; Sohn, H. Impacts of Redox Chemical Conditions on the Occurrence and Transformation of Hexavalent Chromium in Drinking Water. 249th American Chemical Society National Meeting and Exposition. San Francisco, CA. August 10-14, 2014.
7. Chebeir, M.; Liu, H. Oxidation of Cr(III) Solid Phases by Chlorine in Drinking Water and Implications on Cr(VI) Formation. In preparation. To be submitted to Environmental Science and Technology.
8. Chen, G.; Chen, M.; Yin, Y; Liu, H. Photocatalytic reductive treatment of hexavalent chromium using barium doped TiO2. 249th American Chemical Society National Meeting and Exposition. Denver,

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9. Chebeir, M.; Liu, H. Transformation of hexavalent chromium via redox pathways in drinking water: Implications on Cr(VI) control and treatment. 249th American Chemical Society National Meeting and Exposition. Denver, CO. March 22-26, 2015.
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11. Liu, H.; Chebeir, M.; Sohn, H.; Chen, M.; Wang, W.; Yin, Y. Transformation and reoccurrence of hexavalent chromium via redox pathways in drinking water: implications on Cr(VI) control and treatment. California-Nevada Sectional Conference of American Water Works Association Annual Fall Conference. Reno, NV. October 22-24, 2014.
12. Liu, H.; Chebeir, M.; Sohn, H. Impacts of Redox Chemical Conditions on the Occurrence and Transformation of Hexavalent Chromium in Drinking Water. 249th American Chemical Society National Meeting and Exposition. San Francisco, CA. August 10-14, 2014.

RESEARCH PROGRAM:

1. Hexavalent chromium Cr(VI) is a highly toxic and soluble compound that poses great public health risks. Regulatory agencies are currently considering revision of rules regarding its presence in drinking water. Commonly available technologies reductively transform soluble Cr(VI) to less toxic Cr(III) particles during coagulation. However, residual Cr(III) could be inadvertently converted back to Cr(VI) by chlorine in downstream disinfection and distribution system. This study investigated the kinetics and mechanisms of Cr(III) solids oxidation by chlorine and formation of Cr(VI) in drinking water condition. Batch experiments were carried out with chromium hydroxide $Cr(OH)_{3(s)}$, chromium oxide $Cr_2O_{3(s)}$, and copper chromite $Cu_2Cr_2O_{5(s)}$ as three model Cr(III) solid phases, with pH varying between 6.0 and 8.5 and bromide concentrations varying between 0.1 and 5 mg/L. Results showed that as Cr(III) solids were oxidized by chlorine, Cr(VI) was generated rapidly in environmentally relevant time scale. Solution pH impacted the rate of oxidation, with an increase in pH moderately enhancing Cr(VI) formation. Furthermore, the presence of bromide acted as an electron shuttle and catalyzed the formation of Cr(VI) by at least one order of magnitude. The formation of Cr(VI) in bromide-containing water could be problematic considering t One manuscript is currently under preparation for submission to *Environmental Science and Technology* he wide existence of bromide in groundwater sources.

2. One manuscript is currently under preparation for submission to *Environmental Science and Technology*.

3. Chromium(VI), known as hexavalent chromium, is a highly toxic and soluble compound that has been widely observed in groundwater across California. A new drinking water standard specific to chromium(VI) was recently proposed by the California Department of Public Health. The proposed low drinking water standard for chromium(VI) is estimated to pose great challenges for water systems to upgrade treatment approaches to meet the regulation. This research project is advancing the mechanistic understanding of chromium(VI) conversion and formation pathways from water resources to treated drinking water, specifically by residual disinfectants and corrosion scales in water distribution systems. The research will enable the optimal design of treatment strategies and accurate prediction of treatment performance for chromium(VI) removal.

INFORMATION TRANSFER PROGRAM:

Summary of the research project objectives and findings have been published on the website of California Institute of Water Resources (http://ciwr.ucanr.edu/CIWR_Making_a_difference/Completed_projects/Minimizing_Hexavalent_Chromium_in_Californian_Water_/)

Assessing Environmental Justice Impacts and Social Learning of Integrated Regional Water Management Planning

Basic Information

Title:	Assessing Environmental Justice Impacts and Social Learning of Integrated Regional Water Management Planning
Project Number:	2014CA325B
Start Date:	3/1/2014
End Date:	2/28/2016
Funding Source:	104B
Congressional District:	44
Research Category:	Social Sciences
Focus Category:	Management and Planning, None, None
Descriptors:	None
Principal Investigators:	Jonathon London

Publications

There are no publications.

RESEARCH PROGRAM:

Throughout California, the provision of unsafe and unaffordable water is an everyday reality in many disadvantaged communities (DACs). Given that many water quality problems are concentrated in small, rural systems that lack economies of scale to solve their drinking water problems, California policy makers have acknowledged the need to address challenges on a *regional* basis. Here, the field of Integrated Regional Water Management (IRWM) holds much promise. But, until recently, IRWM venues have been inaccessible to DACs. To remedy these problems, the California Department of Water Resources (DWR) funded 7 pilot projects to develop models for improving participation and addressing the water needs of DACs. Our study, Assessing Environmental Justice Impacts and Social Learning of Integrated Regional Water Management Planning asks:

1) How effective were the seven pilot projects in achieving (a) improved participation of DACs, and (b) IRWM plans that include provisions to ensure improved access to drinking water in DACs?, and
2) Did the IRWM plans demonstrate evidence of social learning, and in what ways did this learning lead to improved inclusion?

Four key objectives will allow us to answer these questions:

1) Conduct an evaluation of the 7 pilots
2) Measure and compare the degree to which social learning contributed to environmental justice goals.
3) Produce publications on lessons learned.
4) Report results at a convening.

As proposed, in our first year of this project, we sought to accomplish objectives 1 and 2. To do so, we first convened a research advisory group, consisting of key leaders from the 7 DAC pilot projects, and research colleagues at CSU Fresno. Our evaluation of the 7 pilots used semi-structured interview guides to gather data. We interviewed key stakeholders involved in the DAC pilot projects, including 4 broad groups: 1) IRWM group leaders, 2) pilot project leads (e.g. consultants or lead agencies), 3) Department of Water Resources agency staff, and 4) environmental justice/IRWM leaders across the state. In each region we conducted approximately 4-10 interviews (we have not completed all interviews in the North Coast and Santa Cruz regions because these projects only recently finished). Each interview has been/will be analyzed alongside final DAC pilot project reports for assessments of social learning. While we anticipated implementing a survey tool as well, we decided against this approach as each region had such divergent project goals and approaches. Following a "collaborative research model", an additional opportunity emerged this year that we added to our approach and methodology. In particular, Dr. Balazs convened a "Disadvantaged Community" panel at the American Water Resources Association summer specialty conference on IRWM. As a result of this panel, project leads from 4 different IRWM regions jointly developed the idea for developing a convening workshop to further discuss pilot project findings. This "Visioning Workshop" took place in December and brought together project leads and IRWM group leaders from all 7 pilot regions, alongside representatives from the California Department of Water Resources (DWR) and the State Water Resources Control Board. Both Dr. London and Dr. Balazs attended this workshop, and used it as a moment for participant observation (in addition to an applied research/collaborative research venue). As our original objective was to hold a "convening workshop", we concentrated our efforts on this critical convening in Year 1, rather than Year 2.

Extending Balazs and Lubell's (2014) previously developed social learning framework our preliminary analysis explores the role and potential of IRWM to address water justice governance. In particular, we trace three dynamics at play: multi-level water governance, the institutionalization of environmental justice,

and the role of new constituencies (i.e. DACs) and related boundary-crossing relationships in water management. We (preliminarily) find unprecedented participation of environmental justice communities in regions with strong social capital, resulting in a shift of the dominant water planning discourses and moderate incorporation of some DAC needs. And yet, our cases underscore that the extent to which IRWM can fundamentally address root causes of water inequities and change power dynamics, even in strong learning environments, remains in question.

Our project is significant in at least two main ways. First, the process of our research, as well as the very results of our analysis has already resulted in statewide learning of the success, challenges and learnings from each Pilot Project. In summarizing lessons for the December Visioning workshop we helped contribute to policy-level action and learning (see broader impacts below). At the same time, in our current drafting of our research results we aim to contribute to the literature on environmental justice regional water planning, and IRWM.

(Workshop Recommendations) Drew, M., Alpert, H., Skaags, A., Beutler, L., Balazs, C., Bailey, C., Antos, M. 2014. Disadvantaged Communities Visioning Workshop December 3-5, 2014. http://inyo-monowater.org/2015/02/an-investment-to-help-disadvantaged-communities-pays-off-2/ (note: these conference proceedings are one piece of data being analyzed in the research project)

(Conference Presentation) Balazs, C. Environmental justice in Integrated Regional Water Management: The Case of Upper Kings. *American Water Resources Association Summer Specialty Conference in IWRM, July, 2014.*

INFORMATION TRANSFER PROGRAM:

As stated in our original proposal, our research project is based in a collaborative research model where "community" partnerships form a central part of the research enterprise. In particular, we sought to align our research objectives with policy relevant outcomes, and engage relevant members of the IRWM or environmental justice "community" at large. In this vein, our information transfer activities had two components. The first was to convene an informal research advisory group at the beginning of the project to receive input on study design and approach. While we originally anticipated more constant communication with this advisory group, the December Visioning Workshop took more of our attention, and proved to be a more useful format for engaging with relevant environmental justice groups and state agencies. As such, we decided to place less emphasis on the research advisory group, and to include a final research call with our original advisory group, in Year 2, as the project reaches completion (e.g. potentially in December 2015).

As described above, Dr. Balazs was one of the principal conveners and steering committee members for the Disadvantaged Community Visioning Workshop that was held in Calistoga, CA in December 2014. This three-day workshop convened in included participation of regional project leaders, and representatives of the CA Department of Water Resources and the State Water Resources Control Board. Through a collaborative process, the group identified 7 core recommendations: Disadvantaged Community Identification, Coordination, Agency Alignment, Capacity Building and Technical Assistance, Education, Disproportionate Impacts, Governance and Representation, and Funding. These recommendations are inter-related and ultimately present a vision for a more effective, equitable and accessible roadmap to meeting the water needs of disadvantaged communities. While each can be treated as a "stand-alone" recommendation, the document is organized in a way that recommendations build on each other (e.g. "Funding" describes needs for all previous recommendations). In January 2015, these recommendations were compiled into a set of recommendations that was circulated to the Department of Water Resources, and has since formed the basis for new changes and approaches within the IRWM division.

(Workshop Recommendations) Drew, M., Alpert, H., Skaags, A., Beutler, L., Balazs, C., Bailey, C., Antos, M. 2014. Disadvantaged Communities Visioning Workshop December 3-5, 2014. http://inyo-monowater.org/2015/02/an-investment-to-help-disadvantaged-communities-pays-off-2/

Characterizing the Impact of Salton Sea Water Management and Restoration Practices on Regional Air Quality

Basic Information

Title:	Characterizing the Impact of Salton Sea Water Management and Restoration Practices on Regional Air Quality
Project Number:	2015CA335B
Start Date:	3/1/2015
End Date:	2/28/2017
Funding Source:	104B
Congressional District:	41st
Research Category:	Climate and Hydrologic Processes
Focus Category:	Water Quality, Toxic Substances, Water Use
Descriptors:	None
Principal Investigators:	Roya Bahreini

Publication

1. Frie, Alexander; Justin Dingle; Samantha Ying; Roya Bahreini; Nov. 2015, “Elemental Composition and Pb Isotope Determination in Aerosols, Desert Soils, and Playa at the Salton Sea”, Poster Presentation at The International Symposium on Persistent Toxic Substances, UC- Riverside.

RESEARCH PROGRAM:

Aerosol samples at Salton City and Bombay Beach were collected by a MOUDI sampler, which collects and separates particulate matter by size into 11 stages, between 18 µm and 0.056 µm. In order to capture the difference in daily wind patterns, aerosol samples were collected in two sets: a daytime set between 08:00 to 18:00 and a nighttime set between 19:00 to 07:00. Blank filters were also collected at each site. Pre and post sampling, filters were kept in acid-washed petri dishes and stored individually in anti-static bags.

During year 1, a subset of filters were digested with HF, HCl, and HNO_3 to enable total metal analysis (e.g., Rauret 1998, Chen and Ma 2001). Filters from two size bins were placed inside a 6 ml Teflon vial. Next, 2.5 ml of HNO_3 and 0.5 ml of concentrated HF were added to the vial, and the closed vial was placed on a hot plate at 145-150 °C in a HEPA-filtered micro cleanroom under negative pressure for 15 hours. The vial was then uncapped and heated at 130 °C until only ~0.5ml of liquid remained. To assure total digestion of trace metals, next 0.6 ml of concentrated HNO_3 and 1.8 ml of concentrated HCL were added to the vial. The closed vial was again heated on a hot plate at 145-150 °C for 15 hours. The vial was then uncapped and heated at 130 °C until only ~0.5ml of liquid remained. Finally, 2 ml of 5% HNO_3 was added to the solution. For accurate mass determination of the metals, the exact solution volume was determined by weighing the vial, and the solution was transferred into an acid- cleaned 4ml HDPE bottle. During ICP-MS method development experiments, co-digestions and subsequent analysis were also performed on a USGS G-2 reference and NIST Pb SRM 981 standards. Digests were analyzed by ICP-MS for total Ca, Na, As, Al, Cr, Cu, Fe, Mn, Ni, Zn, V, Ba, Cd, Co, Se, Sn, Ti, K, Th and for Pb^{206}, Pb^{207}, and Pb^{208} isotopes. Stability of the ICP-MS instrument was monitored and it was realized that to eliminate the effect of other geological samples analyzed on the instrument on its background and to improve stability of the instrument for lead isotope measurements, it is best to analyze summer and winter samples from Salton Sea at once. Therefore, specific results from the summertime filters are not available at this time.

Soil samples were collected at 23 locations on the Salton Sea playa or in the surrounding area. Permits and/or permission were obtained from California State Parks, The US Fish and Wildlife Service, and the Imperial Irrigation District. At each site 7-10 samples at a depth 0-2 cm were collected, resulting in 111 samples of arid soil and 46 samples of playa. Where appropriate, 3 depth samples at 40-100cm below the surface were also collected. Soil samples were dried at 22°C while exposed to room air and stored in plastic bags. Soil samples were pulverized by a mortar and pestle and sieved to 50 mm. To examine trace metal content variability of all the soil samples, samples were prepared for analysis on an Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) instrument. Total of 1g of each sample was exposed to 10 ml of 3M HCl and shaken for 16 hours. Samples were then centrifuged, filtered through a 2 µm membrane, and diluted in ultrapure water. Extracts were analyzed by ICP-OES for acid extractable Ca, Na, As, Al, Cr, Cu, Fe, Mn, Ni, Zn, V, Ba, Cd, Co, Se, Sn, Si, Ti, K, and Pb.

Mean and median sodium, calcium, and potassium concentration of the playa samples were significantly higher than those of arid soil while lead and barium content of the playa were less than the arid soils; other elements showed comparable values (e.g., Figure 3). A subset of soil and playa samples will also be analyzed by ICP-MS for more direct comparisons with the total trace metal content of the aerosol filter samples.

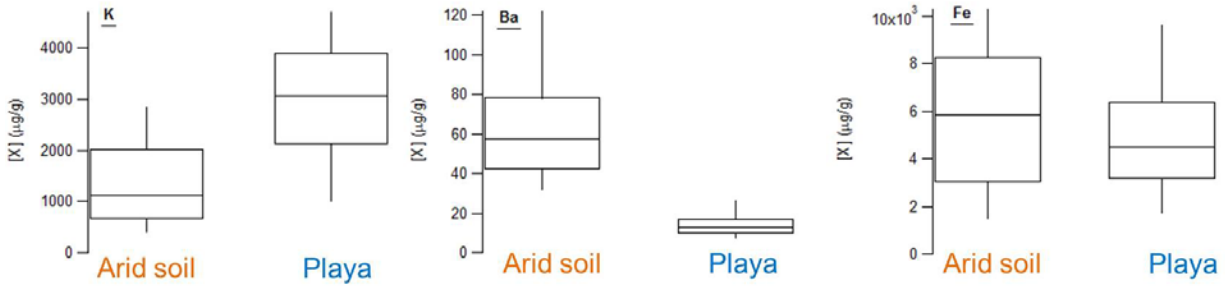

Figure 3. Statistical analysis of elemental content of potassium (K), barium (Ba), and iron (Fe) in arid soil and playa samples as analyzed by ICP-OES. Box and whiskers represent 10th, 25th, 50th , 75th, and 90th percentile values.

INFORMATION TRANSFER/OUTREACH PROGRAM:

Poster Presentation at The International Symposium on Persistent Toxic Substances by Alexander Frie: “Elemental Composition and Pb Isotope Determination in Aerosols, Desert Soils, and Playa at the Salton Sea”, UC- Riverside, Nov. 2015.

Monitoring tree survival and performance in street-side stormwater management facilities

Basic Information

Title:	Monitoring tree survival and performance in street-side stormwater management facilities
Project Number:	2015CA336B
Start Date:	3/1/2015
End Date:	2/28/2017
Funding Source:	104B
Congressional District:	14th
Research Category:	Water Quality
Focus Category:	Wastewater, Treatment, Ecology
Descriptors:	None
Principal Investigators:	Igor Lacan

Publication

1. Lacan, Igor. 2015. Stormwater Trees: Tree growth and condition in street-side bioswales Poster presented at the 2015 UC Agriculture and Natural Resources Joint Strategic Initiatives Conference, Sacramento, California.

RESEARCH PROGRAM:

Street-side bioswales planted with vegetation that often includes ornamental trees are becoming increasingly common, yet little is known about survival, growth, and health of those trees. Should trees be excluded from these facilities over concerns about their condition, as has been proposed by some municipalities, the sustainability of urban areas would be impacted. This project evaluates tree survival, growth, and condition in stormwater facilities, with street trees of the same species and comparable age used as controls, and with the city of Portland, OR (>10 years experience) serving as a long-term comparison for three cities in the San Francisco Bay Area (Berkeley, San Jose, El Cerrito; 0-4 years experience). In addition to measuring trees and rating their condition, I am using datalogging soil moisture sensors to monitor soil conditions – thought to be a major limitation to trees in bioswales – focusing on the potential for either excessive or insufficient soil water content.

A typical small bioswale (with trees), with stormwater flow paths outlined in blue (San Jose).

Installing soil moisture sensors in a bioswale, & connecting them to a datalogger (Portland).

INFORMATION TRANSFER/OUTREACH PROGRAM:

- Formal outreach: poster at the 2015 ANR Joint Strategic Initiative Conference
- Informal outreach: I discuss the project with municipal staff at every event where I am speaking; I have thus managed to sign up additional study partners.
- Plans for 2016: website section with the draft monitoring protocol posted for comment and revision; formal presentation of results to the Bay Area Landscape Supervisors Forum (Dec. 2016); “Bioswales and you” presentation to the UC Master Gardener programs (pilot in San Mateo Counties, then expand to Santa Clara, Alameda, Contra Costa, and Marin Counties)

Metagenomic Analysis of Groundwater Wells for Risk Assessment and Development of Intervention Strategies to Improve Water Efficacy

Basic Information

Title:	Metagenomic Analysis of Groundwater Wells for Risk Assessment and Development of Intervention Strategies to Improve Water Efficacy
Project Number:	2015CA337B
Start Date:	3/1/2015
End Date:	2/28/2017
Funding Source:	104B
Congressional District:	18th
Research Category:	Biological Sciences
Focus Category:	Groundwater, Toxic Substances, Methods
Descriptors:	None
Principal Investigators:	Clarissa Noble

Publications

There are no publications.

RESEARCH PROGRAM:

Methodology Improvements: We have revised our field and lab methodologies to make sample collection more feasible in challenging field conditions. Sustained access to wells has proven to be challenging, and we need to be able to obtain a rapid collection of samples upon well access. We have retooled our protocols so that the hands-on time at a well has decreased from roughly 3 hours to 10 minutes. We have also developed a better understanding of the pass-through volumes required for samples from low-turbidity supply wells. Untrained personnel who are familiar with wellhead operation can now complete the sample collection, and the risk of airborne contamination is greatly reduced. The development of these protocols allows more flexibility as the filter cartridges can be mailed between the project investigators (rather than requiring lab-trained personnel to be present and the field site for all sampling).

Sample Collection: Our simpler capsule-filter based sample collection method is allowing streamlined sampling in a wider variety of conditions with significantly less time. Our previous method was optimized to collect a very wide size range of biological material from small viruses up to large eukaryotic cell aggregates and provided very high quality samples. However, this method was based on a kidney dialysis rig, which required extensive field equipment, sterilization of many parts, and roughly 3 hours of intensive labor per sample. Thus, the method was limited in that few samples could be collected in a given day. The new sample collection method requires very little labor, costs roughly the same amount per sample, and delivers biological material that meets our requirements. The method uses a disposable 0.2 µm flow-through filter that attaches to the well pump outflow fitting. The filter stays in place unattended until it clogs with material, which can take anywhere from 1 to 24 hours depending on the clarity of the water. In this way, many wells can be set up for sampling in a day and then the filters retrieved later. Because the filter cartridges are based on industry-standard technology, personnel unfamiliar with the project can collect samples for us (without providing us direct access to the field sites). And because the filter cartridges are small and sealed, there is little risk of air contamination. To date, we have collected capsule filters from 18 wells, and have scrapings of biofilm materials from inside two of those wells. We were able to collect soil samples during the drilling and installation of one well to document an initial pre-well condition. These samples document a range of aquifer conditions ranging from high-capacity municipal supply wells in shallow alluvial sediments with abundant organic material (and persistent fouling problems) to monitoring wells in deep basalt aquifers. We are currently scheduled to collect soil samples and an initial capsule filter sample during drilling and initial testing of a new supply well in mid-May. We are actively pursuing additional opportunities to sample during well installation, well redevelopment, and to acquire additional samples at select wells over time.

Sample Extraction: We have developed protocols to recover biological material from the filter cartridges, including cartridge deconstruction and membrane recovery, sample lysis, and DNA/RNA purification. Cartridge deconstruction and membrane recovery are

labor intensive, so 12 filter cartridges can be processed comfortably in a day, which means we can now process a complete sequencing run in roughly a week.

Dry Lab Bioinformatics Analysis Progress: Since we are ultimately interested in discovering molecular mechanisms of well biofouling so that we can develop strategies to combat it, we are using whole metagenome sequencing. This approach gives us sequence information on all of the genomes found within a water sample. Thus we can identify specific genes that are associated with biofouling in specific well conditions. To this end, we have been building our analysis pipeline to best utilize the whole metagenome data that our lab work produces. First, we have optimized our assembly pipeline. Second, we have improved our genomic binning (assigning assembled contigs to genomes) pipeline to use a combination of automated and manual curating. Finally, we have begun using an improved functional annotation pipeline (ClusterFinder) that predicts operons rather than just gene functions.

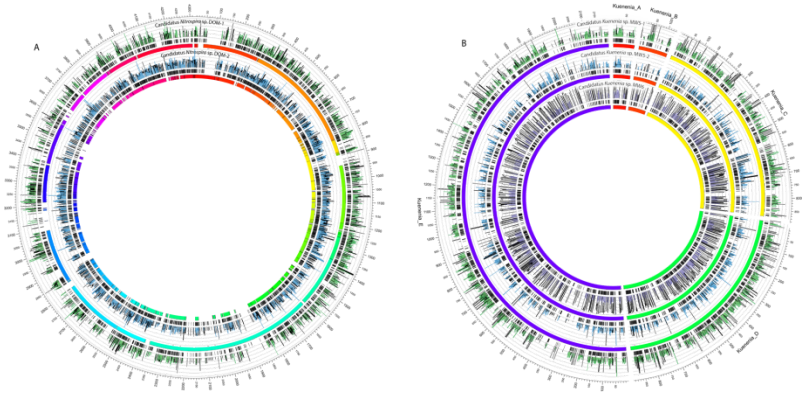

Figure 1 – Synteny and homology in the Nitrospira and Kuenenia genomic bins. Circle plots showing the Nitrospira and Kuenenia genomic bins mapped to their respective reference genomes. (A) Plot showing homology to Candidatus Nitrospira defluvii reference genome. Colored bars indicate homology (0-100%), black bars indicate depth of coverage (0-100x), and colored blocks indicate locally collinear blocks as determined. The outer genome is Nitrospira sp. DOM-1, and the inner genome is Nitrospira sp. DOM-2. (B) Plot showing homology to the Candidatus Kuenenia stuttgartiensis reference genome. Colored bars indicate homology (0-100% nucleotide identity), black bars indicate depth of coverage (0-100x), and colored blocks indicate locally collinear blocks as determined by Mauve. The outer-most genome is Kuenenia sp. MW5-1, the middle genome is Kuenenia sp. MW5-2, and the inner-most genome is Kuenenia sp. MW6.

Metagenomic Assembly and Binning Pipeline: We now use IDBA_UD (iterated DeBruijn graph assembler for uneven depth of sequence coverage) to assemble contigs from the raw sequencing reads. This step generates a wide range of contig sizes based mostly on the depth of coverage. We use REAPR to check that the assembled contigs are valid and break contigs where misassemblies are detected. We next assign these contigs to genomic bins using a combination of kmer frequency distribution-based methods: CONCOCT (automated), VizBin (manual), and ESOM (manual). We then use custom scripts to validate the bins. Finally, we extend the assemblies using PRICE targeted assembly, which extends and joins many of the contigs in the genomic bins. Overall, this improved pipeline generates much cleaner results with fewer contigs assigned incorrectly to bins. Using pilot data, we have been able to distinguish strain-level variation between genomes in individual samples (e.g. we discovered two new Nitrospira-related denitrifier genomes and three new Kuenenia-related anammox genomes in a Central Valley monitoring well; Figure 1).

Functional Prediction of Operons: We have begun using the ClusterFinder module within the AntiSMASH framework to make predictions of secondary metabolite gene clusters in our genomic bins. This software predicts secondary metabolite operons using a Markov model based on clustering of similar function genes from validated

reference datasets. Annotation of the above-mentioned genomes revealed rich diversity of secondary metabolite biosynthetic clusters.

INFORMATION TRANSFER/OUTREACH PROGRAM:

We are continuing our outreach efforts to gain access to additional wells as this has been a challenge especially in the Central Valley region of California. Individuals we have consulted include Jason Gianquinto (General Manager of Semitropic Water Storage District), Armando Quintero (Executive Director of SNRI), Paula Landis (Executive Director of CA Water Commission), Steven Phillips and Claudia Faunt (USGS), Jim Strandberg (GRA), Chris Peterson (President of GEI Consultants), Thomas Harter and Rob Atwill (UC Davis).

Quantifying methylmercury loads from California rice fields

Basic Information

Title:	Quantifying methylmercury loads from California rice fields
Project Number:	2015CA338B
Start Date:	3/1/2015
End Date:	2/28/2017
Funding Source:	104B
Congressional District:	3rd
Research Category:	Water Quality
Focus Category:	Agriculture, Toxic Substances, Water Use
Descriptors:	None
Principal Investigators:	Bruce Linquist

Publications

1. Tanner, K. Christy, Lisamarie Windham-Myers, Jacob A. Fleck, Kenneth W Tate, Stephen McCord, Bruce Linquist. January 2016. Methylmercury Export From Rice: Field Scale Methylmercry Budgets for the Sacramento Valley. Poster presentation for Revisiting the 2003 Mercury Strategy for the Bay-Delta Ecosystem, Biogeochemistry Workshop.
2. Tanner, K. Christy, Lisamarie Windham-Myers, Jacob A. Fleck, Kenneth W Tate, Stephen McCord, Bruce Linquist. August 2015. A Methylmercury Budget for a Sacramento Valley Rice Field. Poster presentation for the Rice Experiment Station Rice Field Day.
3. Tanner, K. Christy, June 2015. Sacramento Valley Rice Field Mercury Studies, Oral presentation for the Delta Tributaries Mercury Council.

RESEARCH PROGRAM

Problem

Hg can undergo a number of chemical transformations in rice fields including methylation (the formation of MeHg by bacteria) and demethylation (the conversion of MeHg to inorganic Hg mediated by sunlight, bacteria, or reaction with sulfide). Additionally, MeHg may move between surface water, soil and plants, which determines how easily it is exported from the field. While MeHg is known to be produced in rice fields, the multitude of other processes affecting MeHg make it difficult to determine the overall export of rice field MeHg to downstream ecosystems. Research in the Delta and Yolo By-Pass suggest that rice systems are large sources of MeHg. However, most of the rice in California is not grown in this region and therefore research was need to quantify MeHg budgets in more "typical" rice systems.

Research objectives

- Develop a better understanding of Hg dynamics within Sacramento Valley Rice fields.
- Measure annual MeHg and THg budgets in Sacramento Valley Rice fields to determine if fields are sources or sinks.
- Track seasonal changes in MeHg import, export and storage within rice fields.

Methodology

The annual MeHg and THg budget was monitored in a Butte county field in May 2014 – March 2015 and a Yolo county field in April 2015 – February 2016. The fields differed in size, irrigation source water, water management, rice variety and soil Hg concentration, and represented the range of characteristics typical of California rice production. Both fields were managed by rice farmers for conventional rice production.

We measured water flow into and out of the fields. Water samples were collected regularly for MeHg, THg and a variety of other water quality parameters. Soil samples were collected four times annually at the end of each management period and analyzed for MeHg and THg as well as soil characteristics known to influence Hg transformations. Rice grain and straw was collected at harvest to measure MeHg storage within plants.

Principal findings

Preliminary results indicate that both fields were MeHg sinks during the growing season, but MeHg sources during the winter fallow period. Loads from these rice fields in the primary rice growing region of California were much lower than those reported from the Delta and Yolo By- Pass. Analysis of soil and plant samples is currently ongoing. Results of soil analysis will allow us to determine if seasonal differences were a result of changes in MeHg storage in the soil.

The fields differed in the overall level of Hg contamination in soil and irrigation water. The more contaminated field had both larger imports as well as exports of MeHg and THg throughout the year, but both fields had similar patterns of export.

INFORMATION TRANSFER/ OUTREACH PROGRAM

Results of this study were presented in two poster presentations to differing audiences. The first was to an audience of rice growers and industry professionals at the Rice Experiment Station Annual Field Day in August 2015. Secondly the research was presented at “Revisiting the 2003 Mercury Strategy for the Bay-Delta Ecosystem” a workshop that included researchers and government agency personnel. These findings will be critical as the state weighs potential water quality regulatory measures.

Assessing Environmental Justice Impacts and Social Learning of Integrated Regional Water Management Planning

Basic Information

Title:	Assessing Environmental Justice Impacts and Social Learning of Integrated Regional Water Management Planning
Project Number:	2015CA339B
Start Date:	3/1/2015
End Date:	2/28/2016
Funding Source:	104B
Congressional District:	3rd
Research Category:	Social Sciences
Focus Category:	Law, Institutions, and Policy, Management and Planning, Water Use
Descriptors:	None
Principal Investigators:	Jonathon London

Publications

1. Balazs C, Lubell M, London J. Social learning and environmental justice in the 'waterscape' of Integrated Regional Water Management. In Preparation. Journal TBD.
2. Lubell M and Balazs C. 2017. Adaptive Governance and Integrated Water Resources Management, in Ken Conca and Erika Weinthal, editors, Oxford Handbook of Water Politics and Policy, Oxford U. Press. [this book chapter references this research project]
3. July 2014: AWRA conference panel: Dr. Balazs convened and led a panel focused on environmental justice and IWRM, focusing on the 7 pilot projects. Four of the seven pilot regions participated in this panel. Networking from this event led to the development of the 3-Day Workshop focused on debriefing the pilot projects. Information on the conference can be found at: http://www.awra.org/meetings/Reno2014/
4. Balazs, C. Environmental justice in Integrated Regional Water Management: The Case of Upper Kings. American Water Resources Association Summer Specialty Conference in IWRM, July, 2014. This is the presentation given at the AWRA conference.
5. Balazs, C. December 2014. Common Themes in DAC Outreach Project Recommendations: A Preliminary Compilation of Recommendations from the Coachella, Greater Los Angeles County, Imperial, Inyo-Mono, Kings, North Coast and Santa Cruz Regions. A synthesis of the 7 pilot project's lessons learned was compiled by Dr. Balazs and used as a guiding document at the December workshop. This document is on-file with the investigators, if desired.
6. Balazs, C. Applying a Social Learning Framework to DWR's 7 Pilot Projects. DAC Visioning Workshop, Calistoga, CA. Presentation of the social learning framework and initial results for feedback at the 3-Day Workshop. This document is on-file with the investigators, if desired.
7. DAC Visioning Workshop Recommendations. January 2015. Calistoga, CA. This document consists of the recommendations coming out of the DAC Visioning Workshop. This document was circulated to Water Plan Update 2013 EJ/DAC Caucus. This final set of recommendations can be found at: http://inyo-monowater.org/wpcontent/uploads/2014/06/2014_DAC_Workshop_Recommendations_20150202_

8. Balazs C and Antos, M. April 2015. Blog Post for DAC Visioning Workshop. http://www.switzernetwork.org/grant-outcomes/disadvantaged-communities-visioning-workshop
9. February 2016: UC ANR wrote a blog on the research project: http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=20228

RESEARCH AND OUTREACH FINDINGS OVER LIFE OF THE PROJECT:

We applied a social learning framework alongside theoretical issues of water justice and the 'waterscape'. Our results highlight the important role that bridging organizations (i.e. those organizations that work across spatial and temporal boundaries) play, especially environmental justice non-profit organizations (NGOs), in catalyzing regional and statewide change. In pilot regions where there was a stronger existing network of NGOs, NGOs were able to catalyze institutional changes within IRWM to better accommodate the needs and demands of disadvantaged communities. These same organizations have played a pivotal role in influencing changes to statewide governance and policy platforms. At the same time, we found that a deep consideration of the historical context of each region (including the economic and political forces that shaped the inequities in access to resources such as drinking water) is necessary to understand the successes and failures of each pilot project. Our study is important because the literature on social learning and integrated water management has not sufficiently engaged with these concepts and therefore has not provided an adequate empirical to inform public policy.

The project has had a strong public outreach component (described below.) Based on these experiences, we have identified the importance of bringing together state actors (e.g. Department of Water Resources) alongside NGOs and community residents was critical for creating a space for reflection and collaboration.

Project outcomes, impacts and benefits

Our project resulted in several outcomes. In the applied/outreach realm, we helped develop a 3-day workshop that included state agency representatives (e.g. from the Dept. of Water Resources, the State Water Resources Control Board), academics, community groups and members from Integrated Regional Water Management (IRWM) Groups. This workshop provided very rich observational data for our fieldwork, but helped create a unique and valuable opportunity for collaboration and networking across sectors. We were able to present preliminary results from our research and analysis to this group and obtain input. In addition, the material we analyzed and presented became a bedrock for discussion at this workshop. We are currently in the process of finalizing a manuscript for submission to a Water Policy/Planning journal where our results will be highlighted. In the interim, DWR has asked that we present results from this research and use it to inform their future planning for IRWM. This emphasizes the unique nature of our research—that it has/seeks to impact both the academic literature, as well as the water planning sphere in California. As a whole, the findings of this research will not only help IRWM more adequately address DAC needs.

Photo of DAC Visioning Workshop. December, 2014. Balazs (First row, center) London (Back row, second from left).

RESEARCH PROGRAM:

- Brief research report, including problem, research objectives, methodology, and principal findings and their significance for your project.

Problem

Existing regional water planning efforts in California have seldom included adequate attention to the drinking water infrastructure needs of disadvantaged communities. To address this gap, the DWR implemented 7 pilot projects from 2011-2013. While these pilots offered the potential for providing crucial feedback to DWR, without an independent analysis such as ours, the successes, challenges, and lessons learned from this policy experiment would not have been documented and shared with policy and advocacy leaders.

Objectives

Our study sought to assess of how well these IRWM planning efforts addressed the needs of DACs through an assessment of the seven pilots. We asked:

1) How effective were the seven pilot projects in achieving (a) improved participation of DACs, and (b) IRWM plans that include provisions to ensure improved access to drinking water in DACs?, and
2) Did the IRWM plans demonstrate evidence of social learning, and in what ways did this learning lead to improved inclusion?

Methodology

We used and extended a social learning framework to track lessons learned and impacts of the pilots. Data was collected through semi-structured interviews with IRWM group members, community groups, pilot project team members, state representatives

working on IRWM and pilot project participants. We conducted participant observation at IRWM meetings, as well as regional workshops and IRWM conferences. Interviews were analyzed using nVivo software. We used a social learning framework developed in the field of Integrated Water Management and adapted by Balazs and Lubell (2014) to an environmental justice context was used to help track and assess findings and impacts.

Key Findings

We found that "bridging organizations" (i.e. those organizations that work across spatial and temporal boundaries), especially environmental justice NGOs, play a key role in catalyzing regional and statewide change in IRWM. In pilot regions where there was a stronger fabric of these NGOs, NGOs were able to catalyze institutional changes within existing IRWM to better accommodate the needs and demands of disadvantaged communities and address long-standing environmental justice issues. These same organizations have played a pivotal role in influencing changes to statewide governance and policy platforms. At the same time, we found that a deep consideration of the historical context of each region
(including the economic and political forces that shaped the inequities in access to resources such as drinking water) is necessary to understand the successes and failures of each pilot project. Our study is important because the literature on social learning and integrated water management has not sufficiently engaged with these concepts and therefore has not provided an adequate empirical to inform public policy.

Significance for our project

The findings of this work are significant for several reasons. First, our findings will contribute to the emergent literature on social learning and integrated water management by synthesizing these two fields and adding a key under-emphasized dimension—environmental justice(Sze and London 2008; Balazs and Ray 2014; Pahl-Wostl 2009; Pahl-Wostl et al. 2007). In addition, by drawing on literature and theories from political ecology (i.e. 'the waterscape' as articulated by (Perreault, Wraight, and Perreault 2012) we hope to further expand notions of how to conceptualize and analyze water justice in a water planning context. Second, our work made a significant impact in the policy and advocacy realm. The workshop/convening we helped support and convene and the dialogue with key stakeholders in the development, implementation and dissemination of the research led to key collaborations and learning Important relationships, both for us as researchers, and for participants attended emerged as a result.

- In section 7 below, provide citations* for any publications associated with the research project.

INFORMATION TRANSFER/OUTREACH PROGRAM:

- Brief description of the information transfer/outreach activities for your project.

Information transfer and outreach in relation to our project occurred at the following venues:

- A panel organized by Dr. Balazs on DACs, environmental justice and IRWM at an IRWM conference sponsored by the American Water Works Association
- The 3-Day Disadvantaged Communities Visioning Workshop was co-led and co-organized by Dr. Balazs and attended by both Dr. Balazs and Dr. London
- De-brief meetings with water justice NGOs and agency representatives from the Dept of Water Resources

Sorghum as a low-input crop for bioenergy, food and feed in California

Basic Information

Title:	Sorghum as a low-input crop for bioenergy, food and feed in California
Project Number:	2015CA340B
Start Date:	3/1/2015
End Date:	2/28/2016
Funding Source:	104B
Congressional District:	21st
Research Category:	Biological Sciences
Focus Category:	Agriculture, Water Use, Water Quantity
Descriptors:	None
Principal Investigators:	Jeffrey Dahlberg

Publications

There are no publications.

RESEARCH PROGRAM:

This project investigated sorghum as a low-input crop for the production of bioenergy, food and feed in California and had three broad goals: 1) to identify the best sorghum varieties for the production of bioenergy, food and feed in California, 2) conduct experiments to determine irrigation management responses and water use of forage and grain sorghum types in California, and 3) validation, calibration and implementation of crop production and economic models.

Results from the variety trial and water use research are being used to test the accuracy of the APSIM model (Agricultural Production Systems sIMulator) for predicting sorghum production and resource utilization (water, nutrients) in California production conditions. The model will then be used to determine how sorghum will behave under different irrigation and fertilization regimes, as well as under future climate scenarios.

Results:

Grain Evaluations: Strong genotype by environmental (GxE) interactions were observed in the three years of grain research over the locations; however, GxE was random and therefore cultivar evaluation was based on mean performance and stability across all environments. For the most part, grain yields were relatively stable, while R-0413 and KN8416 had yields slightly lower than the grand mean and were highly unstable across years and locations.

Forage Quality and Bioenergy Potential: Forage sorghum samples were taken at time of harvest from 4 locations around the state of California and analyzed for forage quality. This included research sites at UC Davis, WREC in Five Points, El Centro (DREC) and from two trials (early and late-planted crops) at KARE. NIRS was used to determine crude protein, ADF, aNDF, dNDF30, dNDF48 and TDN, among other quality parameters. NIRS involve grinding samples, scanning, managing calibrations, and doing wet chemistry to confirm the NIRS calibrations. Forage sorghums typically have crude protein values similar to corn, and ranged from 7.0 to 10.6 across the state. Crude protein (CP) ranged from 8.0% -10.2% for the late and early-planted trials, respectively, at KARE. Probably more important than CP is the fiber analysis and the fiber digestibility. Acid Detergent Fiber (ADF) ranged from 34.0%-42.1%, and amylose-Neutral Detergent Fiber (aNDF%) ranged from 57.0%-66.9% across locations. Thus, as a forage, sorghum is quite higher in fiber concentration than many forages, and somewhat higher than corn, but not corn stover. BMR (Brown Mid-rib) types of sorghum on average have higher digestibility than non-BMR sorghums, but it is important to note that there are large variations within a type. Further work on digestibility of the fiber fraction (since it's so high as a percentage of the dry matter), and the issues associated with quality for biofuel production are undergoing further analysis. Differences in analysis between silage-processed sorghum and sorghum samples analyzed directly from the field are on-going.

APSIM Modeling: The APSIM program is highly customizable and past CIMIS weather data (California Irrigation Management Information System; www.cimis.water.ca.gov/)

from each of our locations, soil characteristics, soil water and nutrient levels, and select dates and amounts for management operations, such as planting, irrigating, and fertilizing, have been uploaded to the model. Preliminary testing with the APSIM model has been positive, especially for grain sorghum. It has accurately predicted the grain yield and maturity date from one of our past trials and it is being evaluated on other years and locations to see if further modifications are needed. The sweet sorghum model has promise for predicting results for forage sorghum, but more testing needs to be done. It is possible to write code to more accurately describe the particular sorghum varieties used in our trials, and this is being explored.

INFORMATION TRANSFER/OUTREACH PROGRAM:

California has been dealing with severe drought over the last 4 years and this has impacted the dairy industry that has relied on heavily irrigated corn silage for their dairy feed. Currently 400,000 acres of silage are produced to support the dairy industry, which is predominately planted to corn silage and alfalfa in the summer months. Prior to our research efforts beginning in 2011, approximately 20,000 acres of sorghum silage were planted in the California according USDA-FSA data. In 2015 those acres were reported to be approximately 55,871. Our outreach and extension efforts have provided information to farmers in the Valley, who have looked for forage options that use less water and provide an alternative, high quality forage. This is reflected in the number of hits to the sorghum.ucanr.edu website, which have totaled over 6,000 since its launch in August 20, 2014.

We have been able to leverage this research into several new funded projects that build on some of the initial data and collaboration, which has allowed the UC sorghum group to expand into additional areas of drought and other research.

Improving forage crop water productivity through innovation irrigation management

Basic Information

Title:	Improving forage crop water productivity through innovation irrigation management
Project Number:	2015CA344B
Start Date:	3/1/2015
End Date:	2/28/2016
Funding Source:	104B
Congressional District:	3rd
Research Category:	Water Quality
Focus Category:	Irrigation, Agriculture, Water Use
Descriptors:	None
Principal Investigators:	Jeff Mitchell

Publications

There are no publications.

RESEARCH PROGRAM:

Results of this experiment indicate that if water stress occurs during the growing season, corn can show dramatic decreases in yield, compared to sorghum which showed greater resilience to water deficits. The numerically higher digestibility of BMR sorghum over conventional corn varieties support the finding that BMR sorghum can substitute conventional corn in dairy rations without a negative impact on milk production. Although a 20% water reduction in water resulted in significantly higher yields of conventional sorghum over BMR sorghum, thought must be given to the lower digestibility of conventional sorghum.

Currently, inclusions of starch-rich grains (such as corn) may be necessary to balance high sorghum forage diets for dairy production. If future genetic improvements were to lead to sorghum cultivars with increased starch content, sorghum might become more widely used. However, it is questionable as to whether high starch sorghums could match that of corn, and if the grain and starch yield of forage sorghum were to be increased, the plant's drought tolerance might decrease.

A third year of this experiment, should lead to more conclusive results. Additionally, if the sections with corn and sorghum were to be fully randomized so as to create a strip-plot configuration, the two species of crop could be compared and a statistical comparison could be made between corn and sorghum.

Further analysis should be done on quantifying the economic profitability of sorghum versus corn in order to provide a better understanding of the potential of sorghum as a substitute for corn in dairy systems. The cost and availability of water should be included in this analysis.

INFORMATION TRANSFER/OUTREACH PROGRAM:

Results and findings generated by this project have been and will be in the future widely disseminated. An MS student in Horticulture and Agronomy, Gerardo van den Hoek, at UC Davis was hired by the project and he successfully completed his degree based in part on this work. He has agreed to work with our project team during the 2016 season as we attempt to get a third year of data. The project was presented at annual meetings of the American Society of Agronomy in Long Beach, CA and in Minneapolis, MN in 2014 and 2015, respectively. Several other lesser formal presentations of the work in progress were made over the two years of the study at the field site to various groups.

Water Footprint, Productivity, and Wine Quality of Twenty Winegrape Cultivars Under Water Deficits in the San Joaquin Valley

Basic Information

Title:	Water Footprint, Productivity, and Wine Quality of Twenty Winegrape Cultivars Under Water Deficits in the San Joaquin Valley
Project Number:	2015CA345B
Start Date:	3/1/2015
End Date:	2/28/2016
Funding Source:	104B
Congressional District:	3rd
Research Category:	Biological Sciences
Focus Category:	Agriculture, Irrigation, Water Use
Descriptors:	None
Principal Investigators:	Larry Williams

Publications

There are no publications.

RESEARCH PROGRAM:

In recent years, deliveries of water for agricultural use in the San Joaquin Valley (SJV) have been reduced, or in some instances cut all together. Growers in the SJV would have the most potential to conserve water if the amount of irrigation water needed to produce a unit of product could be accurately measured.

Since 1980, the acreage of annual crops has decreased by 40%, while the acreage of perennial crops has increased 77%. Recent research has shown that perennial crops have a higher potential for water conservation. Also, it has been shown that yields do not decrease significantly under some levels of water stress. As trends in California agriculture shift away from traditional field crops, more detailed information is needed on the amount of water required to grow tree and vine crops.

Vineyards now account for nearly half of the total acreage of woody perennial crops. However, there is a lack of data detailing how much water is necessary to produce a ton of grapes. Similar in concept to the carbon footprint, the volume of water required to produce a ton of grapes is deemed the 'water footprint.' Knowledge of a vineyard's water footprint can help growers make better irrigation management decisions, effectively using less water to produce the same amount of fruit.

Our long-term goal is to identify red wine grape cultivars with lower water requirements than currently in production, and to develop irrigation requirements and strategies to minimize water use and maximize yield and quality for those cultivars. The overall objective we have for this project is to evaluate cultivar responses to water stress on a physiological level. It is our central hypothesis that cultivars respond differently to the same level and timing of water stress. We further hypothesize that wine quality to SJV can be improved through cultivar selection and water management.

The specific aims of this proposal are to:

1.) Impose water stress on various red wine grape cultivars and quantify blue water footprints of each cultivar.
2.) Measure physiological responses in vegetative and reproductive growth parameters.
3.) Make select wines to examine the effect of irrigation treatment and cultivar on wine quality.

This project addresses the need to generate detailed information on the amount of water to produce a specific agricultural product, and is pertinent to the California Institute of Water Resources' goal of developing science-based information on water issues. The outcomes of this research will be valuable in increasing knowledge of water use and fruit quality for specific cultivars, therefore allowing growers to apply a minimum amount of irrigation water to sustain profitable production levels.2

Methods: Vineyard Site and Cultivars

The study site is a 0.53 ha vineyard located at the Kearney Agricultural Research and Extension Center near Parlier, California (36° 48'N, 119° 30'W). The rootstock 1103P

was planted in June, 2003 and the Vitis vinifera L. scions grafted May, 2004 at 3.05 x 1.83 (row x vine) spacing, for a total of twenty rows, each 48 vines in length. The vines were cordon trained and spur pruned. Twenty cultivars were field grafted in a pattern of twelve vines per experimental plot with four replicates. Cultivars were blocked across rows. The plot layout is a randomized complete block and comprised of four replicates with twelve vines per experimental unit within each experimental plot (12 vines in length). The cultivars (and clones) are:

Aglianico – 03
Cabernet Sauvignon – 08
Carmenere – 02
Cinsaut – 02
Durif – 03
Freisa – 01
Grenache noir – 515
Malbec – 06
Montepulciano – 02
Petit Verdot – 400
Refosco – 03
Souzão – 01
Syrah – 07
Tannat – 474
Tempranillo – 02
Tinta Amarela – 01
Tinta Francisca – 01
Tinta Madeira – 01
Tinto Cão – 04
Touriga Nacional – 02

Irrigation Treatments

The irrigation treatments will consist of: A. Early Deficit (ED) = no applied water until veraison and then irrigated at 50% ETc; B. Late Deficit (LD) = irrigated at 100% of ETc through veraison and then no applied water; C. Sustained Deficit (SD) = irrigated at 50% of ETc throughout the growing season. These irrigation treatments were imposed during the 2013 growing season. These same treatments will be imposed during the 2014 and 2015 growing seasons. The vineyard will be drip irrigated using two, 2 L emitters per vine. Emitters will be plugged or unplugged to impose the irrigation treatments. Inline (in the drip line) water meters will be used to quantify applied water amounts for determination of blue water footprints. Vineyard ETc will be estimated using the following equation: ETc = ETo * Kc, where ETo is reference ET and Kc is the crop coefficient. Reference ET will be obtained from the CIMIS weather station located at KARE. Variables measured and calculations used to determine daily ETo can be found in Snyder and Pruitt (1992). The seasonal crop coefficients will be those developed in this vineyard across seven growing seasons (Williams, L.E., unpublished data).

Vine responses to water deficits
Midday leaf water potentials (ΨI) will be measured as described by Williams and Araujo (2002) at regular intervals throughout the growing season for each cultivar listed above as a function of irrigation treatment. Stomatal conductance (gs) will be measured using a LI-COR 1600 steady state diffusion porometer at the same time. Diurnal measurements of both water status parameters will be conducted at key phenological stages. Prior to budbreak in 2014, carbohydrate status of vines will be measured by sampling basal cane wood of the three middle vines in each four vine replicate and quantified according to the methods described in Chow and Landhausser (2004). Flower number measurements will be taken at flowering according to the methods described in Bennett et al. (2005). Canopy development will be evaluated by measurements of percent shaded area according to Williams and Ayars (2005). Leaf drop will be quantified by counting missing leaves along selected shoots, and correlated with carbohydrate status. Pruning weights will be taken during vine dormancy.

Fruit and wine responses to water deficits
Fruit will be sampled at pea size, veraison and harvest to determine berry growth responses to water deficits. Veraison timing will be determined by quantifying the fraction of clusters/vine and berries/cluster with color. Blue water footprint of each cultivar (m3 applied water/ton of fruit) will be calculated at harvest as a function of irrigation treatment. Yield components of cluster number, berry weight and berries per cluster will be determined. At harvest, berries will be sampled and soluble solids, titratable acidity, pH, Harbertson-Adams assay of anthocyanins and total phenolics measured. Small lot wines will be made of selected cultivars as a function of irrigation treatments on the UC-Davis campus. The wines will be analyzed by Harbertson-Adams assay for anthocyanins and total phenolics.5

INFORMATION TRANSFER/OUTREACH PROGRAM:

Anticipated outcomes and benefits
With increasing concern about the availability of water to SJV wine grape growers, more complete information is needed about the water use of different cultivars used in production viticulture. The experimental vineyard is established, well designed, and healthy. Irrigation regimes will be based in part on an estimated crop coefficient (Kc). Dr. Williams has been scheduling irrigations in this vineyard for the past seven years and has developed seasonal crop coefficients by measuring the amount of shaded area across cultivars and converting shaded area to a Kc using the technique developed by Williams and Ayars (2005). We have preliminary data that indicate a very high probability of success of finding cultivars with widely varying blue water footprints and responses to water deficits.

The three irrigation treatments to be utilized in this study were imposed last year (2013). Therefore, any carry-over effects of these treatments on the reproductive biology and carbohydrate status will be quantified the coming growing season. Yields were also measured last year as a function of both cultivar and irrigation treatment, and wines were made at the UC-Davis Pilot Winery. Initial data also show a wide range among

cultivars in the responses of berry growth (size) and sugar accumulation across irrigation treatment and color and tannins across cultivars. These data from one season indicate substantial differences among the cultivars in blue water footprint, vegetative growth, fruit growth, yield, and wine quality parameters. In the coming years, we hope to better elucidate the nature of the difference in drought response by cultivar. Ultimately, a tailored irrigation protocol will be developed per cultivar to maximize water use efficiency and wine quality in the San Joaquin Valley.

The Principal Investigators will disseminate the information obtained in this study by participating in grape industry meetings and those sponsored by the UC Cooperative Extension. It is anticipated that the results will also be published in the popular press and scientific journals such as Practical Vineyard and Winery and the American Journal of Enology and Viticulture.

Numerical Modeling of Local Intense Precipitation Processes

Basic Information

Title:	Numerical Modeling of Local Intense Precipitation Processes
Project Number:	2015CA368S
USGS Grant Number:	
Sponsoring Agency:	Nuclear Regulatory Commission
Start Date:	3/6/2015
End Date:	3/15/2016
Funding Source:	104S
Congressional District:	44
Research Category:	Climate and Hydrologic Processes
Focus Category:	Climatological Processes, Water Use, Water Quantity
Descriptors:	None
Principal Investigators:	Levent Kavvas

Publications

There are no publications.

RESEARCH PROGRAM

The objective of this project is to assess the suitability of a regional numerical weather model to simulate local intense precipitation processes, and then investigate the physical mechanisms of storm systems that lead to extreme precipitation by means of a regional numerical weather model. To achieve this objective, the performance of a selected regional numerical weather model by means of its application to an extreme mesoscale convective system and a tropical cyclonic storm are configured and evaluated, and then its performance in modeling extreme precipitation in these storm systems is judged by comparing the model results to detailed time-space observations. Then, the physical mechanisms of storm systems leading to local intense precipitation are investigated. After the numerical modeling validation for each of the historical extreme precipitation storm events, caused by MCS and TC storm systems, that are identified within the two model domains based on Stage IV data (January 1, 2002 - present), the precipitation fields will be maximized in the next stage of the project. During the reporting period, we found that the selected regional numerical weather model (Weather Research and Forecasting Model: WRF) is capable of simulating the selected local intense precipitation processes (MCSs and TCs) over continental USA.

Figure 1 presents the observed precipitation field in the simulation inner (nested) domain associated with Hurricane Frances (2004), while Figure 2 presents the simulated field. Figure 3 presents the observed precipitation field associated with a Mesoscale Convective System (2007), while Figure 4 presents the simulated field

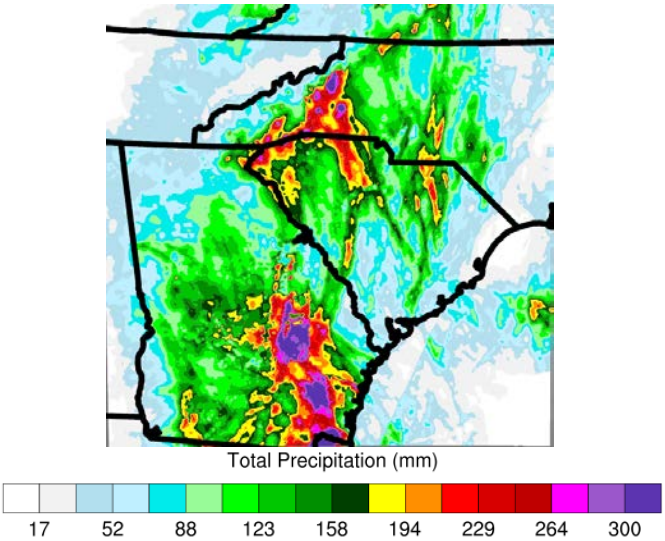

Figure 1: Observed precipitation field for Hurricane Frances (4-km resolution accumulated precipitation from 09/05/2004 12h to 09/09/2004 12h)

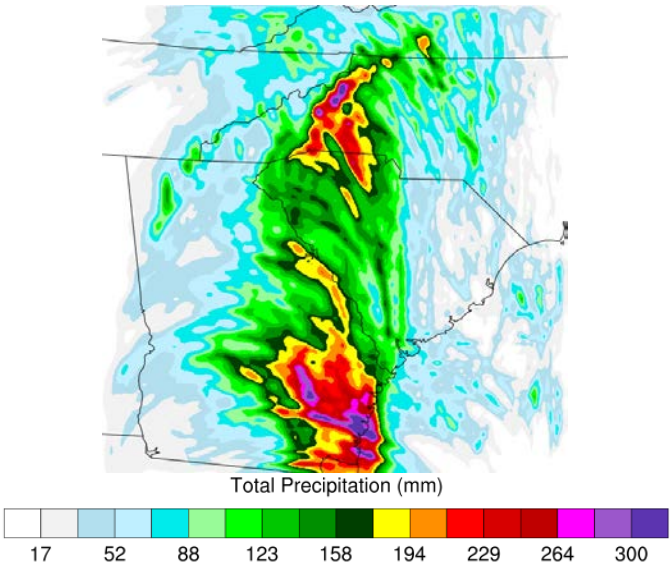

Figure 2: Simulated precipitation field for Hurricane Frances (5-km resolution accumulated precipitation from 09/05/2004 12h to 09/09/2004 12h)

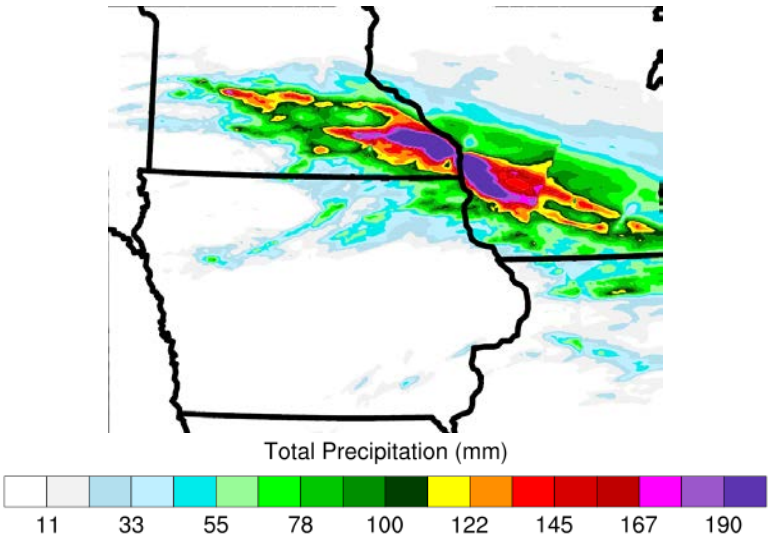

Figure 3: Observed precipitation field for the Mesoscale Convective System (4-km resolution accumulated precipitation from 08/18/2007 18h to 08/19/2007 18h)

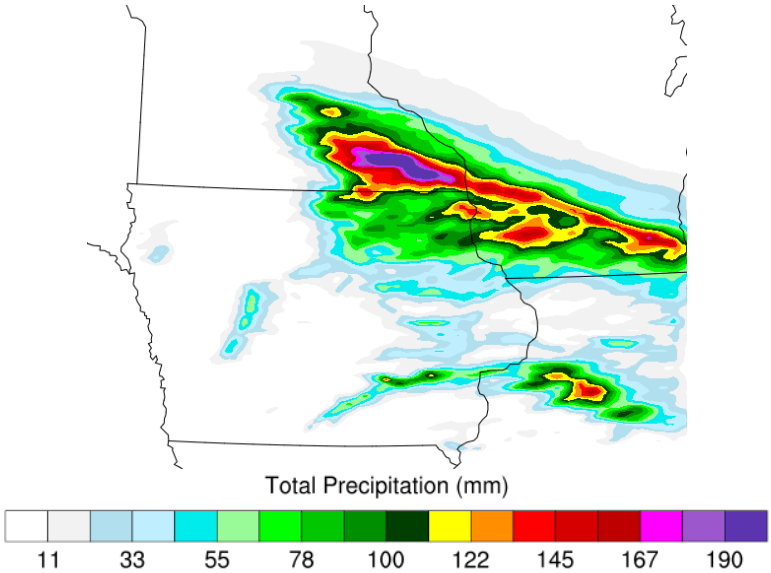

Figure 4: Simulated precipitation field for the Mesoscale Convective System (5-km resolution accumulated precipitation from 08/18/2007 18h to 08/19/2007 18h)

INFORMATION TRANSFER/OUTREACH PROGRAM

We gave presentations through the Internet several times to explain the methodology, the results, and the findings of this project to NRC. In addition, we attended the First Annual NRC PFHA Research Program Workshop in Maryland on October 14-15, 2015, and gave a presentation about the findings of the project.

Information Transfer Program Introduction

None.

USGS Summer Intern Program

None.

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	2	0	0	0	2
Masters	2	0	0	0	2
Ph.D.	3	0	0	0	3
Post-Doc.	3	0	0	0	3
Total	10	0	0	0	10

Notable Awards and Achievements

2015CA336B, Igor Lacan: I discovered that the concerns over trees in bioswales have become more widespread: San Francisco, for example, intentionally will not include trees in their new bioswales until 2017 (and I thus needed to replace them); Berkeley is not including trees in future bioswales. I secured three additional study partners: city of Berkeley (to replace San Francisco), City of San Carlos, and City of Burlingame. I secured an additional grant, which has allowed me to expand this study in scope and in duration: from USDA Forest Service via the National Urban and Community Forestry Advisory Council (NUCFAC). The new grant has allowed me to expand the number of study sites in the original partner cities, and to equip with soil moisture sensors the bioswales in the new partner cities, as well as to extend data collection for an additional year. Please note that the two grants are completely separate (sites, equipment, my time, etc.) and that the NIWR grant is not in any way used for the matching requirements in the NUCFAC grant. Preliminary results from the soil moisture sensors suggest that excessive water is not likely to be a problem (as the duration of waterlogged period is relatively short); however, water deficiency may be a problem: sensors at 30 cm depth indicate very low water content (

2015CA337B, Clarissa Nobile: Based on our findings from this grant, we received a UC Academic Senate Faculty Research Grant to further expand our sampling efforts to include wells outside of California.

2015CA338B, Bruce Linquist: We have quantified MeHg loads from rice fields that are typical of the California rice growing region. This is a first for this region. While rice systems do represent a source of MeHg loads to surface waters, these loads are much lower than previously thought based on data from the Yolo By-Pass and Delta rice growing areas.

2015CA339B, Jonathan London - Carolina Balazs: The major collaboration that resulted from this work was a multi-party collaboration between water justice NGOs, IRWM group leaders of the 7 pilot projects, the two investigators from this project and state agency representatives at the 3-Day Workshop. To implement this workshop we leveraged this funding, and used it to help obtain additional funding ($5,000 from the Grassroots Exchange Fund, $12,500 from the Robert and Patricia Switzer Foundation, and $1500 from The California Wellness Foundation) to support the workshop and related expenses. Media coverage included a blogpost by ANR staff as well as coverage of the workshop results in California Water News and the list-serve for the California Water Plan Update. Results from the DAC Visioning Workshop were incorporated in discussions and planning documents of the IRWM Draft Strategic Plan.

2015CA344B, Jeff Mitchell: This study has provided a strictly-controlled, precision irrigation means for testing the impacts of water shortages on corn and sorghum production and forage quality. We await results from this third year before pronouncing robust findings.