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## Preview of Award 1331940 - Annual Project Report

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### Cover

Federal Agency and Organization Element to Which Report is Submitted:	4900
Federal Grant or Other Identifying Number Assigned by Agency:	1331940
Project Title:	The Eel River Critical Zone Observatory: exploring how the critical zone will mediate watershed currencies and ecosystem response in a changing environment
PD/PI Name:	William E Dietrich, Principal Investigator James K Bishop, Co-Principal Investigator Stephanie M Carlson, Co-Principal Investigator Mary E Power, Co-Principal Investigator Sally Thompson, Co-Principal Investigator
Recipient Organization:	University of California-Berkeley
Project/Grant Period:	10/01/2013 - 09/30/2019
Reporting Period:	10/01/2017 - 09/30/2018
Submitting Official (if other than PD\PI):	William E Dietrich Principal Investigator
Submission Date:	09/30/2018
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	William E Dietrich

### Accomplishments

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

The major goals of the Eel River CZO as outlined in our Management plan are to answer these four questions:

1. Does lithology control rock moisture availability to plants and therefore overall resilience of vegetation to climate change in seasonally dry environments?
2. How are solute and gas effluents from hillslopes influenced by biota in changing moisture regimes?

3. What controls the spatial extent of wetted channels in the channel networks of seasonally dry environments?
4. Will changes in critical zone currencies induced by climate or land use change lead to threshold-type switches in river and coastal ecosystems?

Additionally, we propose to develop a numerical platform – the Atmosphere-Watershed-Ecology-Stream and-Ocean Model (AWESOM) to synthesize findings from smaller scale studies, couple the different critical zone subsystems together, and explore the long-term and large-scale consequences of the dynamics of the critical zone in the context of changes in climate, land use, and water management policy.

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

Major Activities:

**Question 1: Does lithology control rock moisture availability to plants and therefore overall resilience of vegetation to climate change in seasonally dry environments?**

1) Vadose Zone Monitoring System and sampling campaigns (Collaborator Professor Daniella Rempe)

Our vadose zone monitoring system (VMS) was installed at our intensively monitored hillslope, Rivendell, in October 2015. The VMS enables sampling at 10 “matrix” sampling ports spaced at 1.5 m intervals in the upper 16 m, and 10 “fracture” sampling ports spaced at 1.75 m intervals in the upper 18 m. Water samples are also collected from 12 groundwater wells, 2 lysimeters located in soil, Elder Creek, and some Elder Creek tributaries, and trees across Rivendell during sample collection campaigns which have been conducted approximately every two weeks since November 2015. Since May of 2017, 28 water sampling campaigns have been conducted, with a total of 731 cation, 782 anion, 813 stable isotope samples (O and H), 833 dissolved organic/inorganic carbon and total nitrogen samples collected. In the field, 1264 samples were analyzed for dissolved oxygen, temperature, alkalinity, and pH. Additionally, nitrate, ammonium, ferrous iron, and hydrogen sulfide measurements are made on a subset of samples. Approximately 100 samples for laboratory analysis of nitrate and nitrite have been collected. Analysis of samples is ongoing, however, 669 cation, 203 anion, and 499 carbon samples have been analyzed since May 2017. Additionally, organic acid characterization has been conducted in 17 samples, and 32 samples have been analyzed for sulfur isotope composition. The VMS also contains gas sampling ports at 1.75 m intervals. Since May 2017, 478 measurements of O<sub>2</sub> and CO<sub>2</sub> concentration have been measured, and 242 gas samples have been collected. Gas samples have been analyzed for H<sub>2</sub>S and CH<sub>4</sub> as well as carbon stable isotopes. At our Sagehorn field site, streamflow and well samples were collected for cation, anion, and carbon analyses over 6 campaigns (i.e. approximately every two months.)

2) Downhole geophysics (Collaborator Professor Daniella Rempe)

To track the spatial and temporal dynamics of rock moisture, 53 downhole neutron probe and gamma nuclear density (501DR) and 116 nuclear magnetic resonance (NMR) downhole surveys have been conducted at Rivendell over 8 campaigns and 32 downhole neutron probe and gamma (501DR) and 32 downhole nuclear magnetic resonance surveys have been conducted at Sagehorn over 4 campaigns. To characterize unweathered bedrock properties at the Rivendell field site, five new shallow holes were drilled- two in a sandstone outcrop and three in argillite in the streambed. These wells have been logged with neutron, gamma, and NMR.

Over 80 samples of weathered and unweathered bedrock samples from the Rivendell field site have been analyzed for bulk density at UT Austin and 8 samples have been analyzed for pore size distribution via laboratory scale NMR.

3) Aspect, trees, and transpiration: south slope instrumentation

In April 2018, sap flow sensors were installed on the south slope into 8 madrone trees and 2 Douglas firs, and on the adjoining north slope into 6 madrones and 6 Douglas firs.

## **Question 2: How are solute and gas effluents from hillslopes influenced by biota in changing moisture regimes?**

### 1) Dry-season changes in soil carbon cycling

We collected soil cores to quantify the water-soluble and microbe-available soil carbon fractions in early June and early August, and have conducted a suite of analyses of the surface organic layer, the surface (top 25 cm) mineral layer, and the deep (25-55 cm) mineral layer.

### 2) Fluid mobility and shale weathering (Collaborator Professor Jennifer Druhan)

Solutes in our VMS samples associated with highly reactive mineral phases increase deep in the profile where the corresponding weathering front occurs (e.g.  $\text{Ca}^{2+}$  concentrations associated with carbonates). Other solutes associated with mineral phases prevalent throughout the profile (e.g.  $\text{SiO}_2\text{aq}$ ) are closely correlated to the partial pressure of reactive gases  $\text{CO}_2$  and  $\text{O}_2$ . Our numerical simulations of solute evolution now demonstrate the relatively open pore space in the fracture allows diffusion of  $\text{O}_2\text{g}$  from the surface, which is utilized to oxidize organic carbon to  $\text{CO}_2\text{g}$ . This elevated  $\text{CO}_2\text{g}$  then equilibrates with the fluid, and thus drives water-rock interaction.

## **Question 3: What controls the spatial extent of wetted channels in the channel networks of seasonally dry environments?**

### 1) Hydrological modeling

Our data analysis and modeling has revealed two distinct pools of catchment water storage: direct storage ( $S_d$ ) and indirect storage ( $S_i$ ). Direct storage is the subsurface dynamic storage that is hydraulically coupled to the stream. Indirect storage is the volume of water that is dynamic on seasonal timescales yet is not directly hydraulically coupled to the stream. Surprisingly, indirect storage accounts for most dynamic storage, despite discharge being driven by groundwater (Rivendell) or saturation overland flow (Sagehorn).

## **Question 4: Will changes in critical zone currencies induced by climate or land use change lead to threshold-type switches in river and coastal ecosystems?**

### 1) Drought and rainbow trout migration

Initial surveys in northern California suggest that during the recent drought in California, migrating salmon were not able to access breeding habitat due to shallow flows. This appears to be a widespread phenomenon in California.

### 2) Refugia model

We have now developed a simple scaling model, tested with field data, that can predict cold water zones (temperature refugia) at river tributaries.

### 3) Food web phenology

We have used drift measurements to track food web phenology, and novel stereo-video methods to quantify concomitant changes in foraging behavior of juvenile salmonids. We have quantified flow, drift dynamics and fish foraging behavior in four coastal streams – Elder Creek (16.2 km<sup>2</sup>), Fox Creek (2.9 km<sup>2</sup>), SF Sproul Creek (11 km<sup>2</sup>), and mainstem Sproul Creek (42 km<sup>2</sup>).

### 4) Toxic cyanobacteria

We performed metagenomic sequencing for 22 Phormidium-dominated microbial mats collected across the Eel River network to investigate cyanobacterial and co-occurring

microbial assemblage diversity, probe their metabolic potential, and evaluate mat capacities for cyanotoxin production. From these genomes, we have described the first anatoxin-a (Very Fast Death Factor, VFDF) operon from *Phormidium*, and we have characterized microbial communities and metabolic characteristics of mats.

#### 5) Sacramento pikeminnow in the Eel

We have documented that the Sacramento pikeminnow, an introduced predatory fish, migrates upstream as stream temperature rises in the summer. We experimentally tested how temperature influences the predatory interaction between larval odonates and juvenile California roach. We collected spawning California roach to calculate the age of spawning individuals, to build a relationship between length and number of eggs, and to create functional response curves for odonates and California roach at different temperatures.

#### 6) Algal Surveys

We have completed four years of “Eyes on the Eel” surveys of food web structure in four mainstem and four tributary reaches ranging in drainage area from 2.6-6000 km<sup>2</sup>. Food web structure was assessed at 3 times during each of the four years: June (biological peak), July (hottest period), and September (lowest flow).

### **Question 5: AWESOM: The Atmosphere-Watershed-Ecology-Stream and-Ocean Model**

We concluded that tree species-specific characterization of moisture availability, transpiration, and vapor pressure deficit was needed to improve the modeling effort. Hence, our focus was on establishing a monitoring system at Rivendell.

#### Specific Objectives:

#### **Milestone 1: Does lithology control rock moisture availability to plants and therefore overall resilience of vegetation to climate change in seasonally dry environments?**

- 1.1 Monitor vadose zone moisture dynamics
- 1.2 Explore controls on stable isotopes in storage reservoirs and trees
- 1.3 Monitor sap flow, soil moisture, and meteorology on Rivendell south facing slope
- 1.4 Measure and model root forces at the root-bedrock interface

#### **Milestone 2: How are solute and gas effluents from hillslopes influenced by biota in changing moisture regimes?**

- 2.1 Conduct methanol incubation experiments on soils
- 2.2 Continue annotation of assembled soil genomes
- 2.3 Explore genome-resolved analysis of subsurface rhizosphere community
- 2.4 Continue periodic sampling of gas weathered bedrock
- 2.5 Collect and analyze VMS samples from Rivendell, as well as rainfall and runoff samples from Rivendell and Sagehorn

### **Milestone 3: What controls the spatial extent of wetted channels in the channel networks of seasonally dry environments?**

3.1 Develop further the model for critical zone dependent runoff

3.2 Relate concentration-discharge relationships to the extent of wetted channels in Sagehorn

### **Milestone 4: Will changes in critical zone currencies induced by climate or land use change lead to threshold-type switches in river and coastal ecosystems?**

4.1 Document effects of wet and dry years on steelhead

4.2 Continue assessment of cyanotoxin bioaccumulation in macroinvertebrates and cyanobacterial dispersal dynamics

4.3 Continue analysis of cold water refugia

4.4 Quantify the phenology of food webs in salmon bearing streams

4.5 Document temperature controls on the spread of invasive fish

4.6 Conduct repeat surveys along South Fork and mainstem Eel at tributary junctions of habitat, insects, algae, and fish abundance

### **Milestone 5: Synthesis Modeling (the Atmosphere-Watershed-Ecology- Stream-Ocean Model)**

5.1 Develop further the 1-D vadose zone model based on observations on the south slope

5.2 Advance the coupled model for stream flow and temperature

#### Significant Results:

#### **Significant Results:**

1.1 NMR surveys are revealing porosity structure and where moisture is stored

1.2 Large shifts in vadose zone stable isotopes not detected in trees using these waters

1.3 Sap flow and soil moisture sensors were installed throughout 2017-2018 and are now gathering data

1.4 On-going, no significant results

2.1 on-going, no significant results

2.2 on-going, no significant results

2.3 on-going, no significant results

2.4 Gas sampling has revealed that O<sub>2</sub> oxidized organic carbon, producing chemically reactive CO<sub>2</sub>

**2.5** Samples collected every two weeks have documented distinct and systematic solute trends with depth through the vadose zone.

**3.1** Our analysis shows that discharge is explicitly sensitive to changes in only some fraction of seasonally dynamic storage that we call “direct storage,” whereas the remaining storage (“indirect storage”) varies without directly influencing discharge. The indirect storage constitutes the vast majority of dynamic catchment storage, even at the wettest times of the year. Indirect storage exhibits lower variability over the course of the wet season (and in successive winter periods) than does direct storage. Predicted indirect storage volumes and dynamics match field observations.

**3.2.** The comparison of the concentration-discharge relationships between Rivendell (all subsurface runoff, much delayed from initial rainfall as it travels through the deep critical zone) and Sagehorn (rapid surface runoff due to thin critical zone and seasonal saturation of the entire watershed) provides an opportunity to test theories regarding the controls on solute chemistry with runoff. Initial results show that once the Sagehorn site fully wets up the concentration in the runoff declines much more rapidly with increasing discharge, but it never reaches the condition of simple dilution- implying ongoing shallow water exchange with the surface waters.

**4.1** We’ve completed a study focused on describing how inter-annual variation in stream flows influence movement timing and growth of *O. mykiss*. We found that in the late summer months, from late July – early September, fish grew very little (almost none). We were surprised to find that this trend of zero growth remained constant despite antecedent rainfall – wet years and dry years did not show different patterns in growth.

An analysis of *O. mykiss* genotypes has found that migratory *O. mykiss* genotypes were present further in the watershed of Elder Creek in 2014, which was the driest year during which we sampled. We are currently exploring reasons for this surprising pattern. In Fox Creek, we have found strong inter-annual variation in genotype frequencies, with migratory genotypes dominating the stream in some years, and resident genotypes in others.

**4.2** Cyanotoxin sampling: Anatoxin-a levels were higher than microcystin for both SPATT and cyanobacterial mat samples. Of the benthic mats sampled, 58.9% had detectable anatoxin-a, while 37.6% had detectable microcystins. Cyanotoxin levels peaked in mid-summer in warm mainstem reaches of the watershed. This is one of the first documentations of widespread anatoxin-a occurrence in benthic cyanobacterial mats in a North American watershed.

Cyanobacteria metagenomics: We’ve found that microbial assemblage composition within a *Phormidium* mat was different in samples where *Phormidium* genomes contained the anatoxin-a synthesis operon. Oxygenic photosynthesis and carbon respiration were the most common metabolisms detected in mats, but other metabolic capacities include aerobic anoxygenic photosynthesis, sulfur compound oxidation, and breakdown of urea. These results reveal the diversity of metabolisms fueling the growth of mats, and a relationship between microbial assemblage composition and the distribution of anatoxin-a producing cyanobacteria within freshwater *Phormidium* mats.

**4.3** Comparison between predicted and observed spatial patterns of stream temperature at the junction of Elder Creek and South Fork Eel during the summer low flow was favorable.

**4.4** We have analyzed flow, drift dynamics, and fish foraging behavior. We’ve found that as drift wanes in the river, fish appear to move more to track it, and eventually change

from drift feeding to less profitable roaming through pools to pick at benthos. Based on our observations from 2016, however, fish may reduce their overall movement as risk of predation increases with waning pool depth in the later summer.

**4.5.** Warmer than average spring flows caused the invasive predatory Sacramento pikeminnow to migrate upriver (into key salmon habitat) sooner than expected. This is an important link between climate and effects of invasive species.

**4.6** on going, “Eyes on the Eel” fourth year field campaign completed

**5.1** on going, no significant results

**5.2** Initial field observations and modeling results indicate that spring flow can warm significantly as it emerges and travels to main channels. This is not considered in stream temperature models.

Key outcomes or Other achievements:

*Consequences of critical zone storage to river ecosystems: low flows, elevated temperature, cyanobacteria dispersion, and fish fate*

Our research now shows that in a seasonally-dry Mediterranean climate, critical zone storage of wet-season precipitation plays a dual role: retained rock moisture deep in the zone sustains summer forest transpiration and the slow drainage of groundwater to streams keeps river ecosystems alive. The rock moisture storage is surprising. At our Rivendell site, it is up to 30% of the annual precipitation, and at any time, even during the wet season, it is volumetrically *much larger* than the seasonally stored groundwater (whose runoff sustains stream). The first rains of winter restore the rock moisture, and once that occurs, more rains pass the rock moisture zone, recharge the groundwater and generate runoff. Salmon migration is tied to the onset of this winter runoff. We have found that the late onset of winter rain and eventual runoff can have direct consequences for access to upstream breeding habitat (and salmon survival). This aspect of potential climate change is given little attention.

Winter groundwater storage also drives storm runoff, and if that runoff is sufficiently high, it mobilizes the river bed, sweeping away benthic algae-eating insects, allowing subsequent flows in the Spring to give rise to flourishing, extensive algae mats. Our evidence that “big algae” years (which sustain more salmonids and other predators) follow winter food scour has now extended by an 83-year record from off-shore sediments deposited in submarine canyons of the Eel River. This, too, points to an aspect of climate (intense rainstorms) that works through the critical zone-mediated runoff to drive river food webs.

The magnitude of summer low flow, *derived from cool deep waters of the critical zone*, is critical for the state of summer ecosystems. Heating occurs as the water enter the channel and as it travels downstream through the network. Hot weather and low flows can warm mainstem rivers to temperatures higher than edible algae (e.g. diatoms) can tolerate, and release proliferation of toxic cyanobacteria. Higher total dissolved nitrogen is another environmental condition that may increase mat toxicity. Our survey in the Eel River is one of the first documentations of widespread anatoxin-a occurrence in benthic cyanobacterial mats in a North American watershed. Anatoxin-a is a cyanobacterial neurotoxin that can, if ingested, kill dogs and potentially other mammals within minutes. Experiments in the Eel River revealed that mats dominated by the potentially toxic cyanobacteria *Anabaena* develop buoyancy and can remain floating for extended periods. During the summer growth season, buoyancy facilitates the downstream dispersal of these potentially toxic mats and allows them to collect along shorelines, where they threaten animal and public health.

These elevated temperatures during summer low flows directly influence salmon populations in the Eel. We have found that across a threshold of temperature, infection of young salmon by black spot disease rapidly rises. Salmon respond to elevated temperatures in the South Fork Eel by seeking refuge in outflows from the tributaries where flows through narrow canyons under dense canopy have remained cool. We now have a mechanistic model that predicts the spatial extent and temperature gradient of these flows as they enter the South Fork Eel.

We have also compared salmon feeding behavior in the relatively elevated summer flows draining the thick critical zone of the Eel with that of streams draining thin critical zones that lead to insufficient flows and isolated pools in late summer. Surprisingly, the early spring warmer pools from thin critical zone support a dense population of young salmon. But these favorable conditions become a death trap as the flows constrict to warm, shallow pools.

Finally, we have discovered seasonal upstream migrations of the Sacramento pikeminnow, an introduced predatory fish, also depends on stream temperature. Pikeminnow are a significant threat to young salmon and other native species.

Mechanistic understanding of these links between critical zone drainage to rivers and river ecosystems, often regulated by temperature, provides the foundation for explaining and anticipating the effects of land use and climate change. Modeling is underway to now scale up this understanding.

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

In the ER CZO post-docs, graduate students and undergraduate typically work with several of our PIs whose expertise range across atmospheric science, tree physiology, geomorphology, microbial ecology, geobiology, hydrology, stream ecology and geochemistry. Geologists and atmospheric scientists work on where trees get their water, microbial ecologists study hydrologic processes and geochemistry, and stream ecologists explore the geomorphic processes that control fish distribution and foodwebs. Students freely interact across four departments, four deans and three colleges. This training will create "critical zone scientists."

During monthly meetings attended by all ER CZO participants, both undergraduate and graduate students present their research and debate findings. These presentations fine tune their speaking skills and sharpen their research efforts. We discuss research findings, future plans and ways to connect the pieces of the critical zone. We subsidize students to attend meetings and work closely with them to prepare them for presentations and to advise them on manuscript preparation. Additionally, many of the CZO graduate students have supervised multiple undergraduates, both in the field and in the laboratory.

The graduate students are forming a group identity and regularly share technology and field skills. Students frequently train new students on deployment, operation and data collection from field instruments. Students engage with the public through invited talks, outreach activities, and collaborations with non-profits and government organizations. The PIs also spend considerable time in the field with graduate students, training them in field methods and developing measurement procedures, and in the laboratory to teach analytical and modeling methods.

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

Our CZOMP lists our strategy for engagement with other CZOs – which focused on common questions and measurements and cross-site research. We proposed that several strategies to engage the larger community including publishing papers, presenting findings at meetings, sharing data, and welcoming participation by groups not affiliated with the CZO network.

Researchers in the CZO regularly present their findings at conferences, meetings, invited talks, and seminars. In the past year, graduate students, postdocs, and PI's have presented at: the 2017 American Geophysical Union Meeting (J. Hahm, D. Dralle, A. Tune), the 2017 Society of Exploration Geophysics Annual Meeting, (J. Hahm), the 2017 Geological Society of America Annual Meeting (L. Schmidt, J. Hahm, A. Tune), Humboldt State University Dept. of Geology (invited talks by J. Hahm and D. Dralle), Portland State University (invited talk by D. Dralle), California State University Sacramento (invited talk by D. Dralle), University of Illinois (J. Hahm), the 2018 Society for Freshwater Sciences Meeting (S. Carlson, S. Kelson), the 2017 American Fisheries Society Meeting (S. Kelson), University of Puget Sound (invited talk by K. Crutchfield-Peters), the

2017 California Aquatic Bioassessment Workgroup/Society for Freshwater Science Meeting (G. Rossi), the 2018 Salmonid Restoration Foundation meeting (G. Rossi, P. Georgakakos), 2017 US Harmful Algal Bloom Symposium (K. Bouma-Gregson), the 2018 Western Society of Naturalists Meeting (plenary speaker, M. Power), the NAS Board of Life Sciences (M. Power), Save the Redwoods League (M. Power), University of Wisconsin, Madison (J. Druhan), and the 2018 Metal Stable Isotope Geochemistry Meeting (keynote presentation by J. Druhan), 2017 UC Natural Reserve System Manager's Meeting (invited talk by C. Bode), University of California, San Diego (invited talk by S. Carlson), University of British Columbia (invited talk by S. Carlson), San Francisco State University (invited talk by S. Carlson), Oregon State University (invited talk by S. Carlson), The 2018 International Symposium: Earth Surface Shaping by Biotic Processes, Leopoldina German Academy of Sciences (Invited talk by W. Dietrich), 2018 International Workshop on Surface Earth System Science, Tianjin University (invited talk by W. Dietrich), 2018 River Restoration Northwest (invited talk by W. Dietrich).

Engagement by the research community is extensive and continues to grow. In the past year we have collaborated with University of California, Davis (M. Miller) to conduct genetic analyses on *O. mykiss*, Babson College (N. Karst) on methods of stream flow time series analysis, University of Illinois (J. Druhan) and University of Texas, Austin (D. Rempe) on hydrologic processes, solute evolution, and reactive transport modeling through the critical zone, Universite de Rennes (M. Bormans) on cyanobacterial flotation, University of California, Santa Cruz (R. Kudela) on cyanobacterial toxicity, the California Dept. of Fish and Wildlife (A. Renger, S. Gallagher, M. Knechtle) on pacific salmon populations, Wright State University (Y. Vadeboncoeur) on algal blooms, University of South Carolina (K. Brewitt) on fish thermal refugia, Lawrence Livermore National Laboratory (A. Visser) on water tracing using radioisotopes, Notre Dame University (M. Muller) on hydrologic stochastic modeling, University of California, Berkeley on evapotranspirative modeling (D. Baldocchi, Y. Ryu), freshwater food webs (T. Grantham), and algal food webs (J. Marks, B. Hungate, J. Brashares, M. Polson, E. Biber), the California Sea Grant Salmon and Steelhead Monitoring Program in the Russian River, the Gold Ridge Research Conservation District, E&J Gallo Vineyards to conduct work at Porter Creek, University of California Santa Cruz (R. Kudela) on toxic cyanobacteria, the Cawthron Institute in New Zealand (S. Wood) on cyanobacteria, Bowling Green State University (G. Bullerjahn, T. Davis) to study and sample benthic cyanobacteria in California and Ohio. We collaborated with University of California Davis (J. Medellin-Azuara), California State University San Marcos (R. Hristova), University of Wisconsin (R. Lowe), St. Catherine University (P. Furey), University of Minnesota (J. Finlay), University of North Carolina Greenville (M. Tsui) on algal food webs, University of Arkansas (J. Marshall) to document wind-induced forces by trees through their roots on underlying bedrock. We hosted visiting researchers from the U.S. Forest Service (L. Keppeler, J. Wagenbrenner; L. Webb, and S. Dymond) at our Rivendell site as part of a rock moisture collaboration.

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

As specified in the CZO reporting guidelines our goals are presented as a graphical timeline. See attached.

### Supporting Files

Filename	Description	Uploaded By	Uploaded On
Graphical Timeline 092018_edit.pdf	Graphical timeline- goals for next reporting period.	William Dietrich	09/29/2018
Special Reporting Requirements 2017-2018.pdf	Metrics, CZO network activities, budget, additional funding	William Dietrich	09/30/2018

## Products

### Books

### Book Chapters

### Inventions

### Journals or Juried Conference Papers

- Baldocchi, D.D., Dralle, D.N., Jiang, C., & Ryu, Y. (2017). How Much Water is Evaporated Across California? A Multi-Year Assessment Using a Biophysical Model Forced with Satellite Remote Sensing Data. . *Agricultural and Forest Meteorology*. . Status = SUBMITTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes
- Bouma-Gregson, K., Kudela, R.M., & Power, M.E. (2018). Widespread anatoxin-a detection in benthic cyanobacterial mats throughout a river network.. *PLoS ONE*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: <https://doi.org/10.1371/journal.pone.0197669>
- Bouma-Gregson, K., Olm, M.R., Probst, A.J., Anantharaman, K., Power, M.E., Banfield, J.F. (2018). Microbial diversity and metabolic potential in cyanotoxin producing cyanobacterial mats throughout a river network.. *ISME journal*. . Status = UNDER\_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: <https://doi.org/10.1101/294421>
- Bouma-Gregson, K., Power, M.E., and M. Bormans (2017). Rise and fall of toxic benthic freshwater cyanobacteria (*Anabaena* spp.) in the Eel river: buoyancy and dispersal. *Harmful Algae*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes
- Brantley, S. L., Eissenstat, D. M., Marshall, J. A., Godsey, S. E., Balogh-Brunstad, Z., Karwan, D. L., Papuga, S. A., Roering, J., Dawson, T. E., Evaristo, J., Chadwick, O., McDonnell, J. J., and Weathers, K. C. (2017). Reviews and syntheses: On the roles trees play in building and plumbing the Critical Zone. *Biogeosciences Discuss*.. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: <https://doi.org/10.5194/bg-2017-61>
- Brantley, S.L., McDowell, W.H., Dietrich, W.E., White, T.S., Kumar, P., Anderson, S., Chorover, J., Lohse, K.A., Bales, R.C., deB Richter, D., Grant, G., Gaillardet, J. (2017). Designing a network of critical zone observatories to explore the living skin of the terrestrial Earth. *Earth Surface Dynamics*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes
- Callahan, R.P., Dosseto, A., Ferrier, K. L., Dixon, J. C., Hahm, W. J., Jessup, B. S., Miller, S. N., Sklar, L. S., & Riebe, C. S. (2018). Lithologic and topographic control of landscape evolution in the southern Sierra Nevada, California.. *Geological Society of America*. . Status = UNDER\_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes
- Chung, M., Dralle, D.N., Detweiler, C., Higgins, J., Ore, J.P., & Thompson, S.E. (2017). Unmanned Aerial System Aids Dry-season Stream Temperature Sensing.. *Ecohydrology*. . Status = UNDER\_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes
- Dralle, D. N., Hahm, W. J., Rempe, D. M., Karst, N. J., Thompson, S. E., & Dietrich, W. E. (2018). Quantification of the seasonal hillslope water storage that does not drive stream flow.. *Hydrological Processes*. 32 (13), . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: <https://doi.org/10.1002/hyp.11627>
- Dralle, D.N., Karst, N., Müller, M., Vico, G., & Thompson, S.E. (2017). Stochastic modelling of inter-annual variation of hydrologic variables. *Geophysical Research Letters*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: [10.1002/2017gl074139](https://doi.org/10.1002/2017gl074139)
- Druhan, J.L., Fernandez, N., Wang, J., Dietrich, W.E., & Rempe, D. (2017). Seasonal shifts in the solute ion ratios of vadose zone rock moisture from the Eel River Critical Zone Observatory.. *Acta Geochimica*. 36 (3), . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes
- Hahm, W. J., Dietrich, W. E., & Dawson, T. E. (2018). Controls on the distribution and resilience of *Q. garryana*: ecophysiological evidence of oak water-limitation tolerance.. *Ecosphere*. 9 (5), . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: <https://doi.org/10.1002/ecs2.2218>
- Hahm, W.J., Dietrich, W.E., Rempe, D.N., Dralle, D.N., Dawson, T.E., Lovill, S., Bryk, A.B., Bish, D., & Schieber, J. (2018). Lithologically controlled bedrock weathering determines water storage capacity and presence of evergreen forest versus savanna under similar climate.. *Water Resources Research*. . Status = UNDER\_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes
- Karst, N.J., Dralle, D.N., & Muller, M. (2018). Capturing inter-annual stream flow variability to improve annual flow duration curves. *Water Resources Research*. . Status = UNDER\_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Lovill, S., Hahm, W. J., & Dietrich, W. E. (2018). Drainage from the critical zone: lithologic controls on the persistence and spatial extent of wetted channels during the summer dry season.. *Water Resources Research*. 54 . Status = AWAITING\_PUBLICATION; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: <https://doi.org/10.1029/2017WR021903>

Rempe, D.M. & Dietrich, W.E. (2018). Direct observations of rock moisture, a hidden component of the hydrologic cycle.. *Proceedings of the National Academy of Sciences*. 115 (11), . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: <https://doi.org/10.1073/pnas.1800141115>

Rempe, D.M., Schmidt, L.M., & Hahm, W.J. (2018). In-situ nuclear magnetic resonance detection of fracture-held water in variably saturated bedrock.. *SEG Technical Program Expanded Abstracts*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = No ; DOI: 10.1190/segam2018-2998484.1

Sculley, J.B., Lowe, R.L., Nittrouer, C.A., Drexler, T.M. & Power, M.E. (2017). Eighty years of food-web response to interannual variation in discharge recorded in river diatom frustules from an ocean sediment core. *PNAS*. . Status = OTHER; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: <https://doi.org/10.1073/pnas.1611884114>

Vadeboncoeur, Y. and Power, M.E (2017). Attached algae as the cryptic base of inverted trophic pyramids in freshwaters. *Annual Review of Ecology, Evolution, and Systematics*. 48 . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Wymore, A. S., N. R. West, K. Maher, P. L. Sullivan, A. Harpold, D. Karwan, J. A. Marshall, J. Perdrial, D. M. Rempe and L. Main (2017). Growing New Generations of International Critical Zone Scientists. *Earth Surface Processes and Landforms*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

## Licenses

### Other Conference Presentations / Papers

Vrettas, M (2014). *A stochastic hydraulic conductivity model for weathered bedrock*.. Math and Climate Research Network Annual Meeting. Chapel Hill, NC. Status = OTHER; Acknowledgement of Federal Support = Yes

Dietrich, W.E Rempe, D. M (2014). *Critical zone evolution legacy: what happened matters to what happens*. CUAHSI Fourth Biennial Symposium on Water Science and Engineering.. Shepardstown, WV. Status = OTHER; Acknowledgement of Federal Support = Yes

Keith Bouma-Gregson (2017). *Cyanobacteria and Citizens in the Eel River, Northern California*. EPA Region 9 HABs Meeting. Costa Mesa, CA. Status = OTHER; Acknowledgement of Federal Support = Yes

Mary Power (2017). *Deepening our sense of place*. Organismal Biology, Ecology & Evolution Seminar Series, University of Montana. Missoula, MT. Status = OTHER; Acknowledgement of Federal Support = Yes

Mary Power (2017). *Deepening our sense of place*. Earth Month at Oklahoma U Distinguished Speaker Series. Norman, OK. Status = OTHER; Acknowledgement of Federal Support = Yes

Stephanie Carlson (2016). *Eco-Evolutionary Dynamics in Pacific Salmon and Trout*. Centre for Ecological and Evolutionary Synthesis, University of Oslo. Norway. Status = OTHER; Acknowledgement of Federal Support = Yes

Carlson, S.M. (2016). *Eco-evolutionary dynamics in Pacific salmon and trout*. Department of Ecology Seminar, University of Barcelona. Barcelona, Spain. Status = OTHER; Acknowledgement of Federal Support = Yes

Carlson, S.M. (2016). *Eco-evolutionary dynamics in Pacific salmon and trout*. Department of Environmental Science, University of Girona, Spain. Girona, Spain. Status = OTHER; Acknowledgement of Federal Support = Yes

Carlson, S.M. (2016). *Eco-evolutionary dynamics in Pacific salmon and trout*. INRA Seminar. Sant-Pee-Sur-Nivelle, France. Status = OTHER; Acknowledgement of Federal Support = Yes

Carlson, S.M. (2016). *Eco-evolutionary dynamics in Pacific salmon and trout*. Centre for Ecological and Evolutionary Synthesis (CEES) Seminar, University of Oslo. Oslo, Norway. Status = OTHER; Acknowledgement of Federal Support = Yes

Carlson, S.M. (2016). *Eco-evolutionary dynamics in Pacific salmon and trout*. Department of Ecology, University of Toulouse.. Toulouse, France. Status = OTHER; Acknowledgement of Federal Support = Yes

- Stephanie Carlson (2017). *Eco-evolutionary dynamics of Pacific salmon and trout*. Southern Illinois University, Zoology Seminar Series. Carbondale, IL. Status = OTHER; Acknowledgement of Federal Support = Yes
- W. Jesse Hahm (2016). *Ecohydrological Consequences of Critical Zone Structure in the Franciscan Formation, Northern California Coast Ranges*. AGU Fall Meeting. San Francisco, CA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Starr, E., Firestone, MK., Banfield, J. (2015). *Eel River Soil Microbial Ecology Update*. CZO Microbial Ecology Workshop, Argonne National Lab. Lemont, IL. Status = OTHER; Acknowledgement of Federal Support = Yes
- Schaaf, C (2015). *Environmental factors in trematode parasite dynamics: water temperature, snail density and black spot disease parasitism in California steelhead (Oncorhynchus mykiss)*. Spring 2015 Environmental Sciences Symposium. Berkeley, CA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Kelson, S., Carlson, SM. (2016). *Evolution and Ecology of Partial Migration in a Pacific Salmonid*. Mildred Mathias Symposium. Bodega Bay, CA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Kelson, S., Carlson, SM. (2016). *Evolution and Ecology of a Partially Migratory Fish*. UC Berkeley Wildlife Conservation Seminar. Berkeley, CA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Suzanne Kelson (2016). *Evolution and ecology of partial migration in a salmonid fish (Oncorhynchus mykiss)*. California Chapter of Society of Freshwater Sciences. Davis, CA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Stephanie Carlson (2016). *Evolutionary Ecology and Conservation of Freshwater Fishes*. Cambridge University, Department of Zoology, Behaviour, Ecology, and Evolution Series. Cambridge, UK. Status = OTHER; Acknowledgement of Federal Support = Yes
- Stephanie Carlson (2016). *Evolutionary Ecology and Conservation of Freshwater Fishes*. University of Lisbon, Center for Ecology, Evolution, and Environmental Change. Lisbon, Portugal. Status = OTHER; Acknowledgement of Federal Support = Yes
- Stephanie Carlson (2017). *Evolutionary ecology and conservation of freshwater fishes*. University of Washington, School of Aquatic and Fishery Sciences. Seattle, WA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Mary Power (2016). *Floods, Droughts, and Food Chains*. HHMI Holiday Lectures. San Francisco, CA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Mary Power (2016). *Floods, drought, and the length of chains in algal-based river food webs*. Graduate Student invited Seminar, University of Arkansas. Fayetteville, AK. Status = OTHER; Acknowledgement of Federal Support = Yes
- Phil Georgakakos (2017). *Interannual variability in of Sacramento Pikeminnow movements into the upper South Fork Eel River*. Cal-Neva AFS annual conference. Eureka, CA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Phil Georgakakos (2017). *Interannual variability in of Sacramento Pikeminnow movements into the upper South Fork Eel River*. ESA Annual Conference. Portland, OR. Status = OTHER; Acknowledgement of Federal Support = Yes
- Dietrich, W.E. (2014). *Linking Weathering, Rock Moisture Dynamics, Geochemistry, Runoff, Vegetation and Atmospheric Processes through the Critical Zone: Graduate Student led Research at the Eel River Critical Zone Observatory*. American Geophysical Union 2014 Fall Meetin. San Francisco, CA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Gabe Rossi (2017). *Mapping Steelhead Behavior -Implications for Water Management*. Cal-Neva AFS Conference. Eureka, CA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Mary Power (2017). *Pattern, process and science-informed policy*. University of California, Santa Cruz Departmental Seminar. Santa Cruz, CA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Fung, Inez (2015). *Plants Water Climate - Assessing the Climatic Impacts of Afforestation*. Johns Hopkins - Dept of Earth Science. Baltimore, MD. Status = OTHER; Acknowledgement of Federal Support = Yes
- Fung, I (2015). *Plants, Water and Climate*. Mills College Women in Science Lecture Series. Oakland, CA. Status = OTHER; Acknowledgement of Federal Support = Yes

Fung, I (2015). *Plants, Water and Climate*. MIT Earth and Planetary Science Department Lecture Series. Cambridge, MA. Status = OTHER; Acknowledgement of Federal Support = Yes

Jill Marshall (2016). *Quantifying the role of trees as Critical Zone architects employing crowbars, wedges and other tools of soil production*. AGU Fall Meeting. San Francisco, CA. Status = OTHER; Acknowledgement of Federal Support = Yes

Suzanne Kelson (2017). *Small Waterfall Barriers Can Alter the Frequency of Resident Versus Migratory *O. mykiss* in Headwater Streams*. California-Nevada Chapter of American Fisheries Society. Eureka, CA. Status = OTHER; Acknowledgement of Federal Support = Yes

Dietrich, W.D. (2016). *The Critical Zone in Hilly and Mountainous Landscapes*. The 3rd International Conference on Hydrogeology. Beijing, China. Status = OTHER; Acknowledgement of Federal Support = Yes

Rempe, D. (2016). *The Ecological Significance of Landscape-scale Weathering Patterns And Rock Moisture: Observations from the Eel River Critical Zone Observatory in Northern California*. Department of Earth, Atmospheric, and Planetary Sciences Colloquia. Lafayette, IN. Status = OTHER; Acknowledgement of Federal Support = Yes

Kelson, S., Carlson, SM. (2016). *The Influence of Natural Barriers on the Distribution of Steelhead and Rainbow Trout in Tributaries of the South Fork Eel River*. Salmonid Restoration Federation Conference. Fortuna, CA. Status = OTHER; Acknowledgement of Federal Support = Yes

Kelson, S, Carlson, SM (2015). *The Influence of Waterfalls and Hydrology on the Spatial Zonation of *O. mykiss**. Pacific States Marine Fisheries Commission Steelhead Managers Meeting. Asilomar, CA. Status = OTHER; Acknowledgement of Federal Support = Yes

Dietrich, W.E. (2014). *The US Critical Zone Observatory program*. Frontiers in International Critical Zone Science. Beijing, China. Status = OTHER; Acknowledgement of Federal Support = Yes

Dietrich, W.E. (2014). *The soil is not enough: going inside hillslopes to understand moisture return to the atmosphere, and controls on tree distribution, stream ecosystems, and landscape evolution*. Invited talk, Department of Earth, Atmospheric and Planetary Sciences, MIT. Cambridge, MA. Status = OTHER; Acknowledgement of Federal Support = Yes

Dietrich, W.E. (2015). *The soil is not enough: going inside hillslopes to understand moisture return to the atmosphere, and controls on tree distribution, stream ecosystems, and landscape evolution*. Invited talk, Department of Geography, Simon Fraser University. Burnaby, BC, Canada. Status = OTHER; Acknowledgement of Federal Support = Yes

Mary Power (2016). *The state of the natural ecosystem: The Water- Landscape-Fire nexus*. Lake Tahoe summit on Aquatic Ecosystems in the Western US under Climate Change. Lake Tahoe, CA. Status = OTHER; Acknowledgement of Federal Support = Yes

Keith Bouma-Gregson (2016). *Tipping towards toxicity: effects of benthic cyanobacteria on food webs and water quality in a California river network*. New Zealand Societies for Freshwater Science. Invercargill, New Zealand. Status = OTHER; Acknowledgement of Federal Support = Yes

Mary Power (2016). *Trophic Cascades in Rivers*. HHMI Holiday Lectures. San Francisco, CA. Status = OTHER; Acknowledgement of Federal Support = Yes

Spencer Diamond (2017). *Uncovering Context and Dynamics of Climate Relevant Biogeochemical Functions in Soil by Linking Microbial Genomes to Functional Genes with Multi-'Omic' Analysis*. ASM Microbe. New Orleans, LA. Status = OTHER; Acknowledgement of Federal Support = Yes

Fung, Inez (2016). *Water in Motion*. Harvard EPS Seminar Series. Cambridge, MA. Status = OTHER; Acknowledgement of Federal Support = Yes

Fung, Inez (2015). *Water in Motion*. Chinese Academy of Sciences - Institute of Earth Environment. Xian China. Status = OTHER; Acknowledgement of Federal Support = Yes

Inez Fung (2016). *Water in Motion: Mysteries from Northern California*. Caltech. Pasadena, CA. Status = OTHER; Acknowledgement of Federal Support = Yes

Mary Power (2017). *Water usage in Oklahoma: How should we share a precious resource?*. Earth Month at OU Distinguished Speaker Series. Norman, OK. Status = OTHER; Acknowledgement of Federal Support = Yes

## Other Products

## Other Publications

## Patents

## Technologies or Techniques

## Thesis/Dissertations

Daniella Rempe. *Controls on critical zone thickness and hydrologic dynamics at the hillslope scale*. (2016). UC Berkeley. Acknowledgement of Federal Support = Yes

Keith Bouma-Gregson. *The Ecology of Benthic Toxigenic Anabaena and Phormidium (Cyanobacteria) in the Eel River, California*. (2017). UC Berkeley. Acknowledgement of Federal Support = Yes

## Websites

## 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? 0

How many REU applicants were selected and agreed to participate during this reporting period? 0

REU Comments:

### What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Dietrich, William	PD/PI	3
Bishop, James	Co PD/PI	0
Carlson, Stephanie	Co PD/PI	2
Power, Mary	Co PD/PI	2
Thompson, Sally	Co PD/PI	1
Banfield, Jillian	Faculty	1
Dawson, Todd	Faculty	2
Firestone, Mary	Faculty	1
Fung, Inez	Faculty	2
Chung, Michaella	Postdoctoral (scholar, fellow or other postdoctoral position)	0

Name	Most Senior Project Role	Nearest Person Month Worked
Dralle, David	Postdoctoral (scholar, fellow or other postdoctoral position)	10
Vaughn, Lydia	Postdoctoral (scholar, fellow or other postdoctoral position)	12
John, Smith	Other Professional	3
Roy, Sarah	Other Professional	6
Baxter, Wendy	Technician	6
Bode, Collin	Technician	6
Minton, Brandon	Technician	6
Speiser, William	Technician	6
Wolf, Marshall	Technician	4
Bilir, T.	Graduate Student (research assistant)	6
Bouma-Gregson, Keith	Graduate Student (research assistant)	3
Crutchfield-Peters, Kelsey	Graduate Student (research assistant)	6
Georgakakos, Philip	Graduate Student (research assistant)	6
Greer, George	Graduate Student (research assistant)	6
Hahm, William	Graduate Student (research assistant)	6
Kelson, Suzanne	Graduate Student (research assistant)	6
Lee, Shawn	Graduate Student (research assistant)	6
Rossi, Gabe	Graduate Student (research assistant)	6
Schmidt, Logan	Graduate Student (research assistant)	6
Sharrar, Allison	Graduate Student (research assistant)	6
Starr, Evan	Graduate Student (research assistant)	6
Tune, Alison	Graduate Student (research assistant)	6
Wang, Jia	Graduate Student (research assistant)	6

<b>Name</b>	<b>Most Senior Project Role</b>	<b>Nearest Person Month Worked</b>
Nelson, Mariel	Non-Student Research Assistant	3
Pneh, Shelley	Non-Student Research Assistant	2
Bolas, Theodore	Undergraduate Student	3
Boslough, Kobrina	Undergraduate Student	3
Flynn, Keanne	Undergraduate Student	3
LaPaglia, Nick	Undergraduate Student	3
Richmond, Keana	Undergraduate Student	3
Schaaf, Cody	Undergraduate Student	2
Schadlich, Daisy	Undergraduate Student	3
Schugel, Cain	Undergraduate Student	3
Setlur, Neeraja	Undergraduate Student	1
Shekelle, Kristen	Undergraduate Student	3
Slaughter, Weston	Undergraduate Student	3
Spankowski, Robert	Undergraduate Student	3
Uva, Victoria	Undergraduate Student	3
Young, Candice	Undergraduate Student	3
Yu, Katelyn	Undergraduate Student	6

#### **Full details of individuals who have worked on the project:**

##### **William E Dietrich**

**Email:** bill@eps.berkeley.edu

**Most Senior Project Role:** PD/PI

**Nearest Person Month Worked:** 3

**Contribution to the Project:** Lead PI, CZO director

**Funding Support:** none

**International Collaboration:** No

**International Travel:** No

##### **James K Bishop**

**Email:** jkbishop@berkeley.edu  
**Most Senior Project Role:** Co PD/PI  
**Nearest Person Month Worked:** 0

**Contribution to the Project:** co-PI

**Funding Support:** none

**International Collaboration:** No  
**International Travel:** No

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**Stephanie M Carlson**

**Email:** smcarlson@berkeley.edu  
**Most Senior Project Role:** Co PD/PI  
**Nearest Person Month Worked:** 2

**Contribution to the Project:** Directs graduate student research in ecology of freshwater fish

**Funding Support:** Grant funding from the Wildlife Conservation Board Stream Flow Enhancement Program

**International Collaboration:** No  
**International Travel:** No

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**Mary E Power**

**Email:** mepower@berkeley.edu  
**Most Senior Project Role:** Co PD/PI  
**Nearest Person Month Worked:** 2

**Contribution to the Project:** Director of Angelo Reserve, leads graduate research in stream food webs

**Funding Support:** NSF award 1656009, Spatial and environmental barriers to gene flow driving cyanobacterial biogeography in a river network

**International Collaboration:** No  
**International Travel:** No

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**Sally Thompson**

**Email:** sally.thompson@berkeley.edu  
**Most Senior Project Role:** Co PD/PI  
**Nearest Person Month Worked:** 1

**Contribution to the Project:** Directed graduate student and postdoc research in hydrological modeling

**Funding Support:** none

**International Collaboration:** No  
**International Travel:** No

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**Jillian Banfield**

**Email:** jbanfield@berkeley.edu  
**Most Senior Project Role:** Faculty  
**Nearest Person Month Worked:** 1

**Contribution to the Project:** Provided guidance on project's objectives; assisted in implementing research questions.

**Funding Support:** NSF award 1656009, Spatial and environmental barriers to gene flow driving cyanobacterial biogeography in a river network

**International Collaboration:** No

**International Travel:** No

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**Todd Dawson**

**Email:** tdawson@berkeley.edu

**Most Senior Project Role:** Faculty

**Nearest Person Month Worked:** 2

**Contribution to the Project:** Provided guidance on project's objectives; assisted in implementing research questions.

**Funding Support:** None

**International Collaboration:** No

**International Travel:** No

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**Mary Firestone**

**Email:** mkfstone@berkeley.edu

**Most Senior Project Role:** Faculty

**Nearest Person Month Worked:** 1

**Contribution to the Project:** Provided guidance on project's objectives; assisted in implementing research questions.

**Funding Support:** none

**International Collaboration:** No

**International Travel:** No

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**Inez Fung**

**Email:** ifung@berkeley.edu

**Most Senior Project Role:** Faculty

**Nearest Person Month Worked:** 2

**Contribution to the Project:** Provided guidance on project's objectives; assisted in implementing research questions.

**Funding Support:** None

**International Collaboration:** No

**International Travel:** No

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**Michaella Chung**

**Email:** michaellachung@berkeley.edu

**Most Senior Project Role:** Postdoctoral (scholar, fellow or other postdoctoral position)

**Nearest Person Month Worked:** 0

**Contribution to the Project:** Using UAVs to collect water samples

**Funding Support:** None

**International Collaboration:** No

**International Travel:** No

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**David Dralle**

**Email:** daviddralle@gmail.com

**Most Senior Project Role:** Postdoctoral (scholar, fellow or other postdoctoral position)

**Nearest Person Month Worked:** 10

**Contribution to the Project:** Assisted in implementing research questions; performed data collection, sampling and analysis. Now working as a postdoc modeling components of the AWESOM model.

**Funding Support:** NSF Graduate Research Fellowship

**International Collaboration:** No

**International Travel:** No

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### Lydia Vaughn

**Email:** lydiajsvaughn@gmail.com

**Most Senior Project Role:** Postdoctoral (scholar, fellow or other postdoctoral position)

**Nearest Person Month Worked:** 12

**Contribution to the Project:** Conducting research in soil carbon turnover rates, decomposition processes, and their biogeochemical controls.

**Funding Support:** none

**International Collaboration:** No

**International Travel:** No

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### Smith Scott John

**Email:** jscottsf@berkeley.edu

**Most Senior Project Role:** Other Professional

**Nearest Person Month Worked:** 3

**Contribution to the Project:** Helped design and implement new sensor database

**Funding Support:** UC Natural Reserve System

**International Collaboration:** No

**International Travel:** No

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### Sarah Roy

**Email:** smroy@berkeley.edu

**Most Senior Project Role:** Other Professional

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Oversees the general administrative functions of the CZO, including financial operations, grants management, and facilities operations, as well as overall technical management of the research, with the authority to organize, coordinate, and monitor projects to meet milestones and goals.

**Funding Support:** University of California Berkeley VCRO and Dean

**International Collaboration:** No

**International Travel:** No

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### Wendy Baxter

**Email:** wendy.l.baxter@berkeley.edu

**Most Senior Project Role:** Technician

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Implementation and maintenance of CZO sampling infrastructure.

**Funding Support:** UC Natural Reserve System

**International Collaboration:** No

**International Travel:** No

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**Collin Bode**

**Email:** collin@berkeley.edu

**Most Senior Project Role:** Technician

**Nearest Person Month Worked:** 6

**Contribution to the Project:** As Data Manager, Mr. Bode maintains the wireless network, operates and maintains the sensor observatories, develops and maintains the sensor observatory database and website for archiving and disseminating data, and performs spatial analysis of the LiDAR flown at the Angelo Coast Range Reserve and extended areas.

**Funding Support:** University of California Berkeley VCRO and Dean

**International Collaboration:** No

**International Travel:** No

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**Brandon Minton**

**Email:** BrandonMinton@austin.utexas.edu

**Most Senior Project Role:** Technician

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Developed and implemented gas sampling and monitoring system. Collected and analyzed vadose zone gas samples. Deployed geophysical instrumentation for monitoring rock moisture.

**Funding Support:** Department of Geological Sciences, University of Texas at Austin

**International Collaboration:** No

**International Travel:** No

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**William Speiser**

**Email:** williamhspeiser@berkeley.edu

**Most Senior Project Role:** Technician

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Led VMS sampling campaigns

**Funding Support:** None

**International Collaboration:** No

**International Travel:** No

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**Marshall Wolf**

**Email:** marshallwolf@berkeley.edu

**Most Senior Project Role:** Technician

**Nearest Person Month Worked:** 4

**Contribution to the Project:** Led VMS sampling campaigns

**Funding Support:** None

**International Collaboration:** No  
**International Travel:** No

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**T. Eren Bilir**

**Email:** tebilir@gmail.com

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Conducted research with stem psychrometers, conducting drone experiment

**Funding Support:** None

**International Collaboration:** No

**International Travel:** No

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**Keith Bouma-Gregson**

**Email:** kbg@berkeley.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 3

**Contribution to the Project:** Task 4- Field work, assisted in implementing research questions; performed data collection, sampling and analysis.

**Funding Support:** NSF award 1656009, SG: Spatial and environmental barriers to gene flow driving cyanobacterial biogeography in a river network

**International Collaboration:** No

**International Travel:** No

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**Kelsey Crutchfield-Peters**

**Email:** kcrutchfieldpeters@berkeley.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Task 3- Field work; performed data collection, sampling and analysis.

**Funding Support:** NSF Graduate Research Fellowship

**International Collaboration:** No

**International Travel:** No

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**Philip Georgakakos**

**Email:** pgeorgakakos@berkeley.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Task 4- Field work; performed data collection, sampling and analysis.

**Funding Support:** UC Berkeley ISEECI graduate award

**International Collaboration:** No

**International Travel:** No

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**George Greer**

**Email:** georgegreer@berkeley.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Task 4- Field work; performed data collection, sampling and analysis.

**Funding Support:** None

**International Collaboration:** No

**International Travel:** No

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**William Jesse Hahm**

**Email:** wjhahm@berkeley.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Task 1- Field work; performed data collection, sampling and analysis.

**Funding Support:** None

**International Collaboration:** No

**International Travel:** No

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**Suzanne Kelson**

**Email:** skelson@berkeley.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Task 4- Field work; performed data collection, sampling and analysis.

**Funding Support:** NSF Graduate Research Fellowship

**International Collaboration:** No

**International Travel:** No

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**Shawn Lee**

**Email:** shawnlee@berkeley.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Analyzed geophysical data collected at ERCZO

**Funding Support:** Jackson School Fellowship, Department of Geological Sciences, University of Texas at Austin

**International Collaboration:** No

**International Travel:** No

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**Gabe Rossi**

**Email:** rossfactor@berkeley.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Task 4- Studying stream ecology

**Funding Support:** UC Berkeley ISEECI graduate award

**International Collaboration:** No  
**International Travel:** No

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**Logan Schmidt**

**Email:** loganmschmidt@utexas.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Monitoring rock moisture using novel geophysical techniques

**Funding Support:** Department of Geological Sciences, University of Texas at Austin

**International Collaboration:** No

**International Travel:** No

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**Allison Sharrar**

**Email:** asharrar@berkeley.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Task 2- Field work; performed data collection, sampling and analysis.

**Funding Support:** None

**International Collaboration:** No

**International Travel:** No

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**Evan Starr**

**Email:** evan.starr@berkeley.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Task 2- Field work; performed data collection, sampling and analysis.

**Funding Support:** none

**International Collaboration:** No

**International Travel:** No

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**Alison Tune**

**Email:** alisontune@utexas.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Leading characterization of dissolved organic and inorganic carbon and carbon isotope characterization of vadose zone fluids

**Funding Support:** Department of Geological Sciences, University of Texas at Austin

**International Collaboration:** No

**International Travel:** No

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**Jia Wang**

**Email:** Jiawang2@illinois.edu

**Most Senior Project Role:** Graduate Student (research assistant)

**Nearest Person Month Worked:** 6

**Contribution to the Project:** Anion analysis

**Funding Support:** University of Illinois Urbana-Champaign

**International Collaboration:** No

**International Travel:** No

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**Mariel Nelson**

**Email:** marielnelson@berkeley.edu

**Most Senior Project Role:** Non-Student Research Assistant

**Nearest Person Month Worked:** 3

**Contribution to the Project:** Data collection, organization, and analysis

**Funding Support:** none

**International Collaboration:** No

**International Travel:** No

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**Shelley Pneh**

**Email:** shelleypneh@berkeley.edu

**Most Senior Project Role:** Non-Student Research Assistant

**Nearest Person Month Worked:** 2

**Contribution to the Project:** Assisted in collection and accession of riverine invertebrate communities

**Funding Support:** None

**International Collaboration:** No

**International Travel:** No

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**Theodore Bolas**

**Email:** bolas@berkeley.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 3

**Contribution to the Project:** Assisted graduate students collecting data

**Funding Support:** None

**International Collaboration:** No

**International Travel:** No

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**Kobrina Boslough**

**Email:** boslough@berkeley.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 3

**Contribution to the Project:** Assisted graduate students collecting data

**Funding Support:** None

**International Collaboration:** No  
**International Travel:** No

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**Keanne Flynn**

**Email:** kmflynn24@berkeley.edu  
**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** Assisted graduate students collecting data

**Funding Support:** None

**International Collaboration:** No  
**International Travel:** No

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**Nick LaPaglia**

**Email:** nalapaglia@berkeley.edu  
**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** Assisted graduate students collecting data

**Funding Support:** None

**International Collaboration:** No  
**International Travel:** No

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**Keana Richmond**

**Email:** krichmond@berkeley.edu  
**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** Assisted graduate students collecting data

**Funding Support:** None

**International Collaboration:** No  
**International Travel:** No

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**Cody Schaaf**

**Email:** codyschaaf@berkeley.edu  
**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 2

**Contribution to the Project:** Assisted in analysis of fish disease occurrence

**Funding Support:** None

**International Collaboration:** No  
**International Travel:** No

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**Daisy Schadlich**

**Email:** dschadlich@berkeley.edu  
**Most Senior Project Role:** Undergraduate Student  
**Nearest Person Month Worked:** 3

**Contribution to the Project:** Assisted graduate students with data collection

**Funding Support:** none

**International Collaboration:** No

**International Travel:** No

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**Cain Schugel**

**Email:** cainschugel@berkeley.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 3

**Contribution to the Project:** Assisted graduate students collecting data

**Funding Support:** None

**International Collaboration:** No

**International Travel:** No

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**Neeraja Setlur**

**Email:** rempe@jsg.utexas.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 1

**Contribution to the Project:** Assisted graduate students collecting data

**Funding Support:** Department of Geological Sciences, University of Texas at Austin

**International Collaboration:** No

**International Travel:** No

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**Kristen Shekelle**

**Email:** kshekelle@berkeley.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 3

**Contribution to the Project:** Assisted graduate students collecting data

**Funding Support:** None

**International Collaboration:** No

**International Travel:** No

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**Weston Slaughter**

**Email:** wslaughter@berkeley.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 3

**Contribution to the Project:** Assisted graduate students collecting data

**Funding Support:** None

**International Collaboration:** No

**International Travel:** No

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**Robert Spankowski****Email:** robert.spankowski@berkeley.edu**Most Senior Project Role:** Undergraduate Student**Nearest Person Month Worked:** 3**Contribution to the Project:** Assisted graduate students collecting data**Funding Support:** None**International Collaboration:** No**International Travel:** No**Victoria Uva****Email:** vuva@berkeley.edu**Most Senior Project Role:** Undergraduate Student**Nearest Person Month Worked:** 3**Contribution to the Project:** Assisted graduate students collecting data**Funding Support:** None**International Collaboration:** No**International Travel:** No**Candice Young****Email:** clyoung@berkeley.edu**Most Senior Project Role:** Undergraduate Student**Nearest Person Month Worked:** 3**Contribution to the Project:** Assisted graduate students collecting data**Funding Support:** None**International Collaboration:** No**International Travel:** No**Katelyn Yu****Email:** katelyn.a.yu@gmail.com**Most Senior Project Role:** Undergraduate Student**Nearest Person Month Worked:** 6**Contribution to the Project:** Assisted graduate students collecting data**Funding Support:** None**International Collaboration:** No**International Travel:** No**What other organizations have been involved as partners?**

Name	Type of Partner Organization	Location
Babson College	Academic Institution	Babson Park, MA

Name	Type of Partner Organization	Location
Berkeley Natural History Museums	Academic Institution	University of California, Berkeley, CA
Humboldt State University	Academic Institution	Arcata, CA
Institut de Physique du Globe de Paris	Academic Institution	Paris, France
Karuk Tribe	Other Organizations (foreign or domestic)	Happy Camp, CA
NOAA National Marine Fisheries Service Southwest Region	State or Local Government	La Jolla, CA
Northern Arizona University	Academic Institution	Arizona
Penn State	Academic Institution	State College, PA
Redwood Forest Foundation	Other Nonprofits	Mendocino, CA
Swedish University of Agricultural Sciences	Academic Institution	Sweden
The Nature Conservancy	Other Nonprofits	San Francisco, CA
The University of Texas at Austin	Academic Institution	Austin, TX
Bureau of Land Management	State or Local Government	California
USFS Caspar Creek Experimental Watershed Study	State or Local Government	Fort Bragg, CA
USGS	State or Local Government	United States
University of Alberta	Academic Institution	Edmonton, Alberta, Canada
University of California Natural Reserve System	Academic Institution	Oakland, CA
University of California, Davis	Academic Institution	Davis, CA
University of California, Santa Cruz	Academic Institution	Santa Cruz, CA
University of Illinois, Urbana-Champaign	Academic Institution	Urbana-Champaign, IL
University of Wyoming	Academic Institution	Laramie, WY
Université de Rennes 1	Academic Institution	Rennes, France
Watercourse Engineering, Inc.	Industrial or Commercial Firms	Davis, CA
CA Department of Fish and Wildlife	State or Local Government	California

Name	Type of Partner Organization	Location
Wright State University	Academic Institution	Dayton, Ohio
California Department of Forestry and Fire Protection	State or Local Government	California
California Heartbeat Initiative	Other Nonprofits	California
California Sea Grant	Other Organizations (foreign or domestic)	California
Caltrout	Other Nonprofits	San Francisco, California
Eel River Recovery Project	Other Nonprofits	Garberville, CA
Friends of the Eel River	Other Nonprofits	Arcata, CA

#### Full details of organizations that have been involved as partners:

##### Babson College

**Organization Type:** Academic Institution

**Organization Location:** Babson Park, MA

**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:**

##### Berkeley Natural History Museums

**Organization Type:** Academic Institution

**Organization Location:** University of California, Berkeley, CA

**Partner's Contribution to the Project:**

In-Kind Support

**More Detail on Partner and Contribution:**

##### Bureau of Land Management

**Organization Type:** State or Local Government

**Organization Location:** California

**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:**

##### CA Department of Fish and Wildlife

**Organization Type:** State or Local Government

**Organization Location:** California

**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:**

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**California Department of Forestry and Fire Protection**

**Organization Type:** State or Local Government

**Organization Location:** California

**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:**

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**California Heartbeat Initiative**

**Organization Type:** Other Nonprofits

**Organization Location:** California

**Partner's Contribution to the Project:**

Financial support

Collaborative Research

Personnel Exchanges

**More Detail on Partner and Contribution:** The California Heartbeat Initiative is a \$2.179 million grant awarded to the UC Natural Reserve System by the Gordon & Betty Moore Foundation to monitor the pulse of water through state ecosystems.

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**California Sea Grant**

**Organization Type:** Other Organizations (foreign or domestic)

**Organization Location:** California

**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:**

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**Caltrout**

**Organization Type:** Other Nonprofits

**Organization Location:** San Francisco, California

**Partner's Contribution to the Project:**

Financial support

Collaborative Research

**More Detail on Partner and Contribution:**

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**Eel River Recovery Project**

**Organization Type:** Other Nonprofits

**Organization Location:** Garberville, CA

**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:** Collaborator on ERCZO Education & Outreach activities.

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**Friends of the Eel River**

**Organization Type:** Other Nonprofits

**Organization Location:** Arcata, CA

**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:** Collaborator on ERCZO Education & Outreach activities.

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**Humboldt State University**

**Organization Type:** Academic Institution

**Organization Location:** Arcata, CA

**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:** Working with Assistant Professor Jasper Oshun (former grad student)

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**Institut de Physique du Globe de Paris**

**Organization Type:** Academic Institution

**Organization Location:** Paris, France

**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:** We are working with J. Bouchez and J. Gaillardet on isotope fingerprints of groundwater

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**Karuk Tribe**

**Organization Type:** Other Organizations (foreign or domestic)

**Organization Location:** Happy Camp, CA

**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:** Collaborator on ERCZO Education & Outreach activities.

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**NOAA National Marine Fisheries Service Southwest Region**

**Organization Type:** State or Local Government

**Organization Location:** La Jolla, CA

**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:**

**Northern Arizona University****Organization Type:** Academic Institution**Organization Location:** Arizona**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:**

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**Penn State****Organization Type:** Academic Institution**Organization Location:** State College, PA**Partner's Contribution to the Project:**

Collaborative Research

Personnel Exchanges

**More Detail on Partner and Contribution:**

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**Redwood Forest Foundation****Organization Type:** Other Nonprofits**Organization Location:** Mendocino, CA**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:**

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**Swedish University of Agricultural Sciences****Organization Type:** Academic Institution**Organization Location:** Sweden**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:** Collaborated on stochastic hydrologic modeling

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**The Nature Conservancy****Organization Type:** Other Nonprofits**Organization Location:** San Francisco, CA**Partner's Contribution to the Project:**

Financial support

Collaborative Research

**More Detail on Partner and Contribution:**

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**The University of Texas at Austin**

**Organization Type:** Academic Institution

**Organization Location:** Austin, TX

**Partner's Contribution to the Project:**

Collaborative Research

Personnel Exchanges

**More Detail on Partner and Contribution:** Working with former grad student, now Assistant Professor Daniella Rempe

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### **USFS Caspar Creek Experimental Watershed Study**

**Organization Type:** State or Local Government

**Organization Location:** Fort Bragg, CA

**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:**

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### **USGS**

**Organization Type:** State or Local Government

**Organization Location:** United States

**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:**

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### **University of Alberta**

**Organization Type:** Academic Institution

**Organization Location:** Edmonton, Alberta, Canada

**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:** We worked with A. Oliver (a CZO SAVI funded proposal) on carbon and nutrient exports from the Eel River

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### **University of California Natural Reserve System**

**Organization Type:** Academic Institution

**Organization Location:** Oakland, CA

**Partner's Contribution to the Project:**

Facilities

Collaborative Research

Personnel Exchanges

**More Detail on Partner and Contribution:**

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### **University of California, Davis**

**Organization Type:** Academic Institution

**Organization Location:** Davis, CA

**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:** Collaborating on nitrogen storage in rocks

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### **University of California, Santa Cruz**

**Organization Type:** Academic Institution

**Organization Location:** Santa Cruz, CA

**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:**

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### **University of Illinois, Urbana-Champaign**

**Organization Type:** Academic Institution

**Organization Location:** Urbana-Champaign, IL

**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:** We are working with Jennifer Druhan on solute evolution (and reactive transport modeling) through the critical zone

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### **University of Wyoming**

**Organization Type:** Academic Institution

**Organization Location:** Laramie, WY

**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:** Collaborated on geophysical exploration at the Eel River CZO field site

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### **Université de Rennes 1**

**Organization Type:** Academic Institution

**Organization Location:** Rennes, France

**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:** We are working with M. Bormans on controls on cyanobacteria.

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### **Watercourse Engineering, Inc.**

**Organization Type:** Industrial or Commercial Firms

**Organization Location:** Davis, CA

**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:****Wright State University****Organization Type:** Academic Institution**Organization Location:** Dayton, Ohio**Partner's Contribution to the Project:**

Collaborative Research

**More Detail on Partner and Contribution:** Collaborated on toxic algal blooms with Y. Vadeboncoeur.**What other collaborators or contacts have been involved?**

The ER CZO collaborates extensively with the labs of Professor Daniella Rempe of UT Austin and Professor Jennifer Druhan of The University of Illinois. Prof Rempe is leading and advising on the bulk of the field research being conducted within the Vadose Zone Monitoring System, and several of her graduate students are conducting thesis work within this system. Prof Druhan and her lab are studying the role of fluid mobility in the development of shale weathering profiles using the Vadose Monitoring System observations. She leads the modeling of the chemical evolution of the critical zone. Both of these collaborators regularly send graduate students and technicians to lead and assist with field campaigns at the VMS.

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

The critical zone is a “thing” and, as such, a kind of critical zone science discipline has emerged. The network of US critical zones has shown the necessity and fruitful consequence of scientists working for multiple years at a focal study site across traditionally distinct disciplines: geology, atmospheric science, ecology, tree physiology, microbiology and other fields. At Berkeley this is expressed not only in the diversity of fields the PIs represent, but in the fact that students freely work across disciplines, departments and colleges to gain deep insight into integrated critical zone processes. Strong expertise in existing disciplines is still essential, but now such expertise can spread and gain new perspectives in a critical zone context.

**What is the impact on other disciplines?**

The emergence of critical zone science, made possible by observatories focused on understanding mechanisms, has attracted many disciplines. The concept of the critical zone as co-evolving entity is now being explored in many disciplines, including hydrology, geomorphology, pedology, geophysics, ecology, and climate science.

**What is the impact on the development of human resources?**

During the past year, 2 post-doctoral researchers, 14 graduate students and 15 undergraduate students conducted research in the ER CZO. Working through the ER CZO has provided these students with invaluable experience in the practical aspects of designing and conducting research projects as well as access to the broad experiences and perspectives of our PIs and senior personnel. Several of the undergraduates will attend graduate school to pursue related research.

Several of our personnel have attained professional positions related to their work at the ER CZO in the last year, including: 1) Jill Marshall began an assistant professor position at the University of Arkansas in Fall 2017, and 2) David Dralle will begin an assistant professor position at CSU Sacramento in Spring 2019.

**What is the impact on physical resources that form infrastructure?**

The physical infrastructure at our primary field sites, Rivendell and Sagehorn, have been stable. This has created the key infrastructure for research by many of the ERCZO students and post-docs. We expanded monitoring on the south slope of Rivendell, adding a vertical transect of air temperature and humidity sensors, a weather station, and soil moisture. We deployed 44 sap flow sensors across both north and south slopes. With roughly 1,000 sensors onsite, we periodically replace

failing equipment to maintain monitoring quality. This infrastructure is essential to the success and on-going work of graduate students and post-doctoral fellows.

### **What is the impact on institutional resources that form infrastructure?**

The primary field site for the ER CZO is the Heath and Marjorie Angelo Coast Range Reserve (Angelo). Angelo is one of 39 protected natural areas managed by the University of California Natural Reserve System (UCNRS). These areas are maintained by University for the purposes of research, education and public service. Various monitoring apparatuses exist and many of these sites and the UCNRS as recently committed to making near real-time biological, hydrological and meteorological data available to the broader research community.

The UCNRS has provided salary support to ER CZO personnel Scott Smith (data analyst) Wendy Baxter (field technician) and Collin Bode (data manager) to establish and maintain a network of weather stations and to create a database structure to enable access to various data streams generated at the UC reserves. This effort is being modeled after the ER CZO's sensor database, which Virginia Ogle created, and will continue to be supported by UCNRS beyond the lifetime of the ER CZO award.

### **What is the impact on information resources that form infrastructure?**

During the 2017-2018 funding period, the ER CZO expanded its monitoring infrastructure and made extensive changes to its cyberinfrastructure. Our data manager, Collin Bode, is working with Lou Derry at the Central Office on the CZOshare initiative to develop the tools to help all CZOs centralize their datasets and metadata into CUAHSI's HydroShare. Dendra was launched on May 1st, 2018 and is now in production at <http://dendra.science>. Dendra is our new sensor database data curation system. All time-series data is streamed into Dendra in real-time. While operational, it is not feature complete. Features will be expanded over the next year. We started development last year as a collaboration with the University of California Natural Reserve System, hosting their 30 weather station network. A Gordon & Betty Moore Foundation funded project, the 'California Heartbeat Initiative', is now a collaborator on Dendra and will be using the system for their planned deployment of roughly 100 monitoring stations and drone imagery. We have been approached by three other organizations interested in hosting their monitoring data in our system. Dendra is hosted on the NSF funded XSEDE supercomputing network.

### **What is the impact on technology transfer?**

Nothing to report.

### **What is the impact on society beyond science and technology?**

ER CZO researchers, anchored by Co-I Mary Power, have participated in many outreach efforts. In addition to various speaking engagements and meetings the group has been involved in several long-term collaborative partnerships, some of which are ongoing. ER CZO has strong interactions with the very active citizen's river watch group, the Eel River Recovery Project (ERRP). The ERCZO coordinates and shares data from joint temperature, fish, native frog, invasive snail and crayfish, and algal, cyanobacterial, and cyanotoxin monitoring efforts distributed throughout much of the 9546 km<sup>2</sup> Eel River basin. These riverine biota are supported or stressed, depending on the nature, timing, and magnitude of delivery of several Critical Zone currencies (water, heat, solutes, and sediments) to channel networks. CZO researchers regularly attend and speak at ERRP watershed meetings, and ERRP members and leaders speak and participate in our short Angelo Reserve courses and workshops.

#### *Educational Videos*

Eel River Recovery Project Volunteer and videographer, Barbara Domanchuk, came to UC Berkeley with 2 community college interns to interview and film Keith Bouma-Gregson and Mary Power about the Eel River CZO, river ecology, and cyanobacterial ecology. This footage will be turned into a series of 5-10 min science education videos that will be posted on websites and distributed to media and schools in Humboldt County.

#### *Stream Day at HREC*

Graduate Student Suzanne Kelson participated in "Stream Day" at the Hopland Research and Extension Center (HREC). 4th graders and high schoolers from the local area travelled to Hopland, CA for a field trip in the streams, where they learned about how streams can vary in sediment and flow, and the relevance to the life cycle of aquatic organisms.

### *Courses on Benthic Cyanobacterial Identification*

Former graduate student/current postdoc Keith Bouma-Gregson will be leading two California State Water Board Training Academy courses on benthic cyanobacterial identification in summer 2018.

### *CyanoHABs*

Keith Bouma-Gregson has joined the California CyanoHABs (Harmful Algal Blooms) Network Benthic Guidance Group, which is tasked with making recommendations for cyanotoxin public health response trigger levels in benthic cyanobacterial mats in California.

### *Pikeminnow Dive*

Graduate student Phil Georgakakos and his undergraduate field assistants participated in the Eel River Recovery Projects pikeminnow dive. They joined and assisted for 2 full days of snorkeling, helping with fish identification and general methods for snorkel surveys.

### *Algal Identification Field Course*

With collaborators Rex Lowe, Paula Furey, and Rosalina Hrisova, Prof. Mary Power taught an algal identification field course in summer 2017, hosted on the lower Klamath River by the Yurok Tribe.

### *Marijuana impacts*

Mary Power met with the Dept. of Fish and Wildlife and Regional Water Quality Control Boards re. monitoring of stream and watershed impacts of marijuana in Northern CA.

### *Freshwater Ecology Class in the Klamath*

Prof. Mary Power collaborated with Matt Hanington (Yurok tribe) and Laurel Genzoli (Yurok/Karuk biological consultant and RiosToRivers leader) to guide a class of 40 Berkeley Freshwater Ecology students to research organisms in Klamath and their projected responses to 2021 dam removals after 1, 5, and 50 years. Prof. Power also hosted Laurel Genzoli to give a capstone lecture to the class, and an Ecolunch on the RiosToRiver youth education exchange (Klamath tribal youth along with youth from southern Chile).

### *Hosted Institute for Sustainable Forestry meeting*

We hosted a two day site visit to the ERCZO by the Institute of Sustainable Forestry, which included participants from the Bureau of Land Management, the Eel River Recover Project, Redwood Forest Foundation, Why Forests Matter (Richard Wilson), and many local volunteers.

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## Changes/Problems

### **Changes in approach and reason for change**

Nothing to report.

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

Nothing to report.

### **Changes that have a significant impact on expenditures**

Nothing to report.

### **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.