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Accomplishments

*** What are the major goals of the project?**

The overall goals of the Southern Sierra Critical Zone Observatory (SSCZO) include: i) expand process-based understanding of the critical zone in a sensitive, societally crucial ecosystem; ii) provide a platform for long-term physical, biogeochemical and ecological studies; and iii) develop a framework for improving Earth System Models. In addressing these goals, the SSCZO has measurements at five main sites spanning a steep elevation gradient in the

southern Sierra Nevada. This spatial climate gradient in critical-zone properties and processes permits predicting effects of climate change by substitution of space for time. Building on our work of the prior years, the SSCZO is focused on a cross-disciplinary approach to understanding: i) the current distribution of CZ properties across the mountain front, ii) the processes governing CZ behavior, and iii) the rates that CZ properties can evolve and change. Our scientific goals are centered on 5 research questions and 3 implications (See Figure 2 in Management Plan). The research questions follow.

1. How do regolith properties and process of formation vary over 10-m to 100-km scales? This question of understanding regolith properties and formation across climate (elevation) gradients is key to prediction of both short- and long-time-scale processes. Regolith development over time depends on both parent material and climate. In the case of the Southern Sierra, climate is much more variable over space than is parent material. However, the combined variability results in significantly different biota across gradients of elevation, climate and parent material.
2. How do physics, chemistry, and biology interact to influence critical-zone function over instantaneous to decadal timescales? Questions of critical-zone function, central to understanding and predicting the response of critical-zone services to disturbance, management actions and climate, must consider the highly variable physical, chemical and biological inputs and processing across the range of regolith properties. A common conceptual framework and model must accommodate the different rates and processes of key inputs in order to predict outputs over time.
3. How quickly do regolith properties change in response to climate and biota? Recognizing the importance of regolith-climate-biota feedbacks, predictions of regolith development, formation and properties must consider the integrated changes in climate and biota. Time scales for and magnitudes of change depend on the processes. One example, erosion over annual to millennial to million-year time scales, depends on extreme climate events, as well as disturbance of biota.
4. How do regolith development and properties control, limit or modulate effects of climate change, forest management or disturbance on hydrology, biogeochemistry and ecology? Modulation of climate and disturbance is an essential regulating service of the critical zone. For example, in semi-arid regions, the amount of subsurface water storage during drought is emerging as a key critical-zone attribute, and predicting how this modulation varies across the landscape a central critical-zone-service question. The capacity for modulation over longer time scale may not reflect shorter-term responses of critical-zone biota and biogeochemistry to change. For example, drought versus wildfire both affect biota, which may respond in quite different ways over seasonal, annual and multi-decadal time scales.
5. What measurements of the critical zone at appropriate spatial and temporal scales, using cutting-edge technology, can best advance knowledge of the critical zone? The foundation for advances in the above questions rests on making appropriate, strategic measurements of the critical zone. Both continuing, baseline measurements, as well as shorter-term project or campaign measurements are part of the CZO network. Advances in measurement technology over the past decade have greatly expanded the available observations and data. These advances in measurement can not only support critical-zone research, but also inform longer-term resource management.

Management implications of particular concern include the effects of forest management on: i) plant production and the cycling of carbon and nitrogen through the system, ii) streamwater quality and iii) forest evapotranspiration and streamflow. Of note, we emphasize that these are large, thematic issues; we recognize that while the SSCZO will advance knowledge on these questions, more-complete answers will emerge over the next several years through cooperation with sister CZOs and the broader community.

*** What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?**

Major Activities: Activities are described following structure of the five research questions.

Regolith properties and formation. Excavations across the SSCZO transect by Riebe and colleagues started with large (e.g. 3x3 m) profiles through the lower and two mid-elevation sites this summer, and ending with smaller, hand-dug profiles at the high-elevation site due to access and shallow bedrock. We performed infiltration experiments on the bedrock contact; and soil-moisture

monitoring using neutron probe was conducted at three sites in deep boreholes extending to hard bedrock.

Analysis of geophysical data from the near surface (<40 m depth) continues. J. Hayes is coupling seismic refraction data with geochemical analyses of Geoprobe cores collected in 2011. UCD collaborators (O'Geen, Hartsough, Tian) continued to characterize physical, chemical and mineralogical properties of the soils and underlying deep regolith. Over 80% of samples collected have been characterized.

Work by Riebe and Hart on the importance of dust on regolith formation also features collaborator Aciego's work on Sr and Nd isotopic signatures of dust. Our geochemical analyses of regolith and rock samples along the altitudinal transect continues. Expanding the cosmogenic work on quantifying erosion rates, student C. Lukens is doing a comparative analysis of (U-Th)/He ages in apatite from sediment in streams draining the eastern Sierra.

Critical-zone function. We are investigating surface-groundwater exchange of Sierra Nevada montane meadows in the context of greater watershed processes. The small eddy-correlation station was deployed in Long Meadow until Dec 2014, and redeployed in Mar 2015. We developed an Applied Neural Network that used local meteorological, groundwater-table and other SSCZO eddy-covariance-tower data to construct cumulative ET for Mar-Nov in 2013 and 2014.

Work on annual sediment sources, composition and transport continued, with water and nutrient cycling being tracked in discharge and soil flows. Archived water samples were analyzed for TC, TOC, TN, pH, and aromatic C from WY 2010. Investigations were made of nutrient hot spots (persistence of high nutrient concentrations at a single location over multiple time periods) and hot moments (episodically high nutrient concentrations at a single location) at the 3D grids of ion-exchange-resin capsules. Resins have been extracted and chemical analyses completed for the final three sampling dates (2012 and 2013.

In addition to RHESSYs model work on core research questions, we began a new collaborative cross-site initiative. Tague and Moritz used field measurements and modeling to estimate how shifts from conifer forest to shrubs at the rain-snow transition may alter seasonal and annual hydrographs. This project used flux tower measurements, sap-flow measurements and new set of predawn leaf-water-potential and conductance measurements for co-located shrubs and trees in the Providence watershed (Bart et al., paper in prep).

Regolith-climate-biota feedbacks. We completed our initial investigation of our hypothesis that the notable bimodality in soil and vegetative cover is regulated by differences in the geochemistry of underlying bedrock.

R. Ferrell (UCD student) developed a geospatial model to explain relationships between regolith thickness and forest health metrics such as productivity and resilience to drought. This geospatial model uses a clustering technique, partitioning around medoids, to identify clusters of terrain attributes from input variables, including climate, solar radiation, landform, soil properties (depth, water holding capacity, carbon), and wetness index. We hypothesize that these terrain clusters reflect surface processes that influence regolith thickness, and thus, patterns in water storage across the landscape. This geospatial model will be evaluated this summer with field observations of regolith thickness, tree productivity, and tree health metrics. Ultimately we believe that certain

combinations of terrain attributes can be used to predict regolith thickness and forest productivity at the watershed scale.

C. Oroza constructed a modern, open database of 7 years of continuous, distributed SSCZO soil-moisture data and is analyzing patterns.

Modulation of climate and disturbance. Our flux-tower measurements at three of the sites along the SSCZO elevation transect provided observations on carbon uptake and ET before and during the drought. A high-impact paper (M. Goulden and R. Bales) on pre-drought ET patterns along the full transect was published in fall 2014.

Model-based work to explore how storm-size distributions and vegetation growth influence ET partitioning was initiated. A set of papers will cover results from multi-disciplinary approaches used at the SSCZO to answer questions about the long-term development of geophysical features and the implications for biogeochemical cycling and water fluxes in this region (C. Tague and others).

A second set of RHESSys modeling analyses is examining effects of forest thinning and controlled fire on the water balance. Thinning was carried out in 2013, and controlled burns are planned for 2015. These analysts are integrating the full suite of hydrologic and geophysical measurements across the Providence catchments (Bales, Conklin, and postdoc R. Ray).

Earlier modeling work with RHESSys to quantify the partitioning of incoming precipitation between snow and rain was expanded to the full SSCZO elevation transect. A regional-scale model-based assessment was developed that quantifies the relationship between soil-water-storage-capacity and moderate-climate-warming influences on the partitioning of incoming precipitation between snow and rain. Tague collaborated on a cross CZO synthesis/review paper on water-cycle processes in the critical zone and dynamics (Brooks et al).

Measurements of the critical zone. Our catchment-scale time-series measurements of snow, soil moisture, temperature, and matric potential continued. Our U.S. Forest Service collaborator (C. Hunsaker) continued streamflow and met-station measurements. Additional time-series data came from the flux towers. The replacement Short Hair flux tower was installed in Aug 2014 and instruments will be added in late Jun 2015 (original tower was destroyed by tree fall). SSCZO data underwent quality assurance and quality control, and were posted in our digital library. We performed maintenance on the wireless-sensor network and other components. In fall 2014, several nodes were dismantled in anticipation of a controlled burn, and were later reinstalled when the burning was postponed until 2015.

Additional efforts focused on the design, fabrication, and field-testing of a down-looking, tower-top, remote-sensing package that will be installed at the P301 tower in summer 2015. This system includes a suite of cameras and a terrestrial-scanning LiDAR that will continuously image the area round the tower. The package is designed to provide spatially resolved multi-month records of a variety of local attributes. For example, the LiDAR is intended to continuously image the snow depth in a ~5000 m2 circle around the tower, with a depth accuracy of a few cm and a horizontal resolution of 10 cm. The cameras are intended to continuously image the incident radiation and local temperature of the snow surface. The cameras are also intended to continuously image the temperature of foliage at the site, as well as track the gradual changes in vegetation leaf density

and area with seasonal phenology, drought and recover.

In 2014-2015 we completed testing and installing of 23 new data loggers. These will allow additional sensors to be added to each node and have new wireless radios that improve network performance. We began developing tools to understand the inter-annual patterns of data across WSN nodes.

Specific Objectives: Objectives are described following structure of the five research questions.

Regolith properties and formation. We are evaluating trends in soil and regolith thickness across the altitudinal gradient of the SSCZO. The regolith is being imaged by drilling sampling, and seismic imaging. Our objective is to document the characteristics and profiles of the soil bedrock contact along the transect and constrain weathering and water-storage potentials at depth in order to i) expand previous 2D information to 3D subsurface data and modeling; ii) explore connections between lithology and different vegetation types; and iii) investigate the role of subsurface fracturing and weathering on aboveground productivity. Passive source seismology will be used to accomplish this.

We are working towards understanding of the controls on weathering and regolith formation and the relative importance of dust from various sources in the formation of regolith at each of the sites along the transect. An objective of ongoing work is to understand factors that influence the presence/absence of soil and vegetation across the landscape. An objective is also to evaluate the evolution of pedogenic processes (additions, losses, transformations and translocations) in soils and deep regolith across the altitudinal gradient.

An additional specific goal is to use the bedrock ages to constrain the source elevations of stream sediment, which is ultimately generated from rock on slopes and thus carries a geochemical fingerprint of its origins in the form of U, Th, and He concentrations in apatite crystals.

Critical-zone function. We are studying water and nutrient cycles across the heterogeneous ecosystems and varying regolith of the Southern Sierra. Our objectives are to understand water balances across this landscape, with some emphasis on evapotranspiration and controls on vegetation. This improves our predictive ability around questions such as: i) how does soil water holding capacity influence the partitioning of incoming precipitation and snowmelt between evapotranspiration and runoff, ii) how will species change, specifically conversion from trees to shrub in rain-snow transition areas, influence water fluxes, and iii) how do hot spots and hot moments determine larger-scale and longer-term responses of vegetation, weathering, sediment and nutrient export and other soil processes?

In addition to RHESSYs model work on core research questions, we began a new collaborative cross-site initiative. Tague and Moritz used field measurements and modeling to estimate how shifts from conifer forest to shrubs at the rain-snow transition may alter seasonal and annual hydrographs. This project used flux tower measurements, sap-flow measurements and new set of predawn leaf-water-potential and conductance measurements for co-located shrubs and trees in the Providence watershed (Bart et al., paper in prep).

Regolith-climate-biota feedback. Work to understand the relationship between

elevation/climate and exchanges of carbon and water is being undertaken using flux-tower data. Our objective is to develop information on i) vegetation structure, health, and gas exchange; ii) foliage and biomass temperature, to better understand the controls on winter photosynthesis and summer stress; and iii) the 3D structure of the canopy, as well as the patterns of snow accumulation and melt.

An objective is also to determine the relationship between regolith thickness and forest productivity and health across the altitudinal gradient. Related to this, we also aim to unnderstand factors that influence the presence/absence of soil and vegetation across the landscape.

We want to understand the seasonal variability of soil moisture and temperature. We will continue to look at detailed changes in soil moisture and temperature patterns due to specific local-in-time events.

We are monitoring changes in water storage in soils and deep regolith to understand how soil properties may influence storage of water in deep regolith, and water use by vegetation.

Modulation of climate and disturbance. The ongoing California drought has provided the opportunity to shift objectives to understanding how the water cycle and vegetation respond to hotter, drier conditions. We aim to develop an understanding of system resiliency, along the step and variable climate gradient in the Southern Sierra.

A more-specific objective is to use the SSCZOs unique, continuous, spatially dense soil moisture and matric potential measurements over the multi-year time period to better understand the cumulative impact of multiple years of drought in CA.These data are also unique in that they are accompanied
by coincident measurements of spatially distributed snowpack, solar forcing, temperature, and relative humidity. By developing tools to analyze this data over multiple years, we aim to better understand the cumulative impact of multiple years of drought in CA.

Another important relationship we are addressing is between elevation/climate and nutrient cycling. Collaborative efforts of several SSCZO investigators will integrate geophysical measurements of subsurface structure into model parameterization of soil-water holding capacity (and its spatial pattern) into model estimates of vegetation water use and carbon sequestration.

Measurements of the critical zone. One of the hallmarks of the SSCZO has been the development and use of a wireless-sensor network as part of a spatially extensive catchment-scale measurement program. We aim to continue developing improved methods to optimize placements of the sensor clusters, and sensor nodes within the clusters.

Significant Results: Results are described following structure of the five research questions. Figures are appended in a pdf file.

Regolith properties and formation. Initial data on coupling seismic refraction data with geochemical analyses of cores comes from our temporary deployment of a seismic nodal array across the landscape surface to produce a three-dimensional view of the shear-wave velocity structure in the subsurface. The data are used to infer the distribution of weathering and porosity (Figure 1).

A 2014 paper (J. Hahn et al) reports strong evidence in support of the hypothesis that the notable bimodality in soil and vegetative cover is regulated by differences in the geochemistry of underlying bedrock.

Initial findings of the physical, chemical and mineralogical properties of the soils and underlying deep regolith indicate that while plant-available water-holding capacity is highest at Providence (2000 m), fertility (particularly available P, cation exchange capacity, and exchangeable K) is highest at Soaproot (1100 m).

Physical and mineralogical analysis indicate significant pedogenic transformations in soils and within deep regolith at 1100 m. At 2000 m, processes influencing deep regolith appear to be limited to translocations of pedogenic iron, silica, and manganese from the overlying soil. Transformations, additions or translocations are not evident below the soil zone at the 400-m elevation site.

Further observations demonstrate that soil development and weathered-bedrock thickness are out of phase across the elevation transect. Weathering is constrained by low precipitation at the 400-m site, with the layer <2.5 m thick. Soil development at the 1100-m site is 5 m, and <10 m at 2000 m. Soil development is constrained by temperature at high altitude, with weathered-bedrock thickness <2.5 m. Since rooting has been shown to extend several meters in depth, these trends in thickness suggest that forests are more resilient to drought across an elevation band between ~2000 and 3000 m, given that storage at these depths is maintained.

We have established that the flux of dust from Asian sources is similar to the flux of dust from Central Valley sources, despite the fact that these local dust sources are probably higher currently than they have been over the long-term due to the drought (Figure 2).

Critical-zone function. The center of the meadows continues to be a groundwater-discharge point, even three years into the drought (Figure 3). The magnitude of this discharge signal appears to be decreasing as the drought continues, especially in Aug-Sep. The meadow edge exhibits earlier and greater magnitude groundwater recharge signals as the drought continues (Figure 4). Results for analysis of the water for S-35, an isotope with a 90-day half-life, indicate that the water is over a year old.

Based on our neural-network model we predict that meadow ET was approximately 410 mm in 2013 and 325 mm in 2014. The 21% reduction in ET from 2013 to 2104 is a combination of a delayed start in ET and an earlier plateau of cumulative ET seen in the curve plotted for 2014. This moderate increase in cumulative ET indicated that the forest around P301 transpired at nearly identical rates in both years. The 26% decrease in ET at Soaproot saddle from 2013 to 2014 is attributed to drought stress in this forest system. Our results suggest that meadow ET is on the same order as Forest ET during the snow-free season.

RHESSys modeling shows that with increasing available soil-water storage, forest water use increases with a 2°C warming (Figure 5). The available water content at which ET shifts from decreasing to increasing varies with elevation.

Our monitoring of soil moisture in the upper 10 m of deep regolith at Providence shows that deep regolith is slowly becoming dryer as we enter the 4th year of drought (Figure 6). Volumetric water content in Mar 2015 is approximately 4% below May 2012; and previous years did not show this level of drying. Monthly

observations of water content in 2014-15 indicated minimal change in water content in deep regolith. Lack of precipitation has limited recharge to the upper 1.5 m of soil in most months. Relatively small changes in water content over the past four years at depths greater than three m suggests that water extraction by trees is a gradual process. Prior to 2015, significant drying occured in the top 2 m of soil, especially in late summer. Spring drying, especially in deep regolith did not occur. In 2015, there appears to be a shift in water depletion from drying mainly in the upper 3 m to drying at 10-m depth. With the shallower regolith at the lower two sites, there is less storage available so the profiles dry out quickly and uniformly with depth.

Regolith-climate-biota feedbacks. We found that sediment export varied from 0.4 to 177 kg ha-1, while export of total C was between 0.025 and 4.2 kg C ha-1 and export of total N was between 0.001 and 0.04 kg N ha-1. Sediment yield and composition showed high interannual variation, with higher C and N concentrations in sediment collected in drier years. Annual lateral sediment export was positively and strongly correlated with stream discharge, while C and N concentrations were both negatively correlated with stream discharge; C:N ratios were not strongly correlated to sediment yield (Figure 7) .

Synthesizing results across multiple papers in review, we found that precipitation amount, not nature of precipitation (snow vs. rain) determines the amount and composition of organic matter that is transported by soil erosion. We also found that most of the organic matter exported out of the Providence and Bull catchments is derived from litter and O-horizon, with small contributions from the stream bed and bank. The larger implication of the results is that erosion likely contributes a small terrestrial sink for atmospheric carbon dioxide in forested ecosystems, compared to erosion in agricultural or grassland ecosystems.

Clustering algorithms used to evaluate terrain variables that govern regolith thickness and forest resilience to drought appear to be more complicated (more clusters) at the lower catchments (400 m and 1100 m). Conditions appear to be more uniform (fewer clusters) in at the Providence site at 2000 m elevation. These trends may indicate a greater degree of terrain complexity at lower elevation sites (400 and 1100) that may facilitate non-uniform forest response to drought. There are significant microbial-community differences across these sites as well (Figure 8).

Modulation of climate and disturbance. We found that climate warming has the potential to reduce the mountain runoff by accelerating mountain vegetation growth and ET. Warming projected for 2100 could increase ET across the Kings R basin by 28% and decrease Kings R. flow by 26% (Figure 9a). Moreover, we found a consistent relationship between watershed ET and temperature across the wider Sierra Nevada (Figure 9b).

Flux-tower results show a significant decline in ET during the drought at all 3 elevations, with declines the greatest at lower elevations (Figure 10). These results reinforce the finding of greater subsurface water stirage at the 2000-m site, and least at the 400-m site (paper in prep).

Measurements of the Critical Zone. The SSCZO wireless sensor network continues its seventh year of operation. We have developed a computer program to optimize where in a watershed a representative cluster of sensors should go, and where within the cluster to place nodes. On the smaller scale, the approach, based on machine-learning algorithms, optimizes the locations of the network

elements to ensure smoother operation, more-robust radio connections, and the optimal sensing of site variability. This approach, which brings the real world into the computer science virtual world, actually works very well for the three CZOs it was applied to, SCCZO, Jemez River and Boulder Creek (Figure 11).

Key outcomes or Other achievements:

Outcomes cut across the five research questions.

Some of the more-significant findings from the past year are highlighted below. Together, these give new, integrated insights into the processes determining the differences in regolith formation, weathering, forest density, forest resilience to drought and implications of expected climate change and management actions along the very steep climate-ecosystem gradient covered by the Southern Sierra CZO.

1. We found that the degree of soil development across the altitudinal gradient is out of sync with regolith thickness. Soils are intensely weathered at the Soaproot site (1100 m elev.) where mean annual precipitation and potential evapotranspiration are roughly equal. At this site regolith thickness is less than 4-m. Soils are weakly developed at Providence (2000 m elev.), yet regolith thickness extends beyond 10-m. The presence of surplus water (i.e. mean annual precipitation is greater than potential evapotranspiration) may be responsible for the greater thickening. Soil development and weathered bedrock thickness is limited by low precipitation at 400-m elev.
2. Climate change has the potential to reduce the supply of surface water by accelerating mountain vegetation growth and Evapotranspiration (ET), though the likelihood and severity of this effect are poorly known. We used the Southern Sierra CZO as a test bed to determine the sensitivity of runoff to increased ET with warming. We found that riverflow around the SSCZO is highly sensitive to vegetation expansion; warming projected for 2100 could increase ET across the area by 28% and decrease riverflow by 26%. Moreover, we found a consistent relationship between watershed ET and temperature across the wider Sierra Nevada; this consistency implies a potential widespread reduction in water supply with warming, with important implications for California's economy and environment (published in PNAS, Sept 2014).
3. Our results suggest that variability in stream discharge, more than sediment source, is a primary factor controlling the magnitude of C and N eroded from upland forest catchments. Sediment fluxes are comparable to hillslope sediment production rates, but overall are small compared to NPP and soil C and N pools, resulting in only a small net change to the carbon balance for these catchments. The larger implication of the results is that erosion likely contributes a small terrestrial sink for atmospheric carbon dioxide in forested ecosystems, compared to erosion in agricultural or grassland ecosystems.
4. We have found that the flux of dust into the Providence catchments is currently greater than the flux of sediment out of the catchments, as measured in the sediment traps. This is a surprise. It suggests that the input-output mass balance of soil in the ecosystem is strongly influenced by exogenous inputs.
5. We have established that the flux of dust from Asian sources is similar to the flux of dust from Central Valley sources, despite the fact that these local dust sources are probably higher currently than they have been over the long term due to the drought. Again, this will be a surprise to many. Although the importance of transoceanic dust fluxes has been recognized in supplementing the nutrient budget of intensely weathered soils (e.g., in Hawaii and the

Amazon), its importance in montane ecosystems has not been clear.

*** What opportunities for training and professional development has the project provided?**

Students and postdocs associated with the SSCZO receive both formal and informal training in technical issues, and in science communication. At the undergraduate level, students from UC Merced and partnering universities have worked as field and lab technicians. In addition, using supplemental funds from NSF, two REU students worked with the SSCZO in 2014. One focused on soil nutrient cycling while the other worked on meadow water balance.

This marks the fourth year for the UC Merced surface-water methods workshop course, developed by M. Conklin, and the sixth successive year for the UC Davis field-methods course, developed by SSCZO researcher P. Hartsough. The SSCZO site visits with Hartsough and Conklin with the SSCZO staff allow students to learn about research and to collect data for use in class. These classes serve both CZO and non-CZO students.

SSCZO research provided material for other university courses as well. M. Conklin and others are part of an InTeGrate team to develop a critical-zone processes course, which she will teach in fall 2015. Baseline CZO RHESSys model implementations were used to develop educational materials for two courses: ESM 237 Climate Change Impacts and Adaptation, a graduate course in the Bren School for Environmental Science and Management and ESM 495 Introduction to hydrologic modeling. RHESSys simulation results from CZO were also integrated into a new CUASHI Watershed Hydrology Master Class held at Biosphere 2 in Tuscon Arizona. C. Tague was the hydrologic-modeling instructor. R. Bales taught a Mountain Hydrology graduate class at both UCM and UCB, based in part on SSCZO and cross-CZO results. Again, these classes serve both CZO and non-CZO students.

Students regularly work with faculty members to brief visitors to campus, and present off campus to both scientific and public audiences (see Products, and also Dissemination, below). For example, graduate student R. Lucas presented his research to staff and members from 11 Senate and Assembly member offices, as part of University of California Graduate Research Advocacy Day at the State Capitol. Master's student M. Pickard appeared on TV, along with R. Bales, as part of a drought story at one of our field sites.

Several graduate students, undergraduates and recent Ph.D. graduates are involved with the SSCZO, and are preparing themselves for independent measurement and data analysis work in field hydrology, biogeochemistry, geophysics, and modeling. The wireless-sensor network remains an uncommon approach to gathering remote field data. The network installed at the Southern Sierra CZO consists of 57 wireless nodes, constituting one of the largest wireless networks for this purpose. Through the work on the wireless sensor network, training and experience continues for both investigators and graduate students. In addition, two undergraduate students gained first-hand experience in field work and data analysis through the Research Experience for Undergraduates program, funded through a supplemental grant.

*** How have the results been disseminated to communities of interest?**

As described in our Management Plan, from the outset the SSCZO was planned as a resource for the critical-zone research community; and our team has actively engaged other scientists in using this resource. Public education and outreach are equally important; and our activities target both key decision makers and the public. Our SSCZO team members – investigators, graduate students and staff – do knowledge-transfer, dissemination and engagement activities on a regular basis.

Science community. Dissemination to the science community includes alerting potentially interested colleagues of our publications and presentations through our web pages and email, attending scientific meetings and workshops, and participating in CZO-network activities. Over the past year SSCZO team members have organized sessions, given invited talks and contributed presentations based on SSCZO work at annual meetings of the American Geophysical Union (AGU), the Geological Society of America (GSA) the Ecological Society of America and the Goldschmidt conference in Prague, Czech Republic. We also participated in regional scientific meetings, and smaller specialty conferences such as the recent Mountain Research Initiative Global Fair and Workshop on Mountain Observatories in Reno, NV and the CUASHI 4th Biennial Colloquium. Our team also contributed to CZO network activities at AGU, GSA, Goldschmidt and other meetings. During the past year we hosted field trips to the SSCZO for

one national and one international scientific meeting that were held nearby. The Southern Sierra CZO hosted the 2014 All Hands Meeting for the CZO Network in Sep 2014.

Regional stakeholders and the public. Our communication and sharing of scientific products with stakeholders includes frequent talks around the state, briefings to decision makers, hosting of visits to our laboratories and SSCZO site, news articles in local publications, op-ed pieces in newspapers, radio interviews, television reports and web publications. In addition to stakeholders and decision makers, the SSCZO has an active program of education and outreach to K-16 and the general public using CZO data and results.

Two products from the SSCZO have dominated our engagement with regional stakeholders and the public. Conversations around both have heightened because of the drought, and will impact both drought preparedness and sustainability of Sierra Nevada ecosystem (critical-zone) services.

First, our work is informing the debate around water benefits of forest management, with emphasis on climate change and runoff from the Sierra Nevada. Given the unsustainable forest structures in an area that provides about 60% of California's water supply, there is widespread interest in bringing new resources and tools to watershed management. It is also well recognized that the knowledge base for predicting the effects of different management approaches is insufficient. We share our findings about montane forests and their water supplies with resources managers, students, researchers, and stakeholders at local to international scales.

A second major focus has been on working with water leaders in the state to define and develop prototypes for a new water-information system for California that builds on advances in wireless-sensor networks developed at the SSCZO, plus parallel advances in cyberinfrastructure and in measurements by satellite and aircraft.

In addition to talks and briefings and talks listed as products, our team did several informal briefings to elected officials visiting our laboratories (Modesto city council members, Calaveras and Stanislaus County supervisors, local congressman, board members from various water agencies). We also hosted lab visits by university trustees, members of the business community, university donors, agency staff and others.

The ongoing drought has brought us many requests for media interviews. A French film crew visited our mid-elevation sites to film a documentary about water on planet Earth; M. Conklin, and others participated. R. Bales has done several radio and television interviews over the past year, including on public radio in Fresno and San Francisco, NPR nationally, local television in Sacramento, nationally on the Lou Dobbs show on Fox Business News and others.

Within California 48 Integrated Regional Water Management Groups have formed, with the aim of implementing regional solutions to the state's water challenges. Beginning in 2017, these groups will have access to a billion dollars of grant funds to upgrade infrastructure, address knowledge gaps, adapt for climate change, and meet other 21st century challenges. Our team has engaged with over 10 groups having an interest in the Sierra Nevada, and regularly attended meetings, hosted members and collaborated to bring CZO technology to other parts of the Sierra Nevada through state grants. We also engage with multi-agency groups planning and financing forest-restoration activities. For example, E. Stacy continues SSCZO contributions to the Dinkey Landscape Restoration Project; R. Bales and M. Safeeq contribute to the Tulare basin Watershed Connections group; and R. Bales recently presented to a Calaveras forest-management group.

In addition to stakeholders and decision makers, the SSCZO has an active program of education and outreach to K-16 (mainly 7-16) and the general public using CZO data and results. Some of the most-successful education and outreach activities over the past year include building relationships with schools and local organizations. These activities are designed to meet new common-core standards for analytical thinking and problem solving. Partnerships with NatureBridge Yosemite, the Center for Advanced Research and Technology, and other institutions will share research results with educators and students alike. NatureBridge has provided award-winning, residential outdoor education programs in Yosemite National Park (YNP) for school groups since 1971. Approximately 13,000 California students cycle through this program every year. Four SSCZO researchers and staff members presented to NatureBridge teachers this past year, and M. Conklin remains a member of the NatureBridge Yosemite board. SSCZO researchers and education staff also present to grade school students multiple times per year.

Other K-12 partnerships include presenting each year at Southern California Edison's Science Days (4th year) and the American Association of University Girls Science Camp (5th year). At these events CZO colleagues facilitate hands-on activities for students that focus on how Sierra Nevada hydrology impacts California's water resources. At our high school partnership with the Center for Advanced Research and Technology (CART) in Clovis, CA, CZO staff mentoring teams of CART students to conduct a soil-moisture research project (4th consecutive year). Lacking snow the students designed a project to investigate the influence of forest density on soil moisture. L. Sullivan met twice with Merced students from Golden Valley and Atwater High Schools, followed by a lab visit.

Over the next year our outreach using public talks, briefings with decision makers and presentations at scientific meetings will continue along the lines initiated in past years. Some of the additional highlights planned for the next several months follow.

- The Annual Team Meeting will be held Aug 18-19 in Shaver Lake. Approximately 30 researchers attend each year to exchange research results, plan field work, and strategize for the coming year. Local collaborators (in California) join us when schedules allow.
- SSCZO scientists plan to present at the public meeting for the Dinkey Landscape Restoration Project, currently planned for Aug 21. Local elected officials, landowners, and other stakeholders have attended past meetings.
- Presentations are also planned for additional stakeholder groups this summer.

We have been asked by producers of a PBS Nature documentary on the Sierra Nevada to film in July.

*** What do you plan to do during the next reporting period to accomplish the goals?**

The next reporting period will include the balance of year 2 (through Sep 30) and extend through part of year 3. Some work in progress is described above, with a summary of key activities provided here. Several graduate students, postdocs and senior investigators have completed their research and papers based on their work are being submitted for publication. Field research and modeling are proceeding, with several upgrades and subsurface investigations enabled by the new cooperative agreement. New collaborators are also joining the SSCZO. Many of the outreach activities described for 2013-14 are continuing, with additional activities being added for the coming year (see dissemination section). Plans for next year are described following the structure of the five research questions.

Regolith properties and formation. We will instrument the excavations in soil and weathered bedrock with water-potential sensors in summer 2015. Our nodal seismic array will be used to study deep-critical-zone processes and properties. Our geochemical analyses of regolith and rock samples will continue at these three new sites along the altitudinal transect. New grad student R. Callahan (UWy) will work on synthesizing the large volume of geochemical data on weathering, with the cosmogenic nuclide data on erosion that has been collected over the years. Work also continues on understanding factors that influence the presence/absence of soil and vegetation across the landscape. We will also continue our sampling and analysis of aeolian dusts. New grad student L. Arvin (UWy) is seeking a mechanistic understanding of the observed bimodality in soil and vegetative cover controlled by soil chemistry. UWy student N. Taylor will continue exploring critical-zone architecture using passive source seismology.

Work will also focus on quantitative models that describe watershed-scale patterns in weathered bedrock and its relationship to forest productivity. We will investigate the extent to which soil-forming factors, (time, topography, parent material, organisms, and climate) can explain spatial variability of weathered bedrock characteristics, and which factors are more important. Along with this we will study the degree to which digital-soil-mapping techniques and their digital proxies (terrain attributes, airborne-gamma-ray mapping, remote sensing) can explain weathered bedrock thickness and mineralogical, chemical, biological and physical characteristics? We also aim to model how the degree of soil development influence processes in weathered bedrock? This will come together with above-ground landscape characteristics, as we seek a fundamental scaling relationship between the depth of regolith, canopy height, and depth of chemical alteration of bedrock. Finally, we aim to complement hydrologic research to study how hydrologic monitoring and physical characterization of deep weathered bedrock reflect trends in forest response to drought.

Critical-zone function. We plan to deploy the remote-sensing package that was developed over the past year at the P301 site. This system includes separate Vis/NIR and thermal-IR cameras, along with a terrestrial-scanning LiDAR. Instruments will be added to the replacement Short Hair flux tower in late June 2015. We will continue exploring

possible sites above treeline for a higher-elevation flux tower.

We will complete the initial analysis of surface-groundwater exchange of Sierra Nevada montane meadows in the context of greater watershed processes. A new student (M. Thaw) and collaborator from Lawrence Livermore National Laboratory have initiated biogeochemical investigations in meadows.

New UCSB student B. Kastl will investigate how different designs and presentations of model results (specifically RHESSys) are interpreted by non-scientists, including resources managers.

During the summer we will continue on collecting soil samples from the SSCZO transect; developing plans for work in the CJCZO (A. Moreland) and Inyo (M. Barnes) and continuing data analysis on the water samples we have been working on. We will establish productivity plots (for measuring above and belowground productivity and soil respiration) along the SSCZO transect, and take some preliminary leaf-level tree physiological measurements (P. Austin). We will sample soils within the Bull catchments to evaluate changes in soil microbial communities (focusing on mycorrhizae) 1.5 - 2.5 y after forest disturbance (N. Dove). Graduate student Dove will also visit a series of wildfire sites across the mixed-conifer zone of the Sierra looking for suitable sites to expand his mycorrhizal-disturbance work. E. McCorkle (SSCZO alum), M. Barnes (new CZO grad student), Newman (REU researcher), Berhe, Hart, and Hunsaker are currently analyzing the steam geochemical data and plan to submit a manuscript focusing on dissolved C and N fluxes.

Regolith-climate-biota feedbacks. Sediment sampling, soils analyses, and hydrologic/biogeochemical analyses will continue, in concert with tasks described above under regolith properties and formation, and critical-zone function. We are planning to install gas wells and continue further sampling of soils from the entire chronosequence during the summer and fall 2015. We plan to complete a manuscript on based on analysis of 7 years of distributed soil-moisture data, including investigations the rate and seasonality of water infiltration, and drying behavior of the soil and saprock.

We will also collaborate across the SSCZO team to integrate geophysical measurements of subsurface structure into RHESSys model parameterization of soil-water-holding capacity (and its spatial pattern) into model estimates of vegetation water use and carbon sequestration. This work is targeted for set of complementary papers on results from multi-disciplinary approaches used at the Sierra CZO to answer questions about the long-term development geophysical features and the implications for biogeochemical cycling and water fluxes in this region.

Modulation of climate and disturbance. The SSCZO is remarkably well poised to track and understand the hydrological and ecological impacts of the ongoing severe drought in California. The drought's epicenter is roughly located in eastern Fresno County, which is the home of the CZO. A key goal for the coming year will be to begin to synthesize and understand what these data tell us about the vulnerability and mechanistic controls on the impact of extraordinary drought on montane ecology and hydrology. A paper on drought impacts using the flux-tower data is in preparation. This paper also draws on the distributed soil-moisture, snow, precipitation, streamflow and temperature measurements across the catchments.

We plan to complete the data analysis and RHESSys modeling of vegetation treatments at Providence and other measurement sites in summer 2015. Work already in progress includes regional-scale analysis, and expansion of model-based work to explore how storm size distributions and vegetation growth influence ET partitioning. A set of papers will cover results from multi-disciplinary approaches used at the SSCZO to answer questions about the long-term development geophysical features and the implications for biogeochemical cycling and water fluxes in this region.

Measuring the critical zone. The summer months in 2015 are critical to our SSCZO measurement program, and tasks in addition to those noted above will include the following.

- Update the wireless sensor network, including installation of a cellular network repeater, base station, and repeaters to complete the network.
- Do more geophysical work at three sites in preparation for drilling.
- Reassign P301 sapflow/soil moisture equipment at other locations.
- Deploy an eddy-correlation station in Long Meadow (SEKI NP)

- Continue hydrologic measurements (both fluxes and water chemistry, including S-35) in P301 and Long meadows.

Supporting Files

Filename	Description	Uploaded By	Uploaded On
SSCZO_2015_Participants.pdf	Full table of participants, including PIs, advisory board, staff, students, and more than 50 collaborators.	Roger Bales	05/25/2015
Figures_SSCZO_accomplishments.pdf	Figures for Results section of Accomplishments, SSCZO	Roger Bales	05/30/2015
SSCZO_Mgmt_Plan_2014.pdf	SSCZO Management Plan	Roger Bales	05/31/2015
Additional_Reporting_SSCZO.pdf	Additional reporting requirements, SSCZO	Roger Bales	06/03/2015

Products

Books

Book Chapters

Conference Papers and Presentations

Aronson, E.; C. Carey; C. Riebe; S. Aciego; S. Hart. (2014). *Altitudinal contrasts in drought-driven aeolian microbial inputs to montane soil ecology: impacts of a 500-year drought in the Sierra Nevada, California. Abstract # B23E-0247.*. AGU Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Berhe, A.A.; E. McCorkle; E. Stacy; S. Hart; C. Hunsaker; D. Johnson. (2014). *Composition and mean residence time of soil organic matter eroded from temperate, forested catchments: implications for erosion-induced carbon sequestration. Abstract #B12B-02.*. AGU Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Tague, C.L. (2014). *Consequences of warming temperatures and shifts in precipitation regimes for snow-dominated mountain systems.*. 12th British Hydrological Society National Symposium. University of Birmingham, England. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

R. Lucas; M. Conklin; R. Rice; T. Ghezzehei (2014). *Determination of specific yield of montane meadow soils, Sierra Nevada, CA. (Abstract H53B-0852)*. AGU Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Goulden, M.L., and others (2014). *Developing in-situ imaging tools to quantify vegetation stress, plant mortality, and species composition. (Invited Presentation).*. AGU Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Riebe, C. S., and Hahm, W. J. (2014). *Geologic limits on mountain ecosystem productivity and landscape evolution*. Soil Science Society of America, Annual Meeting. Long Beach, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Tague, C.N.; E. Garcia; X. Chen; C. Heckman (2014). *Linking geology, climate and disturbance response in*

California mountain environments. (Abstract H53I-03). AGU Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Tague, C.L. (2014). *Modeling interactions among vegetation structure, function and sensitivity to climate variability and change in mountain watersheds*. Computational Methods in Water Resources International Conference. University of Stuttgart, Germany. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Goulden, M.L., and others. (2014). *Mountain Runoff Vulnerability to Increased ET with Climate Warming. (Invited presentation)*. AGU Fall Meeting,. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Oroza, C, Zheng, Z, Glaser S, Bales, R. (2014). *Optimization of Sensor Placements Using Machine Learning and LIDAR data: a Case Study for a Snow Monitoring Network in the Sierra Nevada*. AGU Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Baguskas S, Bart R, Molinari N, Tague C, Moritz M (2014). *Potential effects of tree-to-shrub type conversion on streamflow in California's Sierra Nevada*. CZO All Hands Meeting. Fish Camp, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Baguskas S, Bart R, Molinari N, Tague C, Moritz M. (2014). *Potential effects of tree-to-shrub type conversion on streamflow in California's Sierra Nevada*. AGU Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Tague, C.L. (2014). *Seasonal and multi-year ecohydrologic responses to forest thinning*. AGU Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Musselman, K.; N. Molotch; S. Margulis (2014). *Snowmelt sensitivity to warmer temperatures: a field-validated model analysis, southern Sierra Nevada, California.(Abstract C43A-0365)*. AGU Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

O'Geen, A.T. (2014). *Soil Stratigraphic relationships influence temporal and spatial patterns in hydrology.*. Soil Science Society of America. Long Beach, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Ferrier, K.; C. Riebe; W.J. Hahm; J. Kirchner (2014). *Testing for supply-limited chemical erosion in field measurements of soil production and chemical depletion (Abstract EP13E-04).*. AGU Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Tague, C.L. (2014). *Translating physiological drought into tree stress and forest response*. Ecological Society of America annual meeting. Sacramento, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Riebe, C. S., and Granger, D. E. (2014). *Using cosmogenic nuclides in multiple detrital minerals to infer rates of erosion and differential weathering*. British Society for Geomorphology, Annual Meeting. University of Manchester, England, UK. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

McCorkle, E.; A.A. Berhe; C. Husaker; M. Fogel; S. Hart. (2014). *Using isotopes to source eroded carbon in captured sediments of two western Southern Sierra Nevada catchments. Abstract TS2*. 2014 CZO All Hands Meeting. Fishcamp, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Kelly, A.; M. Goulden (2014). *Water use efficiency variability and controls across ten California ecosystems. (Abstract H33L-06)*. AGU Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Inventions

Journals

Adrian A. Harpold, Noah P. Molotch, Keith N. Musselman, Roger C. Bales, Peter B. Kirchner, Marcy Litvak and Paul

D. Brooks (2014). Soil moisture response to snowmelt timing in mixed-conifer subalpine forests. *Hydrological Processes*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: DOI: 10.1002/hyp.10400

Beaudette, D.E. and A.T. O'Geen. (). Effectiveness of terrain attributes and parent material on digital soil modeling. *Soil Science Society of America Journal.*. . Status = SUBMITTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Brooks, P., Chorover, J., Reinfelder, Y., Godsey S., Maxwell, R., McNamara J., Tague, C. (). Hydrological Partitioning in the Critical Zone: Recent Advances and Opportunities for Developing Transferrable Understanding of Water Cycle Dynamics. *Water Resources Research*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Dixon, J. L., Riebe, C. S. (2014). Tracing and pacing soil across slopes. *Elements*. 5 (10), . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.2113/gselements.10.5.363

Ferrier, K.L., Riebe, C. S., and Hahm, W. J. (). Testing for supply-limited and kinetic-limited chemical erosion in field measurements of regolith production and chemical depletion?. *Geochemistry, Geophysics, Geosystems*. . Status = SUBMITTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Goulden, M.L., R.C. Bales (2014). Mountain runoff vulnerability to increased evapotranspiration with vegetation expansion. *Proceedings of the National Academy of Sciences*. 111 (39), 14071. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1073/pnas.1319316111

Kelly, A. E., and Goulden, M.L. (2015). A montane Mediterranean climate supports year round growth and high biomass. *Tree Physiology*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Kirchner1, P.B., Bales, R.C., Molotch, N.P., Flanagan, J., Guo, Q. (2014). LiDAR measurement of seasonal snow accumulation along an elevation gradient in the southern Sierra Nevada, California. *Hydrology and Earth System Science*. 18 . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.5194/hess-18-4261-2014

Lucas, R.G., M.H. Conklin, S. Tyler, J. Moran and F. Suarez (). Polymictic pool behavior in montane meadows, Sierra Nevada, CA. *Hydrologic Processes*. . Status = SUBMITTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Oroza, C, Zheng, Z, Glaser S, Bales, R. (2015). Identification of representative sampling regions, optimal sensor number, and resilient network topologies for wireless SWE observatories using LiDAR and machine learning.. *Water Resources Research.*. . Status = SUBMITTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

R. Bales, R. Rice, S. Roy (2014). Estimated Loss of Snowpack Storage in the Eastern Sierra Nevada with Climate Warming. *J. Water Resour. Plann. Manage*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1061/(ASCE)WR.1943-5452.0000453

Riebe, C. S., Hahm, W. J., Brantley, S. L. (2014). Going deep to quantify limits on weathering in the Critical Zone. *Earth Surface Processes and Landforms*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Riebe, C. S., Sklar, L. S., Lukens, C. E., and Shuster, D. L. (). Climate and topography control the size and flux of sediment produced on steep mountain slopes. *Proceedings of the National Academy of Sciences*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Riebe, C.S., Sklar, L.S., Lukens, C E.* & Shuster, D.L (). Climate and topography control the size and flux of sediment produced on steep mountain slopes. *Proceedings of the National Academy of Sciences*. . Status = SUBMITTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Son, K. and Tague, C. (). Importance of soil parameter uncertainty in assessing climate change projections in small two Sierra Nevada watersheds. *Water Resources Research*. . Status = SUBMITTED; Acknowledgment of Federal Support = Yes

Stacy, E., Hart, S.C., Hunsaker, C.T., Johnson, D.W., and A.A. Berhe. 2015. (2015). Soil carbon and nitrogen erosion in forested catchments: implications for erosion-induced terrestrial carbon sequestration.. *Biogeosciences Discuss*. 12 (2491-2532), . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.5194/bgd-12-2491-2015

Stacy, E., Hart, S.C., Hunsaker, C.T., Johnson, D.W., and A.A. Berhe. (). Soil carbon and nitrogen erosion in forested catchments: implications for erosion-induced terrestrial carbon sequestration.. *Biogeosciences*. . Status = SUBMITTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Tague, C., and Moritz M. (). Testing common assumptions associated with thinning as a fire-hazard reduction treatment in water limited forests. *Forest Ecology and Management*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Licenses

Other Products

Other Publications

Patents

Technologies or Techniques

Neomote Wireless Sensor Network: The Glaser-Bales team has been installing the new generation of wireless sensor stations. The new WSN boards provides a platform that provides the capacity for a wide range of sensors, up to forty analog and/or digital, to be added to the current twelve. The network will be comprised of 27 sensor nodes and 30 data relay nodes.

Thesis/Dissertations

Kelly, A. E.. *Climate controls on ecosystem production, biomass, and water cycling.*. (2014). University of California, Irvine. Acknowledgement of Federal Support = Yes

Lucas, Ryan Geoffrey. *Polymictic pool behavior in a montane meadow, Sierra Nevada, CA*. (2015). UC Merced: Environmental Systems. Acknowledgement of Federal Support = Yes

Websites

SSCZO Digital Library
https://eng.ucmerced.edu/snsjho/files/MHWG/Field/Southern_Sierra_CZO_KREW

The main SSCZO online presence is through the CZO website and the SNSJHO digital library. Data, metadata, photos, reports, and other documents are catalogued in the SNSJHO digital library. Data access for public data and files is available to anyone. Additional permissions can be obtained through registration. Criticalzone.org data links connect back to this repository.

SSCZO Facebook
http://www.facebook.com/SouthernSierraCZO

The Southern Sierra CZO updates a SSCZO Facebook page, which is the only active one known to this group. This page is slowly growing, and reaches a local cross-discipline audience (broader than environmental science, hydrology, or the CZO network). The audience is more location based, centered around Merced and SSCZO reseachers.

SSCZO Twitter
http://www.twitter.com/SSCZO

The Southern Sierra CZO was the first CZO in the network with an active Twitter account. Now that the network has expanded and other CZOs are active on Twitter, it is a space for the SSCZO to connect with others observatories and researchers interested in critical zone science. Southern Sierra CZO posts events, photos, and links to other pertinent stories and blog posts on the Twitter page. This avenue has been useful in reaching researchers, media and other professionals, particularly in publicizing research presentations during professional conferences.

Southern Sierra Critical Zone Observatory
http://www.criticalzone.org/sierra

This website is the home of the Southern Sierra CZO. In the 2014-2015 year, SSCZO staff expanded the research field areas, posted multiple opportunities, and regularly updated field and research activities. Staff addressed issues identified in the website content inventory (May 2014), and focused on news stories, interactive maps, photo galleries, and disseminating information for the All Hands Meeting, and field trips to the SSCZO sites.

Twitter - Roger Bales
https://twitter.com/rbalesuc

Since SSCZO PI Roger Bales started a Twitter page in December 2014, he has garnered 262 followers. His page is active in conversations regarding water usage, hydrologic technology and infrastructure, and the CA drought.

Participants/Organizations

Research Experience for Undergraduates (REU) funding

Form of REU funding support:	REU supplement
How many REU applications were received during this reporting period?	10
How many REU applicants were selected and agreed to participate during this reporting period?	2
REU Comments:	

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Bales, Roger	PD/PI	2
Conklin, Martha	Co PD/PI	2
Goulden, Michael	Co PD/PI	2
Riebe, Clifford	Co PD/PI	2
Tague, Christina	Co PD/PI	1
Berhe, Asmeret Asefaw	Co-Investigator	2
Glaser, Steven	Co-Investigator	1

Hart, Stephen	Co-Investigator	2
O'Geen, Anthony	Co-Investigator	2
Bart, Ryan	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Fellows, Aaron	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Kelly, Anne	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Williams, Liz	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Busse, Matt	Other Professional	0
Choate, Janet	Other Professional	4
Davis, Frank	Other Professional	0
Graham, Bob	Other Professional	0
Guo, Qinghua	Other Professional	1
Hopmans, Jan	Other Professional	1
Hunsaker, Carolyn	Other Professional	1
Johnson, Dale	Other Professional	2
Meadows, Matt	Other Professional	1
Meng, Xiande	Other Professional	9
Stacy, Erin	Other Professional	12
Sullivan, Lynn	Other Professional	3
Womble, Patrick	Other Professional	1
Hartsough, Peter	Staff Scientist (doctoral level)	6
Safeeq, Mohammad	Staff Scientist (doctoral level)	4
Alldritt, Katelin	Graduate Student (research assistant)	6

Alvarez, Otto	Graduate Student (research assistant)	1
Austin, Paige	Graduate Student (research assistant)	4
Barnes, Morgan	Graduate Student (research assistant)	4
Caillat, Alexandre	Graduate Student (research assistant)	2
Dove, Nicholas	Graduate Student (research assistant)	4
Ferrell, Ryan	Graduate Student (research assistant)	6
Flanagan, Jacob	Graduate Student (research assistant)	1
Kastl, Brian	Graduate Student (research assistant)	2
Lucas, Ryan	Graduate Student (research assistant)	10
Lukens, Claire	Graduate Student (research assistant)	4
McCorkle, Emma	Graduate Student (research assistant)	3
Moreland, Kimber	Graduate Student (research assistant)	4
Oroza, Carlos	Graduate Student (research assistant)	6
Rungee, Joe	Graduate Student (research assistant)	4
Son, Kyongho	Graduate Student (research assistant)	10
Taylor, Nick	Graduate Student (research assistant)	4
Thaw, Melissa	Graduate Student (research assistant)	4
Tian, Zhiyuan	Graduate Student (research assistant)	6
Wilson, Stu	Graduate Student (research assistant)	1
Wrangham, Ian	Graduate Student (research assistant)	4
Zheng, Zeshi	Graduate Student (research assistant)	1
Busse, Nick	Undergraduate Student	3
Clegg, Joshua	Undergraduate Student	3
Dziegiel, Abby	Undergraduate Student	1

Newman, Alexander	Research Experience for Undergraduates (REU) Participant	3
Offorjebe, Obinwanne	Research Experience for Undergraduates (REU) Participant	2
Deng, Jiayou	Other	4

Full details of individuals who have worked on the project:

Roger C Bales
Email: rbales@ucmerced.edu
Most Senior Project Role: PD/PI
Nearest Person Month Worked: 2

Contribution to the Project: PI, oversight, planning, team lead, hydrologic balance

Funding Support: CZO, other funding

International Collaboration: No
International Travel: No

Martha H Conklin
Email: mconklin@ucmerced.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 2

Contribution to the Project: CZO co-PI, InTeGrate Critical Zone course, groundwater-surface water interactions, especially in meadows

Funding Support: CZO, UCM, other funding

International Collaboration: No
International Travel: No

Michael L Goulden
Email: mgoulden@uci.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 2

Contribution to the Project: Co-PI, flux towers, development of tower-top remote sensing system

Funding Support: CZO, UCI, other funding

International Collaboration: No
International Travel: No

Clifford S Riebe
Email: criebe@uwyo.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 2

Contribution to the Project: Co-PI, geophysics, regolith formation and erosion, vegetation-landscape interactions

Funding Support: CZO, U Wyoming, others

International Collaboration: Yes, Australia
International Travel: Yes, United Kingdom - 0 years, 0 months, 3 days

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Christina Tague
Email: ctague@bren.ucsb.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 1

Contribution to the Project: Co-PI, system modeling especially with RHESSys

Funding Support: CZO, UCSB, others

International Collaboration: No
International Travel: Yes, United Kingdom - 0 years, 0 months, 3 days; Germany - 0 years, 0 months, 3 days

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Asmeret Asefaw Berhe
Email: aaberhe@ucmerced.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 2

Contribution to the Project: Sediment transport & nutrient cycling

Funding Support: CZO & other funds

International Collaboration: No
International Travel: No

Steven Glaser
Email: glaser@berkeley.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

Contribution to the Project: University of California, Berkeley; Investigator

Funding Support: UC salary

International Collaboration: No
International Travel: No

Stephen Hart
Email: shart4@ucmerced.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 2

Contribution to the Project: Sediment transport, nutrient cycling

Funding Support: CZO & other funds

International Collaboration: No
International Travel: No

Anthony O'Geen
Email: atogeen@ucdavis.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 2

Contribution to the Project: Controls on weathering & regolith formation

Funding Support: CZO & other funds

International Collaboration: No
International Travel: No

Ryan Bart
Email: ryanrbart@berkeley.edu
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 1

Contribution to the Project: Post-doctoral student working with Tague and collaborator M. Moritz on shrubs, modeling, and vegetation-water interactions

Funding Support: Other

International Collaboration: No
International Travel: No

Aaron Fellows
Email: afellowswork@gmail.com
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 1

Contribution to the Project: Analysis and data QA/QC for flux tower data

Funding Support: Others

International Collaboration: No
International Travel: No

Anne Kelly
Email: a.kelly@uci.edu
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 1

Contribution to the Project: Previous graduate student, writing and preparing papers for publication

Funding Support: CZO & other

International Collaboration: No
International Travel: No

Liz Williams
Email: ewilliams22@ucmerced.edu
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 1

Contribution to the Project: Postdoctoral researcher working with senior personnel Berhe and collaborator Fogel on project for OM retention and stabilization in the subsurface

Funding Support: Other

International Collaboration: No
International Travel: No

Matt Busse
Email: mbusse@fs.fed.us
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 0

Contribution to the Project: USFS Pacific Southwest Research Station, advisory board

Funding Support: Other; CZO funds for travel for Advisory Board duties

International Collaboration: No
International Travel: No

Janet Choate
Email: jsc.eco@gmail.com
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 4

Contribution to the Project: University of California, Santa Barbara; RHESSys technical support staff

Funding Support: UCSB

International Collaboration: No
International Travel: No

Frank Davis
Email: fd@bren.ucsb.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 0

Contribution to the Project: Advisory Board; University of California, Santa Barbara

Funding Support: Other; CZO funds for travel for Advisory Board duties

International Collaboration: No
International Travel: No

Bob Graham
Email: robert.graham@ucr.edu
Most Senior Project Role: Other Professional

Nearest Person Month Worked: 0

Contribution to the Project: University of California, Riverside; advisory board

Funding Support: Other; CZO funds for travel for Advisory Board duties

International Collaboration: No
International Travel: No

Qinghua Guo
Email: qguo@ucmerced.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: University of California, Merced; Sr. Personnel

Funding Support: UCM, other funds

International Collaboration: No
International Travel: No

Jan Hopmans
Email: jwhopmans@ucdavis.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: University of California, Davis; Collaborator, Alumni Investigator

Funding Support: Other funds

International Collaboration: No
International Travel: No

Carolyn Hunsaker
Email: chunsaker@fs.fed.us
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: USFS Pacific Southwest Research Station; Sr. Personnel

Funding Support: Forest Service

International Collaboration: No
International Travel: No

Dale Johnson
Email: forestrangesoils@gmail.com
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 2

Contribution to the Project: University of Nevada, Reno; Collaborator, Alumni Investigator

Funding Support: Other funds

International Collaboration: No
International Travel: No

Matt Meadows
Email: mmeadows@ucmerced.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: SSCZO staff - Field Manager, ending May 23, 2014, continued as a parttime consultant through November 17, 2014

Funding Support: CZO & other

International Collaboration: No
International Travel: No

Xiande Meng
Email: xmeng@ucmerced.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 9

Contribution to the Project: SSCZO Staff - Data Manager

Funding Support: CZO & other funds

International Collaboration: No
International Travel: No

Erin Stacy
Email: estacy@ucmerced.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 12

Contribution to the Project: SSCZO Staff - Outreach Manager, covering field duties in absence of M. Meadows, Full time Field Manager starting November 10

Funding Support: CZO funds

International Collaboration: No
International Travel: No

Lynn Sullivan
Email: lsullivan3@ucmerced.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 3

Contribution to the Project: Part-time staff for Outreach and Education projects including InTeGrate course, STEM-TRACKS, and others

Funding Support: CZO

International Collaboration: No
International Travel: No

Patrick Womble
Email: pwomble@ucmerced.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: University of California, Merced; Primarily other projects in SNRI

Funding Support: UCM, other funds

International Collaboration: No
International Travel: No

Peter Hartsough
Email: phartsough@ucdavis.edu
Most Senior Project Role: Staff Scientist (doctoral level)
Nearest Person Month Worked: 6

Contribution to the Project: Relationships between soils and weathered bedrock in the O'Geen lab

Funding Support: CZO & other

International Collaboration: No
International Travel: No

Mohammad Safeeq
Email: msafeeq@ucmerced.edu
Most Senior Project Role: Staff Scientist (doctoral level)
Nearest Person Month Worked: 4

Contribution to the Project: Staff Scientist on the project, working collaboratively between UCMerced and Pacific Southwest Research Station (Forest Service)

Funding Support: UCM, others

International Collaboration: No
International Travel: No

Katelin Alldritt
Email: kalldritt@ucdavis.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 6

Contribution to the Project: Graduate student in O'Geen lab, work on neutron probe, saprock investigations, and others

Funding Support: CZO, others

International Collaboration: No
International Travel: No

Otto Alvarez
Email: oalvarez@ucmerced.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 1

Contribution to the Project: University of California, Merced; Primarily LiDAR, with Q. Guo

Funding Support: UCM

International Collaboration: No
International Travel: No

Paige Austin
Email: paustin3@ucmerced.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 4

Contribution to the Project: Graduate student in the Hart lab, working on vegetation, rhizosphere and other projects

Funding Support: UCM

International Collaboration: No
International Travel: No

Morgan Barnes
Email: mbarnes@ucmerced.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 4

Contribution to the Project: Graduate student in the Hart lab, phosphorus in the subsurface

Funding Support: UCM funding

International Collaboration: No
International Travel: No

Alexandre Caillat
Email: ac434@cornell.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 2

Contribution to the Project: University of California, Santa Barbara; New Fall 2014

Funding Support: UCSB

International Collaboration: No
International Travel: No

Nicholas Dove

Email: ndove@ucmerced.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 4

Contribution to the Project: Graduate student in the Hart lab, mycorrhizal study

Funding Support: UCM funding

International Collaboration: No
International Travel: No

Ryan Ferrell
Email: rmferrell@ucdavis.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 6

Contribution to the Project: Graduate student in O'Geen lab, work on neutron probe, saprock investigations, and others

Funding Support: CZO, others

International Collaboration: No
International Travel: No

Jacob Flanagan
Email: jflanagan3@ucmerced.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 1

Contribution to the Project: University of California, Merced; Primarily LiDAR, with Q. Guo

Funding Support: UCM

International Collaboration: No
International Travel: No

Brian Kastl
Email: bkastl@bren.ucsb.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 2

Contribution to the Project: University of California, Santa Barbara

Funding Support: UCSB

International Collaboration: No
International Travel: No

Ryan Lucas
Email: rlucas@ucmerced.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 10

Contribution to the Project: Suface-groundwater interactions

Funding Support: CZO & other

International Collaboration: No
International Travel: No

Claire Lukens
Email: clukens@uwyo.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 4

Contribution to the Project: Regolith formation and erosion; near-surface geophysics; vegetation-landscape interactions

Funding Support: CZO & other

International Collaboration: No
International Travel: No

Emma McCorkle
Email: emccorkle@ucmerced.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 3

Contribution to the Project: Determining sources of carbon in eroded sediments and nutrient (carbon and nitrogen) fluxes of natural waters; Fininshing graduate studies; Preparing results for publication

Funding Support: CZO & other

International Collaboration: No
International Travel: No

Kimber Moreland
Email: kmoreland@ucmerced.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 4

Contribution to the Project: Graduate student in the Hart and Berhe labs working on nitrogen in the subsurface

Funding Support: UC Merced

International Collaboration: No
International Travel: No

Carlos Oroza
Email: coroza@berkeley.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 6

Contribution to the Project: Graduate student on developments for the wireless sensor network and site selection

Funding Support: CZO, others

International Collaboration: No
International Travel: No

Joe Rungee
Email: jrungee@ucmerced.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 4

Contribution to the Project: University of California, Merced; New Fall 2014, Ecohydrology, data modeling

Funding Support: UCM

International Collaboration: No
International Travel: No

Kyongho Son
Email: kson@bren.ucsb.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 10

Contribution to the Project: Core CZO measurements, data management and integration; finishing graduate studies

Funding Support: CZO & other

International Collaboration: No
International Travel: No

Nick Taylor
Email: ntaylor9@uwyo.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 4

Contribution to the Project: Graduate student in the Riebe lab, geophysics and subsurface remote sensing

Funding Support: Wyoming, CZO, others

International Collaboration: No
International Travel: No

Melissa Thaw
Email: mthaw@ucmerced.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 4

Contribution to the Project: Graduate student in the Conklin lab

Funding Support: CZO, LLNL, others

International Collaboration: No

International Travel: No

Zhiyuan Tina Tian
Email: ztian@ucdavis.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 6

Contribution to the Project: Graduate student in O'Geen group, neutron probe, spatial work, and others

Funding Support: CZO, others

International Collaboration: No
International Travel: No

Stu Wilson
Email: stuwilson@ucdavis.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 1

Contribution to the Project: Graduate student in O'Geen lab

Funding Support: Others

International Collaboration: No
International Travel: No

Ian Wrangham
Email: iwrangha@uci.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 4

Contribution to the Project: Graduate student on the flux tower and analysis and contributions to the tower-top remote-sensing system.

Funding Support: CZO, others

International Collaboration: No
International Travel: No

Zeshi Zheng
Email: zeshi.z@berkeley.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 1

Contribution to the Project: Graduate student work on LiDAR ground-truthing, Wireless data at Providence

Funding Support: Others

International Collaboration: No
International Travel: No

Nick Busse
Email: nbusse@ucmerced.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 3

Contribution to the Project: Undergraduate assistant for field work, summer 2015

Funding Support: CZO

International Collaboration: No
International Travel: No

Joshua Clegg
Email: jclegg@ucmerced.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 3

Contribution to the Project: Field technician summer 2014

Funding Support: CZO funds

International Collaboration: No
International Travel: No

Abby Dziegiel
Email: adziegiel@ucmerced.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 1

Contribution to the Project: Undergraduate student assistant for Hart

Funding Support: CZO & other

International Collaboration: No
International Travel: No

Alexander Newman
Email: anewman3@ucmerced.edu
Most Senior Project Role: Research Experience for Undergraduates (REU) Participant
Nearest Person Month Worked: 3

Contribution to the Project: REU student and undergraduate research assistant; 1. Determining sources of carbon in eroded sediments and nutrient (carbon and nitrogen) fluxes of natural waters 2. Assessing Nutrient Hot spot and Hot Moments in soil

Funding Support: REU funds; CZO & other

International Collaboration: No
International Travel: No
Year of schooling completed: Junior
Home Institution: UC Merced
Government fiscal year(s) was this REU participant supported: 2014

Obinwanne Offorjebe
Email: oofforjebe@ucmerced.edu
Most Senior Project Role: Research Experience for Undergraduates (REU) Participant
Nearest Person Month Worked: 2

Contribution to the Project: REU student for Meadow surface-groundwater interactions, land-atmosphere transfers

Funding Support: REU funds; CZO & other

International Collaboration: No
International Travel: No
Year of schooling completed: Junior
Home Institution: UC Merced
Government fiscal year(s) was this REU participant supported: 2014

Jiayou Deng
Email: jdeng@ucdavis.edu
Most Senior Project Role: Other
Nearest Person Month Worked: 4

Contribution to the Project: Staff research associate in the O'Geen lab

Funding Support: Others

International Collaboration: No
International Travel: No

What other organizations have been involved as partners?

Name	Type of Partner Organization	Location
Lawrence Livermore National Laboratory	Other Organizations (foreign or domestic)	Livermore, CA
US Forest Service, Pacific Southwest Research Station	Other Organizations (foreign or domestic)	Fresno, CA

Full details of organizations that have been involved as partners:

Lawrence Livermore National Laboratory

Organization Type: Other Organizations (foreign or domestic)
Organization Location: Livermore, CA

Partner's Contribution to the Project:
Financial support
In-Kind Support
Facilities
Collaborative Research

More Detail on Partner and Contribution: Collaboration with Co-PI M. Conklin on SSCZO meadows

US Forest Service, Pacific Southwest Research Station

Organization Type: Other Organizations (foreign or domestic)
Organization Location: Fresno, CA

Partner's Contribution to the Project:
In-Kind Support
Facilities
Collaborative Research

More Detail on Partner and Contribution:

What other collaborators or contacts have been involved?

In addition to our project team (investigators, faculty, staff, graduate students and others), the list below provides the names of collaborators on active projects, as well as those exploring new opportuntunities.

Sarah Aciego	University of Michigan
Emma Aronson	University of California, Irvine
Sara Baguskas	University of California, Santa Barbara
Joseph Blankinship	University of California, Santa Barbara
Rick Bottoms	USFS Pacific Southwest Research Station
Chelsea Carey	University of California, Riverside
Jeff Diez	University of California, Riverside
Anthony Dosseto	University of Wollongong
Ken Dueker	University of Wyoming
Brad Esser	Lawrence Livermore National Lab
Marilyn Fogel	University of California, Merced
Sarah Hall	College of the Atlantic
Thomas Harmon	University of California, Merced
W. Steven Holbrook	University of Wyoming
Susan Hubbard	Lawrence Berkeley National Laboratory
Steven Jepsen	University of California, Merced
Zion Klos	University of Idaho
Sarah Martin	University of California, Merced

Nicole Molinari	University of California, Santa Barbara
Noah Molotch	University of Colorado at Boulder
Jean Moran	CSU East Bay and LLNL
Max Moritz	UC Berkeley
Michael Pickard	University of California, Merced
Bob Rice	University of California, Merced
Kristina Rylands	NatureBridge at Yosemite
Phillip Saksa	University of California, Merced
Leonard Sklar	San Francisco State University
Carl Steefel	Lawrence Berkeley Lab
Chris Surfleet	California Polytechnic University
Friedhelm von Blanckenburg	GFZ, Helmholtz Center Potsdam
Eric Waller	UC Berkeley
Ken Williams	Lawrence Berkeley Lab
Steve Wilson and Staci Bynum	Center for Advanced Research & Technology
Ate Visser	Lawrence Livermore National Laboratory

Impacts

What is the impact on the development of the principal discipline(s) of the project?

In addition to broad outreach to resource managers and stakeholders, the SSCZO attends to other audiences. The general public is the audience for many of our communications, including press reports and newspaper opinion pieces. We have given public talks in local communities, as well as presentations to civic organizations. The Southern Sierra CZO has been employing internet tools as part of its outreach program. SSCZO presences on Twitter and Facebook have gained more followers. These social-media platforms are available to the public, and also provide a way to disseminate information about events and activities to CZO and non-CZO researchers and students. E. Stacy has organized a monthly Science Café for the City of Merced, drawing on SSCZO as well as other science issues of public interest. SSCZO PI R. Bales and Co-PI M. Conklin have presented to local groups (including Merced City Council and Rotary Club), California Partnership for the San Joaquin Valley, UC Merced trustees, and the University Friends Circle, and other public audiences. SSCZO staff E. Stacy contributed a research perspective to two region-wide meetings of watershed managers, non-profit groups, and interested parties.

From the outset the Southern Sierra CZO was planned as a resource for the critical-zone research community, and our team has actively engaged others in using this resource. Three levels of users are represented at the Southern Sierra CZO: the core CZO team, research collaborators and cooperators. Our core team represents six universities

plus the USFS. Over 20 research groups are collaborators; these groups are not formally part of the Southern Sierra CZO grant but work with the core team using largely other resources and are an important part of the SSCZO. In addition, several additional cooperators use Southern Sierra CZO data, collect samples at the Southern Sierra CZO or make use of other CZO resources in their own work.

Modeling holds an important role in disseminating research results. Modifications by C. Tague to the Regional Hydro-Ecologic Simulation System (RHESSys) serve as mechanisms for encoding advances made by our field-based analyses. RHESSys is made freely available to the community and regular user training is provided.

The Southern Sierra CZO has a high profile with resource-management stakeholders in California and the broader region. Our research addresses fundamental knowledge gaps around management of water supplies, forests, hydropower and integrated ecosystem services. The enhanced predictive capabilities that we are developing provide much-needed tools to understand the effects of management actions, disturbance and climate warming on ecosystem services. Adapting to climate change basically involves managing ecosystem services, with water-related ecosystem services being an early if not primary focus. Having a CZO with major capability to inform and influence adaptation around water supply in California is very timely given the state's global leadership role in implementing climate solutions.

California is grappling with many challenges at the intersection of water, forests and climate. Water security is the reliable availability of an acceptable quantity and quality of water for health, livelihoods and production, coupled with an acceptable level of water-related risks. Water security in semi-arid regions is founded on adequate water storage. Three consecutive dry years have emphasized the significance of the problem in California. In some cases, management actions can in part offset the effects of climate warming, and can lower the risk of severe disturbance, e.g. wildfire. Both the knowledge and technology developed by the SSCZO are informing decision making around water storage and ecosystem services.

What is the impact on other disciplines?

We have made several advances in wireless-sensor-network optimization, which are both important to the CZO network and have applications well beyond the CZOs. Existing algorithms in computer science do not have the data necessary to inform real-world deployments of wireless monitoring technologies. We have shown that field-hardened optimization needs to incorporate the long-term evolution of signal strength (RSSI) and packet delivery ratio (PDR) along each link in the wireless network, as well as understanding how environmental factors (such as trees, changes in humidity etc.) impact wireless performance. By analyzing historical signal strength data from the CZO and combining with classification algorithms, graph theory etc., we were able to produce an approach that combines insights from multiple disciplines to create a standard approach to establishing new wireless observatories.

We collaborate with work carried out on several other research grants, including three other NSF awards at UC Merced:

- WSC Category 3: Propogating climate-driven changes in hydrologic processes and ecosystem functions across extreme biophysical and anthropogenic gradients, Award 1204841, PI: T. Harmon.
- MRI: Development of a basin-scale water-balance instrument cluster for hydrologic, atmospheric and ecosystem science, Award 1126887, PI:R. Bales
- REU Site: Yosemite environmental science research training, Award 1263407, PI:S. Hart.

It is planned that the proposed NEON core site and relocatable sites be co-located with the SSCZO; and permitting and planning work is underway by NEON.

The SSCZO works with the U.S. Forest Service and U.S. Park Service they plan forest-restoration strategies for the Sierra Nevada. Our work is central to informing the water-cycle impacts, drought-resilience and other aspects of how the forest will respond to management actions and disturbance.

Tague received a SESYNC (National Socio-Environmental Synthesis Center) grant that will support a two-year working group on integrating economic and biophysical models to examine pre and post ecosystem service impacts of wildfire and fuel treatment (title: *Wildfire Management, Ecosystem Dynamics, and Climate: The Role of Risk*

Salience in Driving Ecological Outcomes).The SESYNC working group use several Western US case study sites, including the Sierra CZO. RHESSys will be the core biophysical model used in coupled analysis, and its parameterization and application will be based on prior years CZO related work on RHESSys development.

Model–based analysis of the sensitivity of forest hydrology and carbon cycling to climate variability and to forest management practices is increasingly of interest to both forest managers and water resource managers in the Sierra. Both the SESYNC working group and a dissertation supervised by Tague (Kastl) explicitly involve resource-management stakeholders. Kastl's PhD will investigate how science-based model presentation influences how stakeholders understand the complex watershed dynamics studied by scientists at the CZO. The SESYNC working group will involve forest managers from agencies as well as communication expertise through COMPASS a group that specializes in science based communication for the public (http://www.compassonline.org/). Establishing these two outreach/broad-impact initiatives was an important product from 2014/2015.

Our spatially dense soil-moisture and matric-potential measurements over a 7-yr time period, plus the coincident measurements of snowpack, solar forcing, temperature, and relative humidity will be analyzed to better understand the multi-sector, cumulative impact of multiple years of drought in CA.

What is the impact on the development of human resources?

SSCZO staff and students have engaged four curriculum-development or teacher-training partnerships this year. Members of our team have given interactive presentations to, among others, TASTES, a local teacher-training program; and STEM-Tracks, a two-year teacher-development program covering three mountain counties. The interactive Next Generation Science Standards activities included field trips through the Rim Fire burned forests and several climatic biomes in the Sierra Nevada. It should be noted that UC Merced is a Hispanic Serving Institution, and the region around UC Merced has a very high proportion of under-represented students who could be the first in their family to attend college.

SSCZO student R. Lucas was an instructor at the California Institute for Biodiversity (CIB) Climate Change Workshop. He communicated CZO science in the context of climate change to K-12 teachers that attended the workshop. He also participated in an additional institute through CIB that focused on bringing field investigations into K-12 classrooms in the intent to help facilitate the implementation of Next Generation Science Standards. [ems1] M. Goulden used CZO research results to help train K-12 instructors attending a summer workshop at UC Irvine.

An activity simulating water-resource-management decisions, developed by R. Lucas and E. Stacy, was adapted for the American Geosciences Institute for teachers, and distributed by the National office in June 2014. We have answered inquiries from teachers making use of the exercise in their classroom. In conjunction with D. Duggan-Haas, (CZO National Office), a SSZCO Virtual Field Experience was created to stimulate a field visit and present results. Instructors are able to take their students to the SSCZO P301 site and, using an inquiry approach, acquire information regarding our most pressing scientific questions.

[ems1]Is this current?

What is the impact on physical resources that form infrastructure?

The Glaser-Bales team has been installing the new generation of wireless sensor stations. The new WSN boards provide a platform that provides the capacity for a wide range of sensors, up to forty analog and/or digital, to be added to the current twelve. The network will be comprised of 27 sensor nodes and 30 data relay nodes. Through an NSF-MRI grant, plus state and local support, that technology is being applied at the river-basin scale (American River basin) in the Sierra Nevada.

What is the impact on institutional resources that form infrastructure?

The SSCZO infrastructure and data are a resource for both UC and the community. We receive frequent requests for access to both the data and site. We are planning to make the data availability sustained over the long term.

What is the impact on information resources that form infrastructure?

Data and information. Data-management policies and procedures for the SSCZO are laid out in the management plan. The SSCZO continues to maintain a thorough digital library. This is the main repository for data, metadata, protocols, photos, and presentations. Raw data are freely available after upload at multiple points per year, and processed data is made available according to CZO data policies. The SSCZO team also participates in the CZO data-management project.

SSCZO Digital Library:
https://eng.ucmerced.edu/snsjho/files/MHWG/Field/Southern_Sierra_CZO_KREW

Web and social media. Online efforts complement our written and oral presentations. The main SSCZO online presence is through the CZO website and the SNSJHO digital library. Facebook and Twitter accounts provide an informal counterpart where we share field activities, real time information on conference presentations, and pertinent updates on research and current events. Descriptions for each site follow.

Southern Sierra Critical Zone Observatory (www.criticalzone.org/sierra). This website is the home of the Southern Sierra CZO. In the 2013-2014 year, SSCZO staff expanded the research field areas, added data, posted multiple opportunities, and regularly updated field and research activities. In May 2014, staff completed a website content inventory that will direct strategic, regular, and diverse updates on news, photos and data, among other items. In the coming months, we will focus on adding further links to data, interactive maps, more photo galleries and news stories, and centralizing information for CZO presentations at upcoming conferences.

SSCZO Facebook (www.facebook.com/SouthernSierraCZO). The Southern Sierra CZO is the only active CZO Facebook page that we are aware of. This page is slowly growing, and reaches a local cross-discipline audience (broader than environmental science, hydrology, or the CZO network). The audience is more location based, centered around Merced.

SSCZO Twitter (twitter.com/ssczo). The Southern Sierra CZO was the first CZO in the network with an active Twitter account. Now that the network has expanded and other CZOs are active on Twitter, it is a space for the SSCZO to connect with others observatories and researchers interested in critical zone science. Southern Sierra CZO posts events, photos, and links to other pertinent stories and blog posts on the Twitter page. This avenue has been useful in reaching researchers, media and other professionals, particularly in publicizing research presentations during professional conferences.

R. Bales Twitter (twitter.com/rbalesuc). PI R. Bales also uses Twitter regularly to disseminate and comment on issues related to the SSCZO and the CZO network.

What is the impact on technology transfer?
Nothing to report.

What is the impact on society beyond science and technology?

Building on the success of the SSCZO in bringing a multi-campus collaboration to address knowledge gaps that are critical to California and the Western United States, several UC faculty from 5 campuses, including 3 SSCZO investigators, have recently started the UC Water Security and Sustainability Research Initiative (http://wassri.ucmerced.edu) that links headwater rsearch under the SSCZO with complementary research on valley groundwater systems and water policy. UC Water is supported by the UC Office of the President, and aims to focus UC resources on key problems and working alongside California's water leaders to achieve a water-secure future and build the knowledge base for better water-resources management. This multi-campus initiative blends UCs technical advances in water resources with parallel innovations in policy analysis and decision support to meet the state's water-security challenges. Three elements of water security underpin the research. First, salient, credible and legitimate water information at the proper spatial and temporal scale is a bottleneck for sound decision making. UC Water will develop innovative, quantitative water accounting and analysis methods that replace century-old technology and provide the foundation for better decisions under increasing uncertainties. Embedding modern

information systems into both natural and engineered infrastructure is feasible, affordable and timely. Second, understanding the way water flows through the natural environment, and how it is extracted, conveyed and stored in built and natural infrastructure is fraught with uncertainties. UC Water will make immediate research contributions by developing understanding of landcover changes on source-water areas, and tools and techniques for better groundwater management. Third, water-management institutions in California have not kept pace with yesterday's scientific and engineering developments, let alone developed the capacity to adapt to 21st-century stressors. UC Water will tightly weave legal and policy research through its scientific agenda to create an integrated whole. Through integration of measurement and modeling technologies, and drawing on UC expertise across disciplines, UC Water aims to make rapid progress towards filling the gaps.

Changes/Problems

Changes in approach and reason for change

The California drought has led the SSCZO to focus more directly on understanding related to the resiliency of California's critical Sierra Nevada headwaters. Essentially all aspects of the CZO research agenda, as outlined in the five areas presented in the *Accomplishments* section, are contributing to the focus.

Actual or Anticipated problems or delays and actions or plans to resolve them

One planned effort for deep-subsurface drilling was postponed from year 1 until additional geophysical work could be completed to inform the drilling effort; this geophysical work is planned for summer and fall 2015. Our plan is to conduct Geoprobe drilling during and after the geophysical investigations. Some additional carryover, into the early part of year 3 (i.e., Sep and Oct) may be needed due to the timing of the proposed work. [ems1]

The repair and replacement of the Shorthair flux tower has largely being done with insurance money and spare parts up to now. Having a tree fall on it delayed an important data set, but did not significantly affect expenses. Funds budgeted for completion of the tower re-installation should be expended this summer. Other work in the forest prevented us from completing the installation last fall.

Changes that have a significant impact on expenditures

We advanced the Wireless Boot Camp for other CZOs into year 1. This was done to accommodate the needs of the CZO program as a whole, as the other CZOs are interested in installing or upgrading wireless networks at their sites. The cost impact of this is an expenditure of up to $15,000 direct cost. We were also able to partner with CUAHSI to co-sponsor the workshop, and open it up to the broader community.

Significant changes in use or care of human subjects
Nothing to report.

Significant changes in use or care of vertebrate animals
Nothing to report.

Significant changes in use or care of biohazards
Nothing to report.