# California Institute for Water Resources
# Annual Technical Report
# FY 2014

# 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 University of California's 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 may have affiliate faculty from ANR, the different UC 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 three competitive grants programs. We manage a Request for Proposals to allocate funds from our USGS 104b program and the Joseph G. Prosser Trust. 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.

Joseph G. Prosser Trust: The Irrigation Management Program, funded by the Joseph G. Prosser Trust, supports a broad spectrum of research related to crop irrigation management, focusing on conserving water, improving irrigation efficiency, and optimizing yields. Emphasis is placed on research outputs that improve current practices and on dissemination of information.

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.”

2014 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 2014. 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 2014 WRRA (contingent on funding). We supported several new projects on topics ranging from fracking to stormwater to groundwater – all major 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 3000 followers.

Nitrates in groundwater: Building on our 2013 work, we held three additional trainings for over 300 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 and allowed the Advisors to meet the regulatory requirements to write and sign nutrient management plans. 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.

# Effect of forest management on water yields and other ecosystem services in Sierra Nevada forests

## Basic Information

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|---|---|
| **Title:** | Effect of forest management on water yields and other ecosystem services in Sierra Nevada forests |
| **Project Number:** | 2012CA292B |
| **Start Date:** | 1/1/2014 |
| **End Date:** | 12/31/2015 |
| **Funding Source:** | 104B |
| **Congressional District:** | 44 |
| **Research Category:** | Climate and Hydrologic Processes |
| **Focus Category:** | Ecology, Water Supply, None |
| **Descriptors:** | None |
| **Principal Investigators:** | Kevin O'Hara |

## Publications

There are no publications.

**Research Program**

The Sierra Nevada harbors globally distinctive forest resources that deliver a wide variety of benefits to the citizens of California and elsewhere. These benefits derived from natural ecosystems – also called ecosystem services – include recreation, biodiversity-, conservation, water, and forest product-related services. These ecosystem services often pose competing aims relative to forest management, but there are few mechanisms to evaluate the tradeoffs and complements related to different strategies.

Water is arguably the highest-value ecosystem service associated with the conifer forests of California's Sierra Nevada. Yet the provision of this essential service is vulnerable to changes in the energy and water balance associated with climate warming. To date, we have observed more precipitation falling as rain versus snow, earlier snowmelt, and greater summer water deficits. Such climate forcing will impact the water balance for the foreseeable future. However there is the potential to manage the water balance in forest ecosystems. The dominant vegetation (i.e., trees) is highly productive, forms dense canopies, and consequently, uses a great deal of water. There is a strong positive correlation between annual net primary productivity (the ultimate measure of the photosynthetic capacity of the ecosystem) and evapotranspiration (the primary cause of water loss). Any manipulation that reduces the productivity (i.e., removes trees) reduces evapotranspiration, shifts the balance of energy driving snowmelt, and thus may affect soil-water storage and streamflow. Water from the Sierra Nevada provides both hydropower and water supply to downstream users. Reducing and restructuring the forest vegetation density can also mitigate the negative impacts of wildfires as well as accomplishing important forest-restoration.

*Project Objectives*

1. Determine rates of evapotranspiration in Sierran mixed-conifer/true fir forests;
2. Determine the water use efficiency of trees and shrubs in Sierran mixed-conifer/true fir forests;
3. Determine the potential for forest management to delay snow melt in Sierran forests;
4. Determine the potential economic tradeoffs of forest management treatments to affect water yield and ecosystem services; and
5. Involve stakeholders in decision-making regarding forest management and watershed effects.

*Summary of Activities/Outcomes to Date*

This long-term project has completed two years of field work and is active in outreach and site selection for future work. This involves four areas:

1) developing leaf area prediction equations for Sierra Nevada conifers. This work is complete and we now have a set of equations for both prediction of leaf area on intensive research plots and for leaf area prediction from inventory data;

2) we have placed sensors in streams in control and burned areas, as well as in areas scheduled for future forest vegetation treatments to develop streamflow and stream temperature records. We have also placed soil-moisture, temperature, humidity, snow-depth and solar radiation sensors in strategic locations to develop spatial estimates of these quantities (Figure 1). We have initiated hydrologic modeling to estimate the effects of forest vegetation treatments on the water cycle in mixed-conifer mountain forests. This modeling involves extensive analysis of field data and calibration of spatially explicit models using snow, soil moisture and streamflow data. The scales of modeling extend from 300-10,000 ac scale (Figure 2). The initial modeling is being leveraged from ongoing work in the study area.

3) involvement of stakeholder groups through newsletters and a social media presence: http://ucanr.edu/sites/cff/Sierra_Nevada_Watershed_Ecosystem_Enhancement_Project/Newsletters_204/;

4) we have narrowed our search for field implementation sites to two areas on the Tahoe and Stanislaus National Forests. It is possible both areas will be used. Additionally, a private forest products company, Sierra Pacific Industries, has approaches us about installing similar studies on several of their watersheds.

We continue to anticipate that this work will provide new insights into the effects of forest structure on snow retention and water yields from Sierra Nevada mixed-conifer forests. The region continues to experience controversy over wildlife management, threats from fire, and water shortages are becoming a greater threat as we understand more about potential climate change in California. This work is as timely as when it was first proposed.

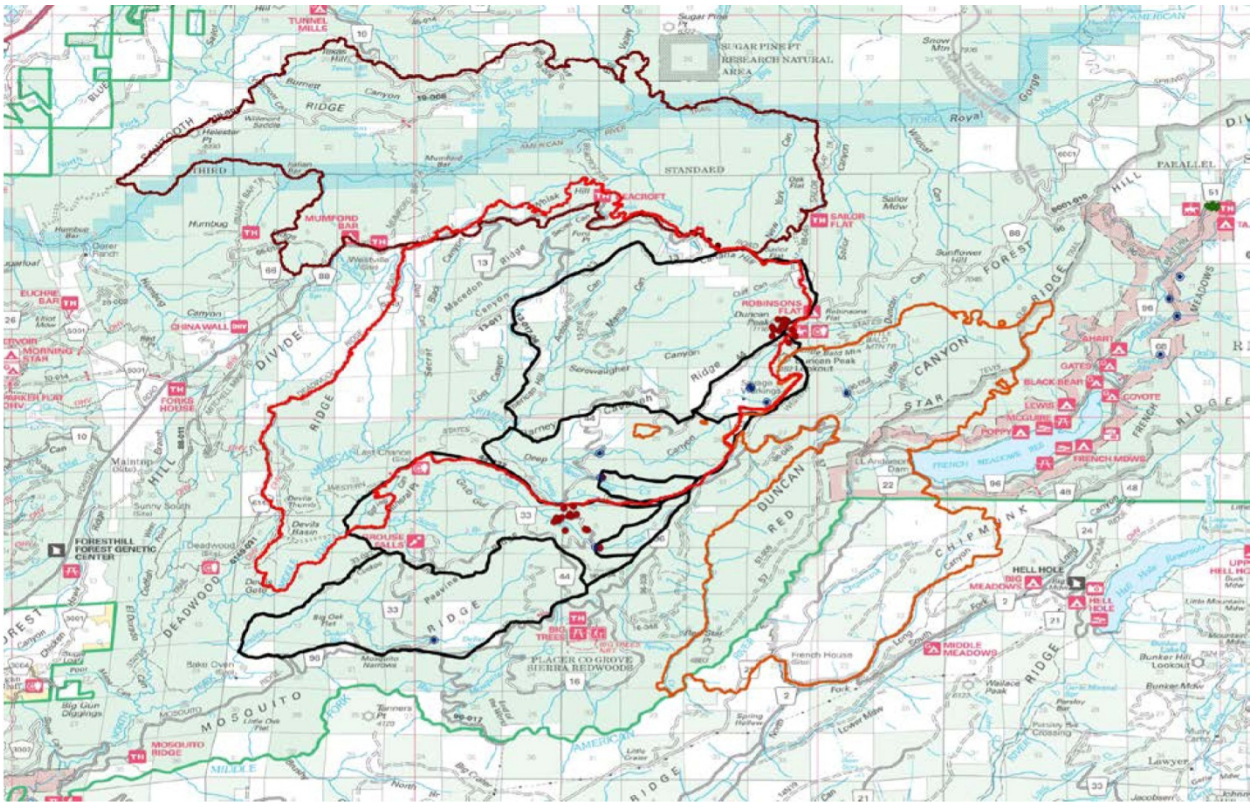


Figure 1. Map showing perimeters of watersheds and fires. Red dots are locations of snow, temperature and soil moisture sensors. Blue circles are stream level sensors.

Figure 2. Watershed surrounding unnamed steam in El Dorado County, California.

**Information Transfer Program**

We have developed an annual newsletter that is posted on our website: http://ucanr.edu/sites/cff/Sierra_Nevada_Watershed_Ecosystem_Enhancement_Project/Newsletters_204/?newslist=4051. We also have a mailing list for distribution of these newsletters as well as a social media presence.

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

## Basic Information

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|---|---|
| **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.

**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_/)

# Regulating the Social and Environmental Costs of Hydraulic Fracturing in California

## Basic Information

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|---|---|
| **Title:** | Regulating the Social and Environmental Costs of Hydraulic Fracturing in California |
| **Project Number:** | 2014CA323B |
| **Start Date:** | 3/1/2014 |
| **End Date:** | 2/28/2015 |
| **Funding Source:** | 104B |
| **Congressional District:** | 44 |
| **Research Category:** | Social Sciences |
| **Focus Category:** | Management and Planning, None, None |
| **Descriptors:** | None |
| **Principal Investigators:** | Brent M Haddad |

## Publications

There are no publications.

## RESEARCH PROGRAM:

California's Monterey and Santos shale, two underground formations located in the San Joaquin and Los Angeles basins, respectively, collectively cover 1,752 square miles and contain approximately 13.7 billion barrels of oil, more than 50% of the nation's total estimated recoverable resources (U.S. Energy Information Administration, 2013). While this extensive resource has the potential to provide substantial benefits, expanded development of unconventional oil and gas production (i.e., hydraulic fracturing) could require dramatic changes in the quantity and quality of water available for other uses, posing significant environmental and socioeconomic risks in California (Bryner, 2003; Carter, 2010; Schindler & Donahue, 2006).

We have undertaken a review and synthesis of existing literature to assess:
**1.** The possible impacts of expanded use of hydraulic fracturing in California on the state's water resource users,

**2.** The legal and institutional mechanisms that currently exist to identify, regulate, and mitigate those impacts and

**3.** Possible future government and community action to balance the needs of the environment, existing water users, and the newly expanded energy development sector.

We are also completing a series of structured interviews that specifically address:
**1.** Which government agencies and stakeholders will be engaged in the development of regulatory policies for hydraulic fracturing in the state,

**2.** How these institutions may be used to manage hydraulic fracturing activities to prevent significant impacts to protected salmonid species, critical habitat, and agricultural users, and

**3.** Areas in which institutional capacity may be inadequate to address hydraulic fracturing impacts to water resources.

There is a small, but growing, literature on the impacts of unconventional oil and gas development and possible regulatory approaches. However, much of this effort is focused on relatively water-rich areas, such as the eastern United States, and therefore does not address some critically important features of water use that are present in California (Kuwayama, Olmstead and Krupnick, 2013). We are highlighting four related aspects of water use that are unique to California and would be significantly affected by expanded use of hydraulic fracturing in the state.

**First**, shale formations that hold the most promise for energy development are located in areas with protected fish species. The quantity and quality of instream flow in these areas is a factor that currently limits the ability of threatened and endangered fish species to recover.
**Second**, with few exceptions, water in California is fully appropriated by existing users. Unconventional oil and gas technology requires large amounts of water and would therefore require re-allocation of existing water rights. This re-allocation will likely affect agricultural users and rural communities. Irrigators in the state are currently constrained not only by water availability in a semi-arid climate, but also by the need for water in meeting environmental goals.

**Third**, because of the unique water delivery system in California, localized water use in the southern San Joaquin Valley has the potential to affect patterns of water use and environmental outcomes in other parts of the state, such as the Sacramento-San Joaquin Delta (Delta). Fourth, there is evidence that hydraulic fracturing may degrade the quality of groundwater and surface water. Therefore, even if issues surrounding allocation of water are resolved, possible water quality impacts could mean that less water is functionally available for environmental protection and irrigation.

## Methods:

Our work is proceeding in two phases:
**First**, we are analyzing existing literature from the physical, biological and social sciences to assess the possible impacts of expanded use of hydraulic fracturing in California on the state's water resource users.
**Second**, we are conducting a series of structured interviews with stakeholders likely to be affected by an expansion in hydraulic fracturing in California. To review how various scientific communities are studying the impacts of hydraulic fracturing to water resources management and protected species, we are reviewing and conducting a content analysis of relevant scientific articles. An interdisciplinary review of the literature is revealing the primary mechanisms by which the stakeholders in California are likely to be impacted by hydraulic fracturing, and clarifying the specific links between hydraulic fracturing and potential impacts to protected fish species, water use in the agricultural sector, the spatial distribution of water use, and water quality in the state.
We are also undertaking archival and secondary research as well as structured interviews with scientists and policymakers in state and federal institutions that are likely to be engaged in scientific and public policy discussions regarding hydraulic fracturing in California.

We are focusing on regional and state institutions from the administrative and regulatory community, such as the State Water Resources Control Board and the California Department of Fish and Wildlife, as well as water management institutions, such as the Department of Water Resources. We are also investigating national policymaking bodies, such as the Bureau of Reclamation and U.S. Fish and Wildlife Service to evaluate their structures and procedures regarding water quality, water supply management and the protection of threatened and endangered species in the context of hydraulic fracturing in California. We are conducting structured interviews with individuals within the administrative and regulatory agencies, as well as key water management stakeholders in the Central Valley. The interviews are designed to identify the government agencies and stakeholders that are likely to be engaged in the development of policies for regulating hydraulic fracturing, and the obstacles and institutional barriers that these actors are likely to encounter when attempting to fit their environmental, economic and political agendas into the development of policies designed to regulate hydraulic fracturing in California, and assess the extent to which existing policies and regulation within their respective agency can be applied to water management issues related to hydraulic fracturing.

**INFORMATION TRANSFER PROGRAM:**

Our research will lead to a better understanding of the potential impacts that shale oil and gas development will have on California water users and the environment. Our research will provide a detailed assessment of the legal and institutional framework by which hydraulic fracturing is likely to be regulated in the state. This project will benefit policymakers as well as environmental and economic stakeholders by establishing clear linkages between hydraulic fracturing and impacts to water resources in California and providing critical information for decision-making and policy development.

Our synthesis of the potential impacts of hydraulic fracturing to California's water resources will be presented in the California Institute for Water Resources' report series, as well as academic conferences, and the findings of the study will be submitted to relevant peer review journals for publication. Additionally, the findings of potential impacts to environmental and agricultural water users in California will be summarized into policy briefs, which will be distributed to appropriate entities and made available to interested stakeholders upon request.

# Balancing salmon populations, aquatic biodiversity, and water resource needs during drought in coastal California

## Basic Information

| | |
|---|---|
| **Title:** | Balancing salmon populations, aquatic biodiversity, and water resource needs during drought in coastal California |
| **Project Number:** | 2014CA324B |
| **Start Date:** | 3/1/2014 |
| **End Date:** | 2/28/2015 |
| **Funding Source:** | 104B |
| **Congressional District:** | 44 |
| **Research Category:** | Biological Sciences |
| **Focus Category:** | Conservation, Drought, Climatological Processes |
| **Descriptors:** | None |
| **Principal Investigators:** | Stephanie Carlson |

## Publications

There are no publications.

**RESEARCH PROGRAM:**

One of the most pressing challenges in the 21st century will be to balance societal needs for freshwater with the maintenance of aquatic biodiversity in the face of climate change. Water withdrawals and climate change pose especially grave threats to stream biodiversity in arid regions, like the western US. How much water is needed to sustain biodiversity is an open question. Such knowledge gaps hamper our ability to design and evaluate the ecological benefits of innovative water conservation projects that strive to balance competing demands for freshwater. The CIWR seed funds are contributing to the development of a research program to identify flow thresholds for sustaining biodiversity during drought, which will be a major step towards providing managers and policy makers with flow targets to support aquatic biodiversity through seasonal and multi-year drought.

Our efforts to date have involved several reconnaissance trips to our focal watershed (the Pine Gulch Creek basin in Marin County) to identify potential study sites. Following these trips, we selected 15 study reaches in the basin in summer 2014, including 8 reaches on tributaries (all with intermittent flow) and 7 sites on the mainstem of Pine Gulch Creek (all with perennial flow). In fall 2014, we deployed flow-state (wet/dry) and temperature remote data loggers at all eight tributary study reaches and at two perennial study reaches on the mainstem of Pine Gulch Creek. These flow-state sensors are the latest technology for measuring flow-state in small, intermittent streams. During summer 2015, we will begin our field campaign to characterize the biotic communities throughout the Pine Gulch Basin (including at the aforementioned 15 reaches) while also recording a suite of abiotic characters. Our aim is to collect abiotic and biotic data throughout the watershed, from the smallest intermittent tributaries to the mainstem of Pine Gulch Creek. Such a field campaign requires a large survey team, and we have leveraged the CIWR funds to secure additional funding to support the continuation of this project, including a Smith Postdoctoral Fellowship to Dr. Michael Bogan, who is leading the field effort. Once the biological data is in hand, we plan to use a recently developed statistical approach (CART regression) to identify flow thresholds for sustaining aquatic biodiversity, including imperiled salmonids, during drought.

During this time period, we have also been advancing related work using data collected from the John West Fork, an intermittent stream that flows into Olema Creek in Marin County. One product from this work is a newly accepted paper (Bogan et al. In Press) describing the incredible aquatic biodiversity found in small coastal intermittent streams. As an example, from the John West Fork alone, we have documented four vertebrate species (including two imperiled salmonid fishes) and >160 aquatic invertebrate taxa.

Our sampling program thus focuses both on raising the awareness of the biodiversity value of small intermittent streams and working towards approaches for balancing societal and ecosystem demands for freshwater to conserve biodiversity through drought.

Bogan, Michael T., Jason L. Hwan, and Stephanie M. Carlson. In Press. High aquatic biodiversity in an intermittent coastal headwater stream at Golden Gate National Recreation Area, California. Northwest Science 89: xxx-xxx.

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

## Basic Information

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|---|---|
| **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/

# Evaluation of Surface Water Quality on Soil Leaching Fraction and Alfalfa Yield in the Delta

## Basic Information

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|---|---|
| **Title:** | Evaluation of Surface Water Quality on Soil Leaching Fraction and Alfalfa Yield in the Delta |
| **Project Number:** | 2014CA326B |
| **Start Date:** | 3/1/2014 |
| **End Date:** | 2/28/2015 |
| **Funding Source:** | 104B |
| **Congressional District:** | 44 |
| **Research Category:** | Water Quality |
| **Focus Category:** | Agriculture, Nutrients, None |
| **Descriptors:** | None |
| **Principal Investigators:** | Michelle LeinfelderMiles |

## Publications


1. Leinfelder-Miles, Michelle. 2014. Evaluation of surface water quality on soil leaching fraction and alfalfa yield in the Sacramento-San Joaquin River Delta, in Third International Salinity Forum. Riverside, CA. p. 227-228.
2. Leinfelder-Miles, Michelle. 2014. Evaluation of surface water quality on the soil leaching fraction in the Delta. Field Notes Newsletter. University of California Cooperative Extension, San Joaquin County. Stockton, CA. p. 4-5. (http://cesanjoaquin.ucanr.edu/newsletters/Field_Notes_Newsletter51594.pdf)
3. Leinfelder-Miles, Michelle. 2014. Salinity management in alfalfa fields. California Dairy Newsletter. University of California Cooperative Extension, Stanislaus County. Modesto, CA. p. 3-4. (http://cestanislaus.ucanr.edu/newsletters/Dairy_Newsletter53385.pdf)
4. Leinfelder-Miles, Michelle. 2014. Salinity management in alfalfa fields. Dairy Herd Management. Vance Publishing Corporation. Lincolnshire, IL. (http://www.dairyherd.com/news/salinity-management-alfalfa-fields)
5. Leinfelder-Miles, Michelle. 2014. Soil salinity in Delta alfalfa fields. Farms.com. Farms.com Ltd. Ames, IA. (http://www.farms.com/Commentaries/soil-salinity-in-delta-alfalfa-fields-75918.aspx)
6. Leinfelder-Miles, Michelle. 2014. Soil salinity in Delta alfalfa fields. Alfalfa and Forage News Blog. University of California, Agriculture and Natural Resources. Davis, CA. (http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=13784)

## RESEARCH PROGRAM:

The Sacramento-San Joaquin River Delta is a unique agricultural region of California. While the region is named for its waterway configuration, the Delta is also unique for its fertile soils, and of the 738,000 total acres, approximately 500,000 acres are farmed. As the Delta Crops Resource Management Advisor for the University of California Division of Agriculture and Natural Resources (UC ANR), my role is to do research and outreach on topics of local concern. My program is shaped by themes of sustainable crop production and soil resource management. In that vein, I am evaluating the effect of surface water quality on soil salinity in Delta alfalfa fields. In 2012, alfalfa was the second most widely grown crop in the Delta at approximately 72,000 acres.

Delta farming is challenged by soil salinity, which can stress crops and reduce yields. In general, plants are stressed by saline conditions because they must expend more energy to take up water, leaving less energy for plant growth. This trade-off is challenging for alfalfa growers because the marketed crop is the vegetative growth, and extra energy to take up water reduces hay yields. To prevent this trade-off, Delta soils should be leached of salts by applying water in excess of that used by evapotranspiration, or the amount of water evaporated by the soil and transpired by the plant during photosynthesis. The leaching fraction is defined as the minimum fraction of the total applied water that must pass through the soil root zone to prevent a reduction in crop yield from excess salts.

Two factors establish the leaching fraction: the salt concentration of the applied water and the salt sensitivity of the crop. Alfalfa is moderately sensitive to salinity and is irrigated with surface water in the Delta; thus, the quality of surface water in the Delta affects growers' ability to leach salts. Currently, state water policy salinity standards for the south Delta – an area southwest of Stockton, CA – are set at levels meant to sustain agricultural yields, based on crop tolerances of salt-sensitive crops. Salinity levels, however, vary over space and time, and sometimes the salinity exceeds the standards.

The project was in its second year during the reporting period. The objective of the work was to gain knowledge on the current leaching fraction being achieved in south Delta alfalfa soils and update the state of knowledge on how surface water quality and rainfall affect the leaching fraction. Seven south Delta alfalfa fields were selected based on soil type and irrigation source water. Measured parameters included soil salinity in the spring and fall, groundwater salinity, surface water salinity with each irrigation, alfalfa yield, and winter rainfall over the 2014-15 season. Preliminary results show that salts are building in the soil during the irrigation season and winter rainfall is not adequate to leach salts. Changes in irrigation practices that lengthen the opportunity time for water to infiltrate could help leach salts during the irrigation season in soils with high sand content. In these soils, there is low risk for standing water and Phytophthora root infection. Many of the soils in the south Delta, however, have high clay content, and the risk of standing water and root infection impair growers' ability to leach salts with irrigation. Thus, a change in the surface water salinity standard that would increase salts in the irrigation water would be detrimental to growers' ability to farm alfalfa or other salt-sensitive crops. Anticipated outcomes of the proposed work will be to update the state of knowledge on the achievable leaching fraction, to inform future policy on south Delta salinity standards and assist growers with irrigation strategies for effective salinity management where possible.

## INFORMATION TRANSFER PROGRAM:

Information transfer has occurred through publications, presentations, and personal consultations. I wrote about the project for newsletters and online publications. Subscription statistics for the Field Notes Newsletter and the Alfalfa and Forage News Blog – two UC Agriculture and Natural Resources publications – illustrate the wide distribution of my writings. The Field Notes newsletter is published by UC Cooperative

Extension in San Joaquin County and reaches 1,787 people. The Alfalfa and Forage News Blog was visited, on average, over 3900 times per month during the reporting period. I also presented the work at the International Salinity Forum in Riverside, CA, the Kearney Agricultural Center Alfalfa and Forage Field in Parlier, CA, and the San Joaquin County and Delta Field Crops Meeting in Stockton, CA. At these venues, I communicated project findings to approximately 200 people.

Personal consultations have been an important means of information transfer. I engaged in frequent conversations with the seven grower cooperators to discuss protocols and findings. Additionally, I communicated with other growers, crop consultants, non-government organizations and government agencies, including the South Delta Water Agency and the State Water Resources Control Board.

# 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:** | 2014CA327B |
| **Start Date:** | 3/1/2014 |
| **End Date:** | 2/28/2015 |
| **Funding Source:** | 104B |
| **Congressional District:** | 44 |
| **Research Category:** | Biological Sciences |
| **Focus Category:** | Agriculture, Economics, None |
| **Descriptors:** | None |
| **Principal Investigators:** | Jeffrey Dahlberg |

## Publication

1. Monk, R., C. Franks, and J. Dahlberg. 2014. Sorghum. p. 293-310. In S. Smith, B. Diers, J. Specht, and B. Carver (eds.) Yield gains in major U.S. field crops. CSSA Spec. Publ. 33. ASA, CSSA, and SSSA, Madison, WI. pp. 293-310.

## RESEARCH PROGRAM:

Replicated field trials of sorghum have been planted throughout the State at various ANR Research Centers and at UC Davis. These were aimed at evaluating grain and forage sorghum's potential as an alternative cropping system that would provide greater water savings and a wide range of end-use products that could enhance farming systems throughout California. The project has three broad goals.

**Goal 1**: Identify the best sorghum varieties for the production of feed, bioenergy and food in California. First-year data has been analyzed for agronomic characteristics, forage quality, and potential for biomass conversion. The second year of variety trials for both forage and grain types of sorghum were planted in four locations (five trials) across the State. The locations were UC-ANR Desert REC, UC-ANR Westside REC, UC-ANR KARE, and UC Davis. Two planting dates are being tested at KARE, while one planting date is being evaluated at each of the other sites. A total of 3,840 replicated grain and forage plots were planted starting on May 7, 2014 with the last planting occurring on June 6, 2014. This is the second year of planting that is working to determine the following:

1. The optimal varieties of sorghum for feed, bioenergy and food in California, with the goals of identifying varieties performing the best at individual sites as well as any with better performance at multiple locations with different growing season conditions.
2. The average yield of each variety at each site and averaged across sites.
3. The performance of sorghum varieties in terms of productivity and suitability for feed, bioenergy and food.

**Goal 2**: Determine the irrigation scheme to optimize WUE. The second year of this experiment was planted in 2014 on June 16$^{th}$ at KARE and June 18$^{th}$ at Westside REC. Five irrigation treatments and three replications of each treatment have been set up for the experiment. Treatments from 2013 have been analyzed and we are beginning to collect data on the second planting of this particular experiment. The specific goals of these irrigation research projects are as follows.

1. Develop improved estimates of crop water use with grain and forage sorghum germplasm representing a range of types and maturity periods of potential interest to producers.
2. Identify yield and select quality component impacts of some deficit irrigation approaches that could be considered for California growers.

**Goal 3**: Validation, calibration and implementation of crop production and economic models.
Results from the variety trial and water use research will be used to test the accuracy of the Agricultural Production Systems SIMulator (APSIM) 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. We will begin to utilize the model later this year and begin validating the model, based upon two years of research data. Currently, the research is following the timeline outlined in the proposal and is currently on schedule.

## INFORMATION TRANSFER PROGRAM:

The project has established a California Sorghum web page that provides a local source of information on sorghum research taking place in California, but also highlights research from around the United States that could benefit producers here in the state. The website can be accessed at: http://sorghum.ucanr.edu. Several presentation were presented in 2014 based upon early research results from the project and earlier research.

- Talk presented at the California Dairy Quality Assurance Program on Drought, held in Modesto and Tulare on July 8-9, 2014 (link to PDF):
    - Dahlberg, J., Hutmacher, R., Wright, S., Keeley, M., Banuelos, G., Sievert, J., Rios, S. and Delgado, R. 2014. Deficit Irrigation of Corn and Sorghum.

- Talks presented at the "Irrigating Field Crops in a Water-Short year" meeting, held at the Tulare County Cooperative Extension office on March 21, 2014 (links to PDFs):
    - Dahlberg, J., Hutmacher, R., Wright, S., Keeley, M., Banuelos, Sivert, J., Rios, S. and Delgado, R. 2014. Forage sorghum varieties, yield and quality for California.
    - Hutmacher, B., Wright, S., Dahlberg, J., Keeley, M., Banuelos, G., Delgado, R. and Sivert, J. 2014. Sorghum Irrigation Management Evaluations 2009-2013.

# Soil Survey Decision Support Tools for Water Resource Sustainability and Agricultural Productivity

## Basic Information

| | |
|---|---|
| **Title:** | Soil Survey Decision Support Tools for Water Resource Sustainability and Agricultural Productivity |
| **Project Number:** | 2014CA330B |
| **Start Date:** | 3/1/2014 |
| **End Date:** | 2/28/2015 |
| **Funding Source:** | 104B |
| **Congressional District:** | 44 |
| **Research Category:** | Water Quality |
| **Focus Category:** | None, None, None |
| **Descriptors:** | None |
| **Principal Investigators:** | Anthony T. O-Geen |

## Publications


1. O'Geen et al., In Press. Soil suitability index identifies potential areas for groundwater banking on agricultural lands. California Agriculture
2. Brauer, N., J.J. Maynard, R.A. Dahlgren, A.T. O'Geen, 2015. Fate of nitrate in seepage from a restored wetland receiving agricultural tailwater. Ecological Engineering. 81:207-217.
3. Sharifi, A., L. Kalin, M.M. Hantush, R.A. Dahlgren, A.T. O'Geen, and J.J. Maynard. 2015. Capturing spatial variability of concentrations and reaction rates in wetland water and soil through model compartmentalization. Journal of Hydrologic Engineering. 10.1061/(ASCE)HE.1943-5584.0001196
4. Saal, Mathew, 2014, Repackaging Soil Survey into a Decision-Support Tool for Agricultural Groundwater Banking in California. Dept. of Land, Air and Water Resources, College of Agriculture and Environmental Sciences, University of California, Davis, CA, p. 1-36.
5. O'Geen, A.T. D.E. Beaudette, M. Walkinshaw 2015. Exploring Soil Survey Information With SoilWeb Apps. California Plant and Soil Conference. Fresno CA.
6. O'Geen, A.T. and M. Bianchi, 2015. Using wetlands to remove microbial pollutants from farm discharge water. UCANR publication #8512. ISBN-13:978-1-60107-890-2.

**RESEARCH PROGRAM:** Our project had three general objectives.

**Obj. 1**. Develop a suitability index for agricultural groundwater banking for the maintenance and protection of groundwater resources in CA: We developed an agricultural groundwater banking index for the Central Valley (Fig. 1). The intent was to identify soil landscapes and cropping systems that could be flooded to recharge aquifers at times of water excess, i.e. flood events. The index evaluates the suitability of the land for this practice based on hydrologic parameters of soil) and the susceptibility of permanent crops to standing water. Moreover, because the permeability of soils has been modified by deep tillage in many places, and this has not been documented by most soil surveys which collected information prior to deep tillage operations, we created a new "modified soils" GIS layer to account for this increase in groundwater recharge potential in the region.

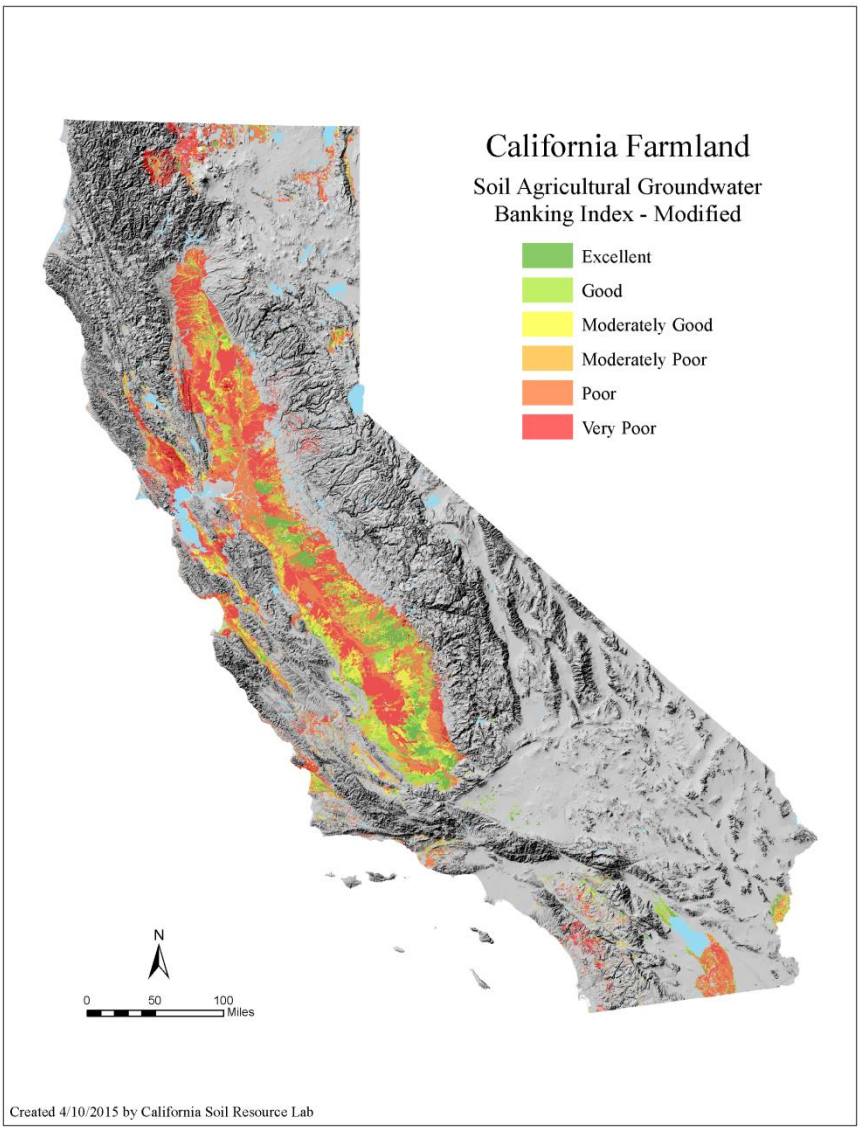


**Figure 1**. Map of soil agricultural groundwater banking index for agricultural land in California. This map considers soil's suitability to route water beyond the root zone rapidly without adverse effects on crops and groundwater quality.

Once completed, this product will serve as a guide for growers to make informed decisions about the potential for recharge and risks to crops associated with flooding their land. It may also serve as a regional guide to develop informed policy in relation to the protection of CA's groundwater supply. This work will be published in California Agriculture in July.

**Obj. 2**. Develop soil-landscape specific nutrient management guidelines and BMP placement tools

We worked to compile an exhaustive dataset of chemical and physical properties of soil. This dataset currently contains over 1000 soil samples where we have measured exchangeable K, K fixation, available P, and P sorption index and several soil characteristics (texture, pH, CEC, Extractable iron, echangeable cations). The conceptual model for the fate of K in soils is largely controlled by the type of parent material (presence of mica) and degree of soil development. The conceptual model for the fate of P in soils is a function of soil pH, extractable iron, clay content and calcium concentration. We have also started work on a data driven nitrate hazard leaching index that will describe the potential of every agricultural soil in CA to leach nitrate to groundwater. These conceptual models will create regional templates that inform nutrient management decisions relative to the propensity of soils to supply and retain nutrients. Once completed, this product will lead to more efficient nutrient management strategies and policies. It will ultimately result in more sustainable agricultural systems by creating place-based nutrient management strategies and BMP placement. Multiple field workshops have been held in the foothill region of central California to promote this effort.

We have also published several papers that focus on constructed and restored wetlands as best management practices to reduce nutrient runoff in irrigated agriculture. These studies evaluate the ability of wetlands to filter a wide range of contaminants in agriculture. Our published studies focused on the ability of these systems to remove pathogens and nitrogen. One study evaluated the hydrology of the system.

**Obj. 3**. Develop drought tolerance decision support tools.

With this objective we are building a geospatial database for rangelands in California. This database will be used to identify landscape susceptibility to drought. It will consider physiographic constraints such as soil's plant available water holding capacity, fertility of soils, climate, landform, aspect and land cover (fig. 2). This geospatial database will be used to feed and downscale the output of a remote sensing effort to predict forage productivity from estimates of evapotranspiration model driven by remote sensing data. The model of forage productivity scenarios will be run across various climate simulations.

The geospatial database will also be used to estimate erosion on rangelands under different climate scenarios and residual dry matter cover classes. We may also explore opportunities to document carbon sequestration potential in various terrains.

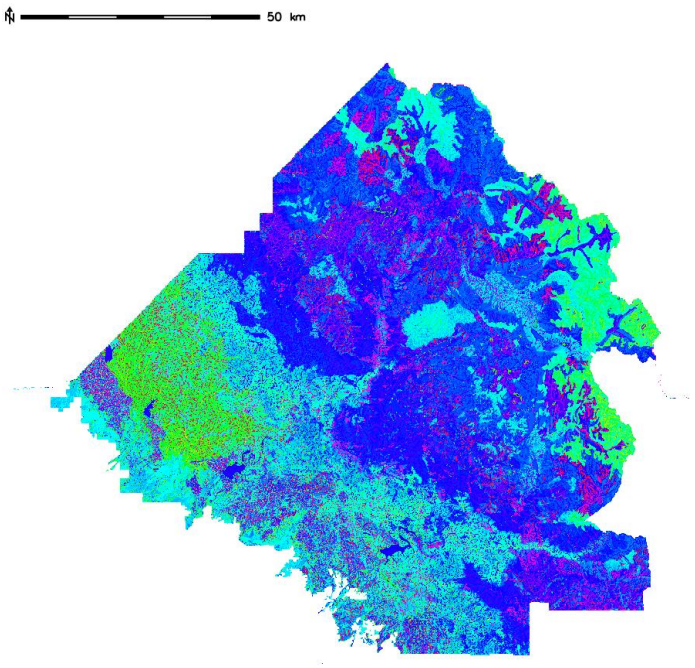


Figure 2. Map of landscape groups in Fresno and Madero Counties created by Partitioning Around Metoids (PAM). A clustering of physical attributes that influence forage productivity (solar radiation, soil water holding capacity, landform, mean annual precipitation, mean annual temperature, slope, soil organic carbon, and soil depth.

**INFORMATION TRANSFER PROGRAM:**

My information transfer program involves the communication of science via written, oral and internet based communications. During this reporting period I performed six presentations to stakeholder groups that pertained to objectives 1-3. During these presentations we discussed the systematic variability of soils, soil landscape relationships, decision support tools for water and nutrient management and soil informed management practices. These addressed stakeholders from viticulture, irrigated agriculture, rangeland and wild land management. Internet-based information delivery is also a major focus of my program.

We have created two new apps that compliment SoilWeb (http://casoilresource.lawr.ucdavis.edu/gmap/ ), our web based soil survey delivery mechanism from which most of our decision support tools are developed from. These new apps include an interactive map display of important soil properties (http://casoilresource.lawr.ucdavis.edu/ca-soil-properties/ ) and an app (Soil Series Extent Explorer) that displays the distribution of soils across the state: http://casoilresource.lawr.ucdavis.edu/see/ . These apps are widely used by clientele across the state and nation-wide. They are also critical development steps in the creation of online decision support tools that are currently under development.

# Effect of forest management on water yields and other ecosystem services in Sierra Nevada forests

## Basic Information

| | |
|---|---|
| **Title:** | Effect of forest management on water yields and other ecosystem services in Sierra Nevada forests |
| **Project Number:** | 2014CA331B |
| **Start Date:** | 3/1/2014 |
| **End Date:** | 2/28/2015 |
| **Funding Source:** | 104B |
| **Congressional District:** | 44 |
| **Research Category:** | Water Quality |
| **Focus Category:** | Climatological Processes, Ecology, Management and Planning |
| **Descriptors:** | None |
| **Principal Investigators:** | Kevin O'Hara |

## Publication

1. Jones, D.A., K.L. O'Hara, J.J. Battles, and R.F. Gersonde. Alternative procedures for leaf area estimation in Sierra Nevada conifer trees. Forests (in review).

## RESEARCH PROGRAM:

The Sierra Nevada harbors globally distinctive forest resources that deliver a wide variety of benefits to the citizens of California and elsewhere. These benefits derived from natural ecosystems – also called ecosystem services – include recreation, biodiversity-, conservation, water, and forest product-related services. These ecosystem services often pose competing aims relative to forest management, but there are few mechanisms to evaluate the tradeoffs and complements related to different strategies.

Water is arguably the highest-value ecosystem service associated with the conifer forests of California's Sierra Nevada. Yet the provision of this essential service is vulnerable to changes in the energy and water balance associated with climate warming. To date, we have observed more precipitation falling as rain versus snow, earlier snowmelt, and greater summer water deficits.
Such climate forcing will impact the water balance for the foreseeable future. However there is the potential to manage the water balance in forest ecosystems. The dominant vegetation (i.e., trees) is highly productive, forms dense canopies, and consequently, uses a great deal of water. There is a strong positive correlation between annual net primary productivity (the ultimate measure of the photosynthetic capacity of the ecosystem) and evapotranspiration (the primary cause of water loss). Any manipulation that reduces the productivity (i.e., removes trees) reduces evapotranspiration, shifts the balance of energy driving snowmelt, and thus may affect soil-water storage and streamflow. Water from the Sierra Nevada provides both hydropower and water supply to downstream users. Reducing and restructuring the forest vegetation density can also mitigate the negative impacts of wildfires as well as accomplishing important forest- restoration.

**Summary of Activities/Outcomes to Date**
This long-term project has completed three years of field work and is active in outreach and site selection for future work. This involves four areas:

1. Developing leaf area prediction equations for Sierra Nevada conifers. This work is complete and we now have a set of equations for both prediction of leaf area on intensive research plots and for leaf area prediction from inventory data. A manuscript is in review detailing this work;

2. We have placed sensors in streams in control and burned areas, as well as in areas scheduled for future forest vegetation treatments to develop streamflow and stream temperature records. We have also placed soil-moisture, temperature, humidity, snow-depth and solar radiation sensors in strategic locations to develop spatial estimates of these quantities. We have initiated hydrologic modeling to estimate the effects of forest vegetation treatments on the water cycle in mixed-conifer mountain forests. This modeling involves extensive analysis of field data and calibration of spatially explicit models using snow, soil moisture and streamflow data. The scales of modeling extend from 300-10,000 ac scale (Figure 1). The initial modeling is being leveraged from ongoing work in the study area;

3. Involvement of stakeholder groups through newsletters (two in 2014) and a social media presence: http://ucanr.edu/sites/cff/Sierra_Nevada_Watershed_Ecosystem_Enhancement_Project/Newsletters_204/;

4. Our search for sites for field implementation continues. There are two probable sites on the Tahoe and Stanislaus National Forests where planning is continuing. Only one of these sites is likely to be used. One site has more support from water agencies and the Nature Conservancy, whereas the other would provide a greater degree of control over our key variables because of one owner. We have also had major discussions and field visits with a private forest products company, Sierra Pacific Industries, about a parallel study on their ownership. Several sites have been identified and we are awaiting the outcome of the decision on Forest Service study sites.

We continue to anticipate that this work will provide new insights into the effects of forest structure on snow retention and water yields from Sierra Nevada mixed-conifer forests. The region continues to experience controversy over wildlife management, threats from fire, our ongoing drought, and water shortages are becoming a greater threat as we understand more about potential climate change in California. This work is as timely as when it was first proposed.

**Project Objectives**

- Determine rates of evapotranspiration in Sierran mixed-conifer/true fir forests;
- Determine the water use efficiency of trees and shrubs in Sierran mixed-conifer/true fir forests;
- Determine the potential for forest management to delay snow melt in Sierran forests;
- Determine the potential economic tradeoffs of forest management treatments to affect water yield and ecosystem services; and
- Involve stakeholders in decision-making regarding forest management and watershed effects.

**INFORMATION TRANSFER PROGRAM:**

We have developed an annual newsletter that is posted on our website: http://ucanr.edu/sites/cff/Sierra_Nevada_Watershed_Ecosystem_Enhancement_Project/Newsletters_204/?newslist=4051
We also have a mailing list for distribution of these newsletters as well as a social media presence. There are no publications yet to report.

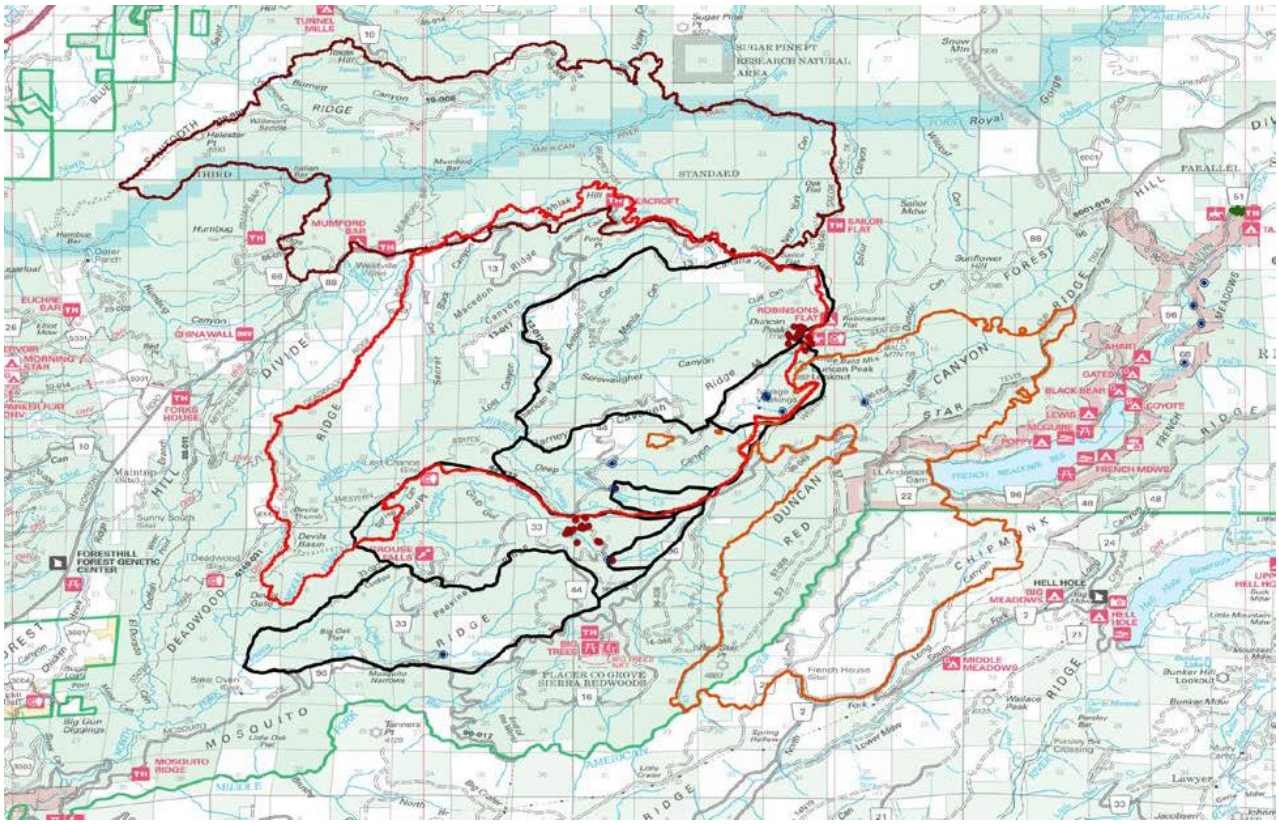

Figure 1. Map showing perimeters of watersheds and fires. Red dots are locations of snow, temperature and soil moisture sensors. Blue circles are stream level sensors.

Figure 2. Aerial view of managed forest land in the Sierra Nevada showing the treatment variation that may occur with a single small catchment.

# 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** | 5 | 0 | 0 | 0 | 5 |
| **Ph.D.** | 5 | 0 | 0 | 0 | 5 |
| **Post-Doc.** | 4 | 0 | 0 | 0 | 4 |
| **Total** | 16 | 0 | 0 | 0 | 16 |

# Notable Awards and Achievements

2014CA330B, O'Geen: SoilWeb and associated web-based apps have been highlighted in the Idaho Press Tribune, USDA-NRCS main web page, Home and Garden TV website, updates to congress by USDA, Beef Magazine, Farm Journal Magazine, Ag Weekly, and Water Citizen News. This funding was used to a leverage grant from the California Department of Food and Agriculture Fertilizer Research and Education Program. This grant will develop a data driven nitrate leaching hazard rating for all agricultural soils in California. It will also model the fate of nitrogen of different soil risk groups under different management practices.

2014CA325B, London-Balazs Key accomplishments in this first year included: •Completion and transcription of 31 interviews across the 7 regions •Convening by Dr. Balazs of a Disadvantaged Community panel at the AWRA Summer Specialty Conference on IRWM (July 2014). Dr. Balazs fundraised for 4 panel participants to have conference fees waived and travel reimbursed. •Dr. Balazs one of the conveners of the Disadvantaged Community Visioning Workshop held in December 2014. This workshop invited over 30 key leaders at the IRWM level, and state agency level to participate in a 3 day workshop on lessons learned from the pilot projects and develop a joint set of recommendations that were presented to the Department of Water Resources. •Broader impacts from the December Visioning Workshop: The recommendations provided by the workshop have been extremely significant in California. Overall, recommendations have impacted both pending and enacted legislation this year, and have been incorporated into the Strategic Plan for IRWM that DWR will be releasing in May or June 2015. One of the most significant recommendations was the need for the state to have a technical assistance capacity available to assist members of disadvantaged communities to develop projects that can be implemented. This recommendation was taken up by a State Assembly Member, and then was drawn into the emergency drought legislation that passed in April. What resulted was a new Center for Sustainable Water Solutions within the State Water Resources Control Board. A second piece of legislation, now being considered in the Assembly will set-up at least one "Center of Excellence" within the California State University to provide the technical assistance capacity. •Feb. 11, 2015 – "Water needs of disadvantaged communities addressed in list of recommendations"http://www.waterplan.water.ca.gov/docs/enews/2015/cwp_enews021115.pdf •Acceptance of abstract into Society and Natural Resources Special Issue on Water Governance

2014CA322B, Haizhou: One Graduate student who was supported by this project, Michelle Chebeir, won a honorable mention for best student poster presentation at the 3rd California Groundwater Association Annual Conference. Michelle Chebeir also won the prestigious NSF Graduate Research Fellowship as a result of this project.

2014CA324B, Carlson: Leveraged funding: Rose Hills Innovator Award, UC-Berkeley, 2014-16 ($135,000) to Stephanie M. Carlson Smith Postdoctoral Fellowship Award, 2014-16 to Dr. Michael Bogan.