

Special Drought Edition

The CSU system and its faculty understand the severity of California's drought and are working toward Governor Jerry Brown's request for a 20% water use reduction by 2020. The following pages (p. 25-37) highlight ways each individual CSU campus is combating the drought. In this Special Drought Edition, we present what each campus' faculty are working on through applied research, followed by what the campus' facilities are implementing.

We conclude this Special Drought Edition with a summary of all campus facilities departments' water reduction efforts (p. 38-39).

If we have missed anything that your campus is working on, please let us know, and we will keep this list updated online.

Thank you!



Effect of the drought on
Uvas Reservoir
Santa Clara, CA
Photo by Don DeBold
March 9, 2014

Multiple CSUs

Faculty Research:

- **David Zoldoske; davidzo@csufresno.edu; 559-278-2066**

Multiple CSUs received DWR's Proposition 50 Agricultural Water Use Efficiency Proposal Solicitation Package funding totaling \$1,168,136. This amounts to 25.6% of total rewards in Table B's various categories.

Bakersfield

Faculty Research:

- **Jan Gillespie; jgillespie@csub.edu; 661-654-3040**

Tracking the increase in groundwater salinity with depth in the various aquifers in the Kern County portion of the San Joaquin Valley, using salinity data from both oil and water wells in order to see how much potentially remediable groundwater exists (i.e. water that qualifies as a USDW under the EPA's definition).

Facilities:

- <http://www.csub.edu/bas/facilmgt/>

Completed projects and current practices include:

- Installation of 20 waterless urinals and flushing mechanisms.
- Renovated all plumbing fixtures (conversion to low flow).
- Rainbird Maxicom Irrigation System utilized.
- Common lawns grown to three inches to slow evaporation.
- Mulch/composting material placed around trees to retain moisture.
- Emergency repairs have all used low-use fixtures.

Short- and long-term projects and practices include:

- Installation of reduced flow shower heads in Athletics, low flow tech in Art Center Building and New Housing, and additional waterless urinals.
- Review pool and chiller plant maintenance practices.
- Slow watering practices (aside from specific areas such as sports fields and Children's Center).
- Monitor watering schedule using Maxicom (less total water) and reduce watering July/Aug.
- Closely scrutinize any irrigation improvements for efficiency.
- Possible dedicated irrigation pipeline may increase functionality of current irrigation system.
- Inform campus and public of water conservation efforts, explaining long-term goals.

Chico

Faculty Research:

- **Todd Greene; tjgreene@csuchico.edu; 530-898-5546**

Although a great majority of our region's water supply is supplied in the "upper" Tuscan Formation aquifer, interest in tapping the Lower Tuscan Aquifer (LTA) is growing stronger every year by multiple counties. Our research results will help create a more accurate geologic framework of the LTA, improve our knowledge of groundwater flow systems including possible recharge mechanisms, and help provide a basis for understanding possible drawdown effects under various pumping scenarios and potential water banking programs leading to more efficient water use of both the upper Tuscan and LTA and gain a better understanding of how the LTA can potentially be used as a supplemental and sustainable source of groundwater for the northern Sacramento Valley region.

- **Eric Houk; ehok@csuchico.edu; 530-898-4146**

- With funding by Agricultural Research Initiative, "Water Transfers in Butte County: Economic Impacts of Short-term Land Fallowing." Irrigated agriculture is often targeted to help meet other water needs. However, the cost associated with these water use changes is often poorly understood. This project focuses on estimating the impact of land fallowing in Butte County and the impact this can have on the regional economy.

- With funding by Agricultural Research Initiative, "Effects of Water Management and Conservation Practices on Aquifer Recharge in the Sacramento Valley." This project uses the USGS Central Valley Hydrologic Model (CVHM) to estimate the impact that that potential water management scenarios would have on regional groundwater levels. It is a multidisciplinary project where we are estimating the impact that these scenarios will have on hydrologic conditions and the economic implications of these effects.

(Chico cont.)

Facilities:

• <http://www.csuchico.edu/fms/>

Future plans include:

- Address current pooling, leaks, and run-off: cap off unnecessary sprinkler heads, adjust alignment of heads, correct radius of nozzles on sprinklers, repair broken sprinkler heads quickly.
- Suspend annual pressure washing of campus: use alternative methods, sweeping, and blowing.
- Revise irrigation schedules: Use only minimum amount of water to keep plants healthy using Evapotranspiration (ET) measurements. Turn controllers down by 20% and off during rainy durations.
- Update irrigation technology and Infrastructure: install flow meters, upgrade emission devices, evaluate new underground irrigation technology.
- Audit and retrofit existing irrigation zones: evaluate landscaped areas for water efficiency, develop new irrigation and planting layouts.
- Plant evaluation and replacement: plant drought tolerant plants, move/dig up antiquated landscape (keeping look and feel of Chico).
- Install low flow toilets, showerheads, and limiting aerators on faucets.
- Fleet washing: wash at self-service car wash stations which use recycled water.
- Attend workshops, send campus announcements re: leaks, send reports re: quarterly or annual water consumed.



Dried up riverbed along Hwy 99
near Bakersfield, CA
Photo by David Kosling
February 26, 2014

East Bay

Faculty Research:

• **Linda Ivey; linda.ivey@csueastbay.edu; 510-885-3272**

Curriculum - HIST 3505 California Environmental History: drought discussed as way of accessing the importance of environmental history in understanding current environmental issues, also used as way to discuss how we got here, including reading on the ways in which migrants to CA brought with them inaccurate expectations of climate and water, and proceeded to build unsustainable cities and industries based on those misconceptions.

• **Chris Kitting; chris.kitting@csueastbay.edu; 510-885-3001**

http://www.mollusca2014.unam.mx/simposia_ing.html

Persistence of habitats and populations of small, native hydrobiid snails in brackish marshes around San Francisco Bay after drought conditions.

• **Jean Moran; jean.moran@csueastbay.edu; 510-885-2491**

http://www.waterboards.ca.gov/water_issues/programs/gama/

http://www.swrcb.ca.gov/board_decisions/adopted_orders/resolutions/2014/rs2014_0016.pdf

With funding from CA State Water Resources Control Board and with collaborators at Lawrence Livermore National Laboratory:

- Development of new tracers of recent recharge to predict drought impacts on groundwater
- Development of a workshop on tracing managed aquifer recharge
- Application of multi-tracer methods to determine age distribution in nitrate-contaminated wells

Facilities:

• **Jim Zavagno; jim.zavagno@csueastbay.edu; 510-885-4149**

Adopted Water Conservation Plan - water reduction initiatives including water monitoring accounting, best management practices for water management, and education/awareness program. Short term measures implemented such as reduced irrigation usage, abandoning of turf areas, planting of native drought tolerant material, and installation of low flow toilets and faucets.

• **Michael Lee; michael.lee@csueastbay.edu; 510-885-3155**

Working in collaboration with our Facilities Development and Operations (FD&O) on various water projects that are ongoing both through class projects and through faculty/staff/student collaborations for sustainability.

Fresno

Faculty Research:

- **William Wright; wfwright@csufresno.edu; 559-278-5591**

Exploring idea of forming working group to document various impacts of drought in the Central Valley, documenting various social, physical and other impacts of the drought. This information would be disseminated to the public over time and keep this issue in the public consciousness.

- **David Zoldoske; davidzo@csufresno.edu; 559-278-2066**

Co-sponsored workshop for landscape irrigation managers on six ways to survive the drought.

- **Samendra Sherchan, ssherchan@csufresno.edu; 559-278-4747**

WaterReuse 11-01 Project, Monitoring for Reliability and Process Control of Potable Reuse Applications. Identifies, evaluates, tests, and validates systems that can be used to assure the public safety of potable reuse.

- **Steve Blumenshine; sblumens@csufresno.edu; 559-241-4122**

<http://zimmer.csufresno.edu/~sblumens/>

With funding from Bureau of Reclamation, goal of reestablishing the southern-most run of Chinook Salmon in North America. Project is to specifically examine the attributes of San Joaquin River floodplain habitats that best support the survival and growth of juvenile Chinook salmon, but there was not enough water this year to create floodplain habitats. Instead we monitored juvenile salmon ecology in the absence of these habitats, allowing address that juvenile Chinook require these floodplain habitats as a component of their early life history. It will also allow us to estimate how little water is needed to support the Chinook salmon reintroduction.

- **Sharon Benes; sbenes@csufresno.edu; 559-278-2255**

<http://alfalfa.ucdavis.edu/+symposium/2013/index.aspx>

Alfalfa seed companies are putting resources into developing more salt-tolerant varieties of alfalfa, but do not always have the proper protocols to test those varieties. In collaboration with UC Davis, evaluating new alfalfa genotypes for their tolerance to irrigation with saline water at the germination, emergence and mature plant stages.

Facilities:

- <http://www.fresnostate.edu/adminserv/facilitiesmanagement/>

Completed projects and current practices include:

- Converted to drip and microsprinklers. 144 acres left fallow this summer.
- Well 5 enlarged to increase water production to allow irrigation of entire campus at night when evaporation is at its lowest.
- An additional Irrigation Specialist hired to better address irrigation repairs.
- Replaced grass in Bulldog Stadium with Sport Turf.
- Repaired leaks in Central Plant Heating & Cooling Loops.
- Low spots in lawn areas have been filled in to eliminate the perception of overwatering.
- Campus vehicle fleet washed only at car wash.
- Existing grass berms, the Peace Garden and Maple Mall were injected with organic hydrogel that retains water and reduces the number of times these areas are required to be watered.
- Peters Building water fountain turned off.
- Replacing selected lawns with decomposed gravel and wood chips.
- Encourage campus community to report irrigation and plumbing issues.
- Landscape islands and strips are no longer included in parking lots.
- Landscape berms will no longer be used in future landscape designs.
- Future Campus landscaping will focus on utilizing native or drought tolerant plants.
- New buildings will be dual plumbed to use non-potable water where possible.
- Installed a "Water-Wise" Demonstration Garden.
- Water conservation stories and articles online.

Short- and long-term projects and practices include:

- When funding becomes available, move all campus irrigation to existing nitrate contaminated wells.
- When funding is available, replace and upgrade failing sections of the campus irrigation system.
- Explore developing a Recharge Basin on 15 acres of campus that is composed of sugar sand.

Fullerton

Faculty Research:

• **William Laton**; wlaton@fullerton.edu; 657-278-7514

http://groundwater.fullerton.edu/Groundwater_Web/Home.html

• **Matthew Kirby**; mkirby@fullerton.edu; 657-278-2158

<http://earthsci.fullerton.edu/kirby/>

Use of sediments from lakes and wetlands to reconstruct the history of droughts, floods, vegetation, and fire in the coastal western United States, specifically southern California.

• **Jochen Schenk**; jschenk@fullerton.edu; 657-278-3678

Research on regulated deficit irrigation in fruit trees, using plant-based measures to monitor plant water status in response to irrigation treatments. Currently focus on Navel orange trees, with plans to extend the studies to avocado. Goal is to find ways to reduce horticultural water use in California orchards.

Facilities:

• <http://fmsc.fullerton.edu/>

Completed projects and current practices include:

- Intelligent irrigation control systems (CalSense) used throughout the campus.
- Incorporating low-flow faucets, toilets and urinals in newly constructed facilities.
- Constructed bio-swales.
- Instituted green cleaning practices and low water usage equipment for custodial activities.
- Installed xeriscape landscaping in several areas on campus.
- Incorporated drip and rotary irrigation sprinkler heads throughout campus.

Short- and long-term projects and practices include:

- Recently funded a new Utility and Sustainability Master Plan that will further analyze and recommend additional water reduction and retention opportunities.
- Continue to reduce the amount of grass areas on campus and replace with xeriscaping.
- Adjust existing smart irrigation controllers to provide less water. However, this may cause areas to turn brown or die completely.
- Convert existing buildings over to low-flow faucets, urinals and toilets.
- Reduction in the quality of the grass in all sport fields. This requires further investigation.
- Elimination of all power washing of hardscape areas.
- Pool water temperature could be reduced to lower evaporation rates.
- Installation of smart water meters to identify exact water distribution and waste.
- Perform comprehensive sprinkler head audit (type, coverage, etc.).
- Evaluate campus auxiliaries water usage.

Humboldt

Faculty Research:

• **Andrea Achilli**; andrea.achilli@humboldt.edu; 707-826-3608

<https://www.facebook.com/pages/Achilli-Research-Teaching-Lab/628842890491088>

The Achilli Research and Teaching Lab (ART Lab) projects include a novel hybrid reverse osmosis – pressure retarded osmosis system for seawater desalination to be funded by the California Department of Water Resources, an integrated osmotic membrane bioreactor system for potable water reuse funded by the Strategic Environmental Research and Development Program, and a novel approach to wastewater treatment for resource recovery based on sewer mining by forward osmosis funded by the WaterReuse Research Foundation.

• **Steve Sillett**; scs6@humboldt.edu; 707-826-5121

Investigating the effects of drought in old-growth coast redwood and giant sequoia forests across California as part of the Redwoods and Climate Change Initiative. We are revisiting each plot exactly 5 years after establishment to quantify above ground productivity and carbon sequestration. We will be measuring ring widths of trees in each plot, to reveal the degree to which the current drought is restricting growth. We will compare the magnitude of this drought's effect on annual growth to conditions across California over the past 1000+ years. Plot re-measurements will also reveal the extent to which the drought is stressing or killing vegetation in each forest. We are also measuring xylem stress to determine the degree to which the drought is causing redwoods to close their stomata early in the day, restricting photosynthesis.

(Humboldt cont.)

• **Tim Bean; bean@humboldt.edu; 707-826-3658**

We have studied the state- and federally-endangered giant kangaroo rat throughout its range since 2009, providing regular updates to the California Department of Fish & Wildlife. Longer-term our research will provide insight into how best to mitigate the effects of increasingly frequent and extreme droughts on endangered wildlife in the Central Valley.

• **Jeffrey Kane; jkane@humboldt.edu; 707-826-5622**

Wildland Fire lab is examining the relative importance of climate and competition on tree growth, defense, and mortality in old-growth sugar pine forests of the central Sierra Nevada in California.

• **Steven Smith; ss7006@humboldt.edu; 707-826-5475**

<http://www.tandfonline.com/eprint/4EGkweG9BbwDeNVITTRZ/full>

Focuses on water management issues in the Henry's Fork Watershed in Idaho where poorly managed development threatens water management and irrigated agriculture.

• **Andrew Stubblefield; Andrew.Stubblefield@humboldt.edu; 707-826-3258**

Research study on the water use of Douglas Fir forests in three locations in Northern California. Trees will be instrumented with sap flow probes to measure tree water use before and after thinning treatments and prescribed fire. The hypothesis is that forests recovering from clearcut logging are now in very high densities resulting in high water use rates and reduced flows in tributary streams. A follow-up hypothesis is that thinning and prescribed burning will lower the water use by trees, while increasing the resilience of the remaining stand to fire and disease and increasing its commercial value.

• **Rosemary Sherriff; sherriff@humboldt.edu; 707-826-4119**

With funding through USDA-NIFA and collaborating with USGS and National Park Service, Tree growth and carbon accumulation in the face of drought: Does forest management confer resistance and resilience? We are planning to determine how differences in stand conditions and management history confer (or don't confer) increased resistance and resilience in tree growth rates to drought-induced moisture stress and an estimate of carbon changes.

Facilities:

• **Traci Ferdolage; traci.ferdolage@humboldt.edu; 707-826-3646**

Short-term strategies being implemented:

- Install aerators at sink faucets and low flow showerheads.
- Retrofit existing flushometers to reduce required water for flushing.
- Ensure all recirculation pumps are working properly and efficiently.
- Conduct domestic and irrigation water system leak detection survey.
- Implement campus education program.
- Manually reduce irrigation watering.
- Reduce water use by eliminating pressure washing in advance of major campus events.
- Replace water-cooled condensing unit at forestry with air-cooled unit.

Long-term strategies:

- Repair domestic and irrigation water system leaks per survey findings.
- Install building and system level metering, soil moisture controlled irrigation system controllers including data lines for programming, low flow fixtures, and water storage system for greenhouse watering.

Long Beach

Faculty Research:

• **Suzanne Dallman; suzanne.dallman@csulb.edu; 562-985-7529**

Researching drought and post-drought responses (government engagement, water use restrictions, incentives, public and media responses, etc.) in Australia and California and comparing the two, focusing on urban water.

• **Rebeka Sultana; rebeka.sultana@csulb.edu; 562-985-5135**

- About 30% of water comes from snowmelt runoff. Studying the changes in peak magnitude of snow water equivalent and timing of snowmelt due to the recent extreme climates and droughts. Also studying which drought index – SPI or SPEI, better represents California's climate.

- Developing a performance based methodology for the evaluation of climate effects on water supply systems.

The framework will work in five stages, providing a method to rigorously account for uncertainty in water system model predictions and allow the selection of a design which achieves a desired level of performance. Stakeholders will select performance goals to be met at various levels of climate hazard. The methodology will provide a more robust understanding of water system resilience and better decision making by stakeholders.

(Long Beach cont.)

• **Matthew Becker; matt.becker@csulb.edu; 562-985-8983**

<http://www.csulb.edu/sites/beachreview/2013/features/tapping-into-water/> or <http://www.csulb.edu/misc/inside/?p=46172>

- In cooperation with Orange County Water District, using fiber optic distributed temperature sensing to understand percolation behavior in artificial groundwater recharge basins.
- Studying hydrology of the chaparral covered hills of the San Bernardino mountains, focusing on how rainfall in the mountains ultimately recharges the groundwater in the LA Basin. We are performing similar studies on Catalina Island to understand how the groundwater there is recharged.

Facilities:

• **<http://daf.csulb.edu/offices/ppfm/facilitiesmanagement/>**

Completed projects and current practices:

- Transitioned to drought-tolerant landscaping.
- Converted landscape areas to drip irrigation.
- Using waterless and low-flow urinals.
- Installed touch free automatic faucets with low-flow restrictors and weather-based central irrigation controllers.
- Using reclaimed water for irrigation.

Short- and long-term projects and practices include:

- Perform a comprehensive water use audit.
- Continue to implement and expand best practices and share with campus auxiliary: more low flow urinals/toilets/ faucet aerators/showerheads, convert more spray irrigation to drip, convert more lawns to drought tolerant ground covering, replace filtration system at Japanese Garden, convert plant cooling tower to reclaimed water, replace swimming pool cover, remove steam boilers and install sterilizers.
- Identify further opportunities to use reclaimed water.
- Implement low-cost, quick-payback projects immediately and plan higher-cost capital projects.
- Communication plan to encourage campus water conservation.
- Collaborate with faculty and students for water related courses and projects.
- Strengthen partnerships with water industry.
- Plan future campus development for water resiliency.



Folsom Lake, CA
Photo by ewoerlen
January 19, 2014

Monterey Bay

Faculty Research:

• **Lars Pierce; lpierce@csumb.edu; 831-331-3889**

<https://sites.google.com/a/csumb.edu/lars/vsim-tops>

Has Department of Water Resources Prop 50 funding for VSIM/TOPS crop water balance modeling system, which utilizes satellite imagery to track vineyard canopy development over growing season, combines data with weather data, grower irrigation logs/actual measurements, and USDA soils data to estimate soil moisture, vine water stress and make irrigation recommendations on block-by-block basis for vineyard. Works with grower to help them maintain accurate irrigation logs, including installing flowmeters.

Facilities:

• **<http://cpd.csumb.edu/>**

Completed projects and best practices:

- Retrofitted low-flow faucets and showers, check/repair leaks.
- Mulch around trees/shrubs, allow grass to grow 3".
- Check for irrigation leaks, quickly repair, appropriate irrigation schedule for weather/time of day.
- Regularly check for leaks in boiler and cooling systems and repair when possible .

Short- and long-term projects:

- Install Pilot Landscape project to test drought tolerant strategies (BIT Building and AVC Building).
- Convert/upgrade irrigation controllers and manage thorough central platform.

Northridge

Faculty Research:

- **Shawna Dark; shawna.dark@csun.edu; 818-677-6937**

- In process of developing a campus **Center for Urban Water Research**.

- In response to the increasing concerns about water resource issues and the current drought conditions, the College of Social and Behavioral Sciences is pursuing an online **Masters in Global Water Resources Management** with Tseng College, the extended learning college at CSUN.

- **Center for Geographical Studies** has been working with a variety of state and local agencies to monitor the state's water resources for the past decade. Currently, CGS has several projects with the State Water Board. CGS has developed statewide standards for mapping water resources and is currently working with USGS, several joint powers authorities, and local cities in providing technical solutions for implementing data systems related to water. Representatives from CGS serve on a variety of statewide advisory boards that focus on both technical and data driven demands in assessing our state's water resources.

- **Dr. Ernest Kwok; Ernest.kwok@csun.edu; 818-677-3383**

Research on a protein in drought-tolerant plants.

- **Dr. Casey Terhorst; Casey.terhorst@csun.edu; 818-677-3356**

Research on an invasive plants species (*Medicago polymorpha*) whose invasion is facilitated soil bacteria that shows drought resistance.

- **Dr. Paula Schiffman (Paula.schiffman@csun.edu; 818-677-3350); Dr. Kim Kirner (kim.kirner@csun.edu; 818-677-5839); and Dr. Soheil Boroushaki (soheil.boroushaki@csun.edu; 818-677-4715)**

Collaborating on an NSF grant, looking at environmental perception, vegetation, and water issues in the Owens Valley.

- **Dr. Amalie Orme; amalie.orme@csun.edu; 818/677-3864**

Developed a long-term study to address drought impacts on eastern California rivers through measuring shifts in ecological and geomorphological processes. The majority of this work is also taking place in the Owens Valley.

Facilities:

- **Colin Donahue; colin.donahue@csun.edu; 818-677-2333**

Helen Cox; helen.m.cox@csun.edu; 818-677-3512

<http://www.csun.edu/facilities/> "Save Our Water" lists completed projects and those currently underway.

- We have made a variety of reductions of in-building water use.
- Changes being made to landscaping as lawn areas are being replaced with a combination of drought-tolerant and native plants, mulch, DG (decomposed granite) paths.
- Audit of all sprinklers systems has been taking place.
- When we developed the ecoregion demonstration garden adjacent to the transit station we purposefully used plants that are not just drought tolerant, but exclusively native to our region.
- Working on strategies with the City and the utility company.

Pomona

Faculty Research:

• With funding from California Landscape Contractors Association, submitted a study on measuring the effects of spacing and nozzle radius adjustment on distribution uniformity (DU) for multi-stream, multi-trajectory (MSMT) rotary nozzles, thereby improving DU and irrigation efficiency.

- **Robert Green; rlgreen@csupomona.edu; 909-869-5293**

<http://www.csupomona.edu/~lis/ctilt.html>

With funding from ARI, conducting research regarding deficit irrigation of Bermudagrass to conserve water while maintaining plant health. Center for Turf, Irrigation and Landscape Technology (CTILT) in Plant Science Department.

- **Jonathan Nourse; janourse@csupomona.edu; 909-869-3460**

<http://geology.csupomona.edu/janourse/Upper%20SAC%20Stuff/webpage.htm>

Acquiring water quantity and quality data from several watersheds of the San Gabriel Mountains during Year 3 of an extended drought period. Students are gauging stream flow, measuring spring discharge, and collecting samples for anion and 18O-deuterium-tritium analyses. We are documenting very low base flow conditions. Sufficient measurements have been taken to calculate base flow recession constants that may be viewed as characteristic for a given watershed. These studies provide an opportunity to document watershed response to heavy rains anticipated for next winter.

(Pomona cont.)

Facilities:

- <http://www.csupomona.edu/~fpm/management/>

Current projects and best practices:

- Identify/repair/replace leaks and damaged features of all systems including landscaping, irrigation, toilets/urinals, faucets/showerheads, and in kitchens and laboratories.
- Adjust irrigation schedules to fit weather, soil conditions, seasons, etc.
- Low-flow toilets/urinals and faucets/showerheads to use minimum amount of water.

Evaluating for possible short- and long-term projects and best practices:

- Create a written water management and conservation policy statement.
- Mulch around trees, establish soil management plan.
- Maintain monthly log of irrigation water use.
- Turn off water fountains.
- Install waterless urinals.
- Identify location and severity of boiler/steam system leaks.
- Establish procedures to reuse steam condensate/boiler blow down/air cooler water.
- Avoid once-through/single pass operations.
- Evaluate laundry facility and vehicle washing procedures.

Sacramento

Faculty Research:

- **Dudley Burton; burtond@csus.edu; 916-278-6620**

www.csus.edu/envs

Department of Environmental Studies Urban Agriculture and Aquaponics Program - housed at the Sustainable Technology Outdoor Research Center (STORC) facility. Multi-trophic system combines plants, fish, decomposers and people. Municipal food waste is used to produce protein for fish feed, and fish produce nutrients through their wastes to feed plants. This combination forms a sustainable, closed-loop system that produces high quality protein and vegetables while minimizing the environmental impacts caused by conventional food production. There can be as much as 90% reduction in water requirements and substantial improvements in yield per unit area using aquaponic strategies.

- **Kevin Cornwell; cornwell@csus.edu; 916-278-6667**

Groundwater and surface water issues associated with the restoration of mountain meadows in the Feather River basin, Sierra Nevada, calculating how much groundwater exists in restored AND unrestored meadow systems, how that volume changes throughout the year and the potential impact that restored versus unrestored meadows have on local ecology.

- **Jamie Kneitel; kneitel@csus.edu; 916-278-3633**

http://www.csus.edu/indiv/k/kneitel/Jamie_M._Kneitel/Home.html

Effects of stressors on the biodiversity and ecosystem functioning of California vernal pool. With an array of research approaches, the Kneitel lab has addressed many drought-relevant questions. Most recently, Dr. Kneitel published a study (Kneitel (2014) Hydrobiologia) that found the amount and timing of rainfall can greatly affect many aspects of this ecosystem with implications for vector mosquito outbreaks.

Facilities:

- <http://www.csus.edu/aba/Facilities/>

Current projects and best practices:

- Created Lead Irrigation Specialist position, reduced irrigation times by 25%, installed upgraded Maxicom irrigation control system.
- Installed automated pool cover, shut down 2 decorative fountains, advocating for changes to fire code (test pumps monthly rather than weekly), vacuum cooling tower rather than dump water, replaced restroom fixtures.
- "Save Our Water" signs on mirrors, flyers in utility rooms, social media posts, Water Conservation Awareness Fair.

Medium-term projects and practices:

- Increase mulching, replace above ground well with submersible well, change sprinkler heads, install bioswales and biostrrips, replace small turf areas with dry-scape, CA native plants and drought resistant plants.
- Change bathroom faucet aerators.

Long-term projects and practices:

- Eliminate/replace larger unnecessary turf.
- Upgrade all campus features to low flow/water conserving, add water meters to all buildings to pinpoint overuse.
- Water saving tips and campus highlights on display monitors on campus, signage throughout campus including lawns and mulched areas.

San Bernardino

Faculty Research:

- Held roundtable on Developing Funding for Disadvantaged Community Infrastructure Projects.
- Using plant growth promoting bacteria to support agriculture in a drier environment. We are focused on the common soil bacterium *Variovorax paradoxus*, which we have seen in our lab has the capacity to stimulate root growth and solubilize phosphate. Since this bacterium is native to the chaparral soil, we feel it has potential as a seed coating or soil amendment to reduce the amount of water needed for irrigation of semi-arid land.

Facilities:

- <http://www.csus.edu/aba/Facilities/>

Current projects and best practices:

- Using automated Calsense irrigation control system at CSUSB and Palm Desert Campus.
- Sensors on high-flow valves to identify broken supply line (shut down automatically).
- Water-wise demonstration garden to educate community.
- Use of xeriscaping and succulents in areas throughout campus.
- 20% reduction on all irrigation controllers.
- Installed low-flow domestic water fixtures throughout campus.
- Replaced/upgraded water closets/urinals/sink aerators/showerheads at locations throughout campus.
- Installed backflow system and pressure regulators to decrease excessive water losses.
- Turned off ghost flush on all automatic toilet valves.

Short- and long-term projects and best practices:

- Continue xeriscaping grounds surrounding all new construction.
- Continue all new construction and plumbing retrofits designed for domestic water conservation.
- Seeking technical assistance from local Municipal Water District and Resource Conservation District.
- Funding for wastewater and greywater reclamation retrofit and future design for irrigation and industrial applications.



Laguna Lake, CA
Photo by docentjoyce
September 9, 2014

San Diego

Faculty Research:

- In progress of writing a history book ("Fluid Boundaries") on US-Mexico relations regarding the Colorado River, focuses specifically on the Colorado River Delta and how the politics of that region influenced the current Law of the River. The sustainability of San Diego, Los Angeles, and Tijuana will inevitably hinge on the redistribution of this massive allotment (more than a quarter of the river's total flow).
- SDSU-IVC Borderlands Institute created, which seeks to foster research on border issues; agriculture and the politics of water are particular areas of focus.

Facilities:

- <http://bfa.sdsu.edu/fpm/>

Current projects and best practices:

- Collect condensate from inlet air cooling coils for use in cooling towers.
- Three 50,000 gallon rainwater collection tanks collect water from roof for irrigation.
- MP rotators and check valves on sprinklers reduce water in installed areas by 30%.
- 1000 low-flow aerators installed on faucets.
- Nearly 300 existing water closets and urinals replaced from high-flow to code fixtures.
- CalSense ET based central irrigation controllers.
- Upgrades to steam infrastructure and increased condensate return significantly.

Future projects:

- Hire grounds manager.
- Group meeting on drought management.
- Training and Education – a multi-week landscape class for grounds staff, other training as needed.
- Normalized comparisons of water usage.
- Identify watering needs of each irrigation zone and stop override of central controllers.
- Identify and convert high water areas to xeriscape.
- Complete irrigation system upgrades – rotators or drip system.
- Explore conversion of grass fields to artificial turf.
- Landscape standards in new construction .
- Sewage meters should be installed to assist in tracking where water is being used and to ensure that we are being billed properly.
- Building level water meters should be installed on all buildings to help identify high water users and leaks.
- Onsite Water Treatment of sewage discharge is currently being evaluated.
- Rainwater collection –currently, Aztec Student Union's rainwater collection system is the only water reuse system on campus. Additional opportunities to use rainwater should be identified and considered.
- Condensate collection –Associated Students is planning to connect condensate to their rainwater storage system. Other opportunities to collect condensate for non-potable use should be identified.
- Cooling setpoints and schedules will be optimized to reduce chilled water usage in compliance with state energy policy.
- Remaining once through cooling systems should be connected to the chilled water system.
- Economizer preventative maintenance to identify dampers and actuators in need of replacement.
- Evaluate zero blowdown.
- Increase Cycles of Concentration on cooling tower.
- Installation of sink aerators and flushometers, and new low water usage fixtures to be installed.
- Improve renovation standards, replace with new low water usage fixtures rather than renovating for optimal operation.
- A new housing sustainability group established.
- Low flow showerheads and faucet aerators, other water conserving fixtures will be considered in the future.
- Recruit residential students as "Eco Leaders" to educate students.
- Water conservation stickers – educational stickers will be provided in the remaining restrooms.
- Campuswide Email and News Article about importance of drought response.
- A drought task force will be convened to ensure that this plan is adopted and implemented.

San Francisco

Faculty Research:

• With funding by State and Federal Contractors Water Agency, Romberg Tiburon, SFSU and Cal Maritime researched how a low-salinity zone in Northern San Francisco Estuary performed in severe drought year 2014 with a focus on nutrients and phytoplankton. The data will be integrated into other data sets collected earlier for comparison across a spectrum of water-year types.

• With funding by Bay Delta Science Program, researchers at Romberg Tiburon published research on rare spring blooms in the San Francisco Bay Delta as a window of opportunity response to multiple factors promoted by the drought. The researchers suggested management practices that favor higher rates of flow may narrow the window of opportunity for phytoplankton growth, potentially leading to low productivity and food limitation for fish. Under high flow, a “washout” may develop where both chlorophyll and unassimilated nutrients are transported out of the Bay and the phytoplankton that do develop are less favorable in terms of community composition for supporting the upper food web.

• <http://sustain.sfsu.edu/>

Diverse selection of courses and programs available within the umbrella of sustainability. There are also a number of sustainability-related research projects underway.

• **Drought Informational Messaging**

- Communications published a news article: <http://news.sfsu.edu/campus-asked-reduce-water-consumption>

- The SF State Xpress student newspaper published a news article:

<http://www.goldengatexpress.org/2014/02/13/conservation-sustainable-sfsu-drought-california-rain-bay-area/>

- Sustainability Office published water saving tips in the University's Campus Memo:

<http://www.sfsu.edu/~news/cmemo/spring14/feb10.htm> and has established social media accounts to communicate best practices and other conservation information to the campus community: <https://www.facebook.com/greensfsu> and

<http://www.twitter.com/greensfsu>

• <http://www.sfsu.edu/~sierra>

With a more holistic understanding of the characteristic montane meadow model can we fully understand the impact of landuse changes. Faculty in three departments are planning an integrated research and teaching program at SFSU's Sierra Nevada Field Campus, focusing on montane meadow research, and specifically addressing ongoing meadow restoration efforts by the US Forest Service and restoration specialists such as the Feather River Coordinated Resource Management.

Facilities:

- Installed a central controller and fine-tuned baseball field irrigation system, reducing water usage by 29%.
- Set all irrigation control settings to water 25% less.
- Replaced non-essential lawns with drought tolerant plants.
- Fitted buildings with low-flow faucets, toilets and urinals where possible.
- Reduced cleaning frequency of hallways and corridors with hard surface flooring by 20%.
- Requested that departments with dishwashers and/or washing machines consider replacement with low-water use, Energy Star machines.
- Replaced shower heads at Student Housing with low-flow models.
- Reduced frequency of car washing of State vehicles by 20%.
- Repaired rainwater collection system so water can be used for cleaning.
- Implemented green custodial practices with equipment and chemicals requiring less water.



Millerton Lake
San Joaquin River Horseshoe Bend
near Friant, CA
Photo by David Prasad
December 17, 2013

San Luis Obispo

Faculty Research:

• Faculty team, led by City and Regional Planning Department professor David Conn

http://hazardmitigation.calema.ca.gov/plan/state_multi-hazard_mitigation_plan_shmp

Completed the 2013 update of California's State Multi-Hazard Mitigation Plan (SHMP) in September 2013. The SHMP was adopted by the California Governor's Office of Emergency Services in mid-September and received its standard and enhanced status approvals from the U.S. Federal Emergency Management Agency (FEMA) on September 30, 2013. The SHMP is California's primary hazard mitigation guidance document, providing a comprehensive description and analysis of California's historical and current natural and human-caused hazards; hazard mitigation goals and objectives for the state; and hazard mitigation strategies. SHMP Chapters 5 and 6 detail each hazard with the potential to affect California communities. Cal Poly's faculty team continues to work with Cal OES on hazard mitigation implementation efforts required as part of FEMA's approval of California's 2013 SHMP. Updates to the Droughts and Water Shortages section, and to the entirety of the SHMP, will occur next in 2018.

• Irrigation Training and Research Center

www.itrc.org

- Providing technical assistance to CONAGUA in the Mexicali Valley of Baja California on water conservation efforts that impact the availability of water transfers to California, as well as the need for flushing flows to the Colorado River Delta.
- Development of strategies and designs in the Uncompahgre Valley in Colorado, to reduce salinity and selenium loading into the Colorado River – which impacts the usefulness of that water in California.
- Development of drought-relief modernization plans for a half dozen irrigation districts in California
- Immediate implementation of various irrigation district automation schemes.
- ITRC is using its METRIC program to develop net groundwater recharge values for eastern Merced County's MAGPI groundwater study – using LandsAT 7 imagery.
- Two teams are in the San Joaquin Valley, evaluating irrigation systems for farmers – providing recommendations for improved performance.
- Assistance to many irrigation districts with efforts to improve water measurement.
- Cooperation with CDFA to provide drought-related training to hundreds of irrigation professionals.
- Execution of about 30 short courses for farmers, irrigation dealers, and irrigation districts – related to water management.
- Assistance to various groups in the Klamath Basin, including Tulelake ID in California, to implement water conservation measures.
- Work with Southern California Edison to identify water-related constraints to sustainability of various agricultural industries.
- Work with Southern California Edison on a number of projects related to the water/energy nexus – in attempts to improve the efficiency of energy consumption as related to water transportation.
- Work with the State Water Board by organizing and chairing a special Expert Panel on solutions for excess water and nitrate leaching into the groundwater.
- Development of web-based short courses in irrigation.

Facilities:

<http://afd.calpoly.edu/facilities/>

Current projects and best practices:

- Installed 260,000 gal rainwater catchment and storage system.
- Installed Rainbird Central Irrigation Control System for largest turf areas (Spanos Stadium, Track Field, Sports Complex).
- Converted 3 recreational soccer fields at the Sports Complex to artificial turf.
- Well placement, well pump VFD retrofits and pressure controls, installation of flow meters.
- Retrofit of 200 urinals, 200 toilets, 300 lavatory faucets, and all housing showerheads with low-flow fixtures.

Short- and long-term projects and best practices:

- Retrofit remaining standard-flow toilets, urinals, lavatory faucets, and showerheads with low-flow.
- Retrofit ice machines, pre-rinse spray nozzles, laundry equipment, install laundry ozone injection, and liquid pool cover technology.
- Irrigation Controller upgrade and expansion of central system serving 76 acres of irrigated landscapes, install new controllers for 59 zones, recommission 33 existing zones, install master valves and flow meters, implement ET control, automate scheduling and rain delay, install soil moisture sensors, replace/upgrade spray heads to improve uniformity.

Sonoma

Faculty Research:

- Reconstructing climate history over the last 10,000 years and human impacts to the natural environment.
- <http://www.sonoma.edu/waters/index.html>

WATERS Collaborative projects have been running since 2012. Copeland Creek runs from the Osborn Preserve, down Sonoma Mountain, across the SSU campus and into the Laguna de Santa Rosa. We are working with faculty and students to study sedimentation, water quality and biodiversity in the watershed.

Facilities:

<http://www.sonoma.edu/fm/>

Current projects and best practices:

- Conduct leak detection surveys of irrigation, toilets/urinals/faucets/showerheads, boiler/steam cooling systems, and kitchen and laboratory equipment and repair leaks quickly when applicable.
- Use of water-efficient landscaping and irrigation practices (mulching, 3" grass, etc.).

Short- and long-term projects and best practices:

- Install pool covers.
- Replace domestic water tanks 1 and 2 (larger, stainless steel – continuous leaks from current concrete tanks).
- Replace domestic water piping (continuous leaks).
- Replace failing IDECooling units with typical HVAC units (water conditions cause silicate scale buildup on IDEC units).
- Replace old irrigation with modern system that can be controlled remotely and watering schedule can be tailored to temperature, season, precipitation, etc.
- Replace toilets, urinals, wash basins, faucets, and showers with water conserving/low-flow fixtures.



Stanislaus River, CA
Photo by Zachary Collier
August 6, 2014

BMP Statistics for CSU Facilities

In 2013-2014, the Chancellor's Office requested information from each campus regarding water management and conservation best practices. The WRPI has gathered this information and created the following summaries. These summaries show where our campuses have been conserving water, areas that are improving, and other areas that need further evaluation.

90%-100% of campuses are currently practicing basic water conservation efforts such as using brooms rather than water to sweep hardscapes, repairing irrigation and toilet leaks, decreasing watering schedules and system pressure, replacing broken features with low-flow or conservation devices, and closely monitoring leaks in laboratory/medical equipment and boiler/steam systems.

Over the last year, more than 50% of campuses began creating and publicizing written water management and conservation policy statements, addressing short-term water conservation goals, and a commitment to the longer-term water management efficiency of the facility. Additionally, about 35% of campuses are evaluating this practice, so the majority of campuses should be doing this soon. This will increase the overall focus and visibility of water conservation efforts.

Many campuses are enacting practices beyond the basics to decrease water use, with close to half of campuses evaluating how they can enact this at their facilities. Efforts such as limiting the use of garbage disposals, turning off equipment when not in use, and using moisture probes to determine exact watering needs for planting areas will soon be used more widely. There are some areas that are not applicable to over half of campuses, mostly related to boiler/steam rooms and finding alternatives to single-pass effluents. More investigation may be required to determine if these features simply are not part of certain campuses or if alternative conservation efforts can be enacted. Further areas for evaluation are related to the use of tank water displacement devices, keeping records of water used for washing vehicles, and more efficiency using multi-pass, closed loop, or air-cooled equipment options for future systems.

The following gives us more detailed statistics:

ASSUMPTIONS: Several campuses chose two or more answers for some items. If a campus indicated a practice was "current" and "new," counted as "new." If a campus indicated "current" and "evaluating," counted as "current." If a campus indicated "evaluating" and "N/A", counted as "evaluating."

90-100% of campuses are CURRENTLY enacting basic practices to conserve water, including:

- Using brooms and rakes to sweep hardscapes near landscaped areas instead of spraying with water
- Checking for leaks in primary irrigation system valves and distribution lines
- Repairing all irrigation leaks and using hose sparingly until repaired
- Adjusting irrigation systems to minimum pressure and installing pressure regulators where required
- Using appropriate irrigation schedules
- Avoiding watering during heavy winds and rainy season
- Replacing leaking shut-off nozzles or quick-couplers for all hoses
- Replacing broken toilet fixtures with low-flow fixtures
- Repairing leaking toilets
- Replacing toilets with low-flow models (as needed)
- Installing water conserving devices when replacing broken faucet and showerhead fixtures
- Repairing boiler/steam system leaks as feasible
- Inspecting boiler/steam system piping and tank insulation, repairing or replacing as necessary
- Performing leak detection surveys of all water use/distribution systems related to lab/medical equipment
- Identifying/recording lab/med equip leaks
- Repairing lab/med equip leaks as feasible (or document in log if non-repairable)
- Enacting procedures to adjust irrigation times and durations seasonally
- Repairing leaking or dripping faucets or showerheads
- Showerheads or faucets in need of replacement due to normal wear-and-tear should be replaced with low-volume models

BMP Statistics for CSU Facilities

Over 50% of campuses have enacted NEW practices, including:

- Creating a written water management and conservation policy statement addressed to staff that addresses short term water conservation goals and a commitment to the longer term water management efficiency of the facility
- Publicizing the water management and conservation policy statement to staff and facility occupants
- 35% of campuses were evaluating these practices, so this should soon be done by a majority of campuses

Many practices are being EVALUATED by some campuses, which others are currently doing, so we should see growth/more water efficiency in these practices, including:

- 55% are evaluating using water moisture probes to a depth of 3" to determine watering needs of planting areas (30% currently doing this)
- 45% are evaluating restricting the use of herbicides and hand-pulling weeds regularly to avoid unwanted plants consuming water (45% currently doing this)
- 45% are evaluating limiting use of garbage disposals (instead, hand scrape or use mesh screens to put waste in garbage containers) (45% currently doing this)
- 65% are evaluating replacing restroom faucets with programmable faucets that use 0.20 gallons per cycle (30% currently doing this)
- 45% are evaluating identifying, modifying, or establishing procedures to turn off laboratory/medical equip when not in use (50% currently doing this)
- 50% are evaluating inspecting lab/med solenoids and automatic shut-off valves for proper function and repair or replace as feasible (50% currently doing)
- 60% are evaluating verifying that all lab/med equip is set to minimum manufacturer pressure and flow rates (35% currently doing)
- 85% are evaluating installing water leak detection devices and reporting systems that can be integrated into existing building security and automated control systems (15% currently doing)

Other practices are being EVALUATED by some campuses and are NOT APPLICABLE to others, mostly due to campus features, including:

- 45% evaluating installing toilet tank water displacement devices (45% N/A)
- 40% evaluating finding alternative uses for single-pass effluents such as landscaping, boiler or cooling tower, make-up water, or toilet flushing (60% N/A)
- 40% evaluating future systems should specify multi-pass, closed loop, or air-cooled equip options (40% N/A)
- 45% evaluating identifying, modifying, or establishing procedures to reuse cooling tower effluent where possible (50% N/A)
- 55% evaluating identifying, modifying, or establishing procedures to keep records of water used per vehicle washed (30% N/A)
- 65% are evaluating procedures to reuse final rinse water for garbage disposals and pre-wash functions (25% N/A)
- 45-50% are evaluating laundry procedures to avoid excess filter and softener back flush, restricting use to full loads, and minimizing use of stand-alone washing machines

There are some categories with a large percentage of campuses saying this practice is NOT APPLICABLE:

- 50% - identifying, modifying, or establishing procedures to avoid once-through/single pass operations of boiler/steam rooms
- 60% - finding alternative uses for single-pass effluents such as landscaping, boiler or cooling tower make-up water, or toilet flushing
- 55% - identifying, modifying, or establishing procedures to eliminate once-through/single pass cooling, or for reusing water elsewhere in facility
- 55% - identifying, modifying, or establishing procedures to reuse treated waste water or other non-potable water sources for cooling tower make-up
- 50% - identifying, modifying, or establishing procedures to use higher pressure rinses instead of flood arches
- 50% say identifying, modifying, or establishing procedures to reduce foam and the resulting need for rinse water when washing vehicles is N/A