SOUTHERN SIERRA CZO AND KINGS RIVER EXPERIMENTAL WATERSHED (KREW)

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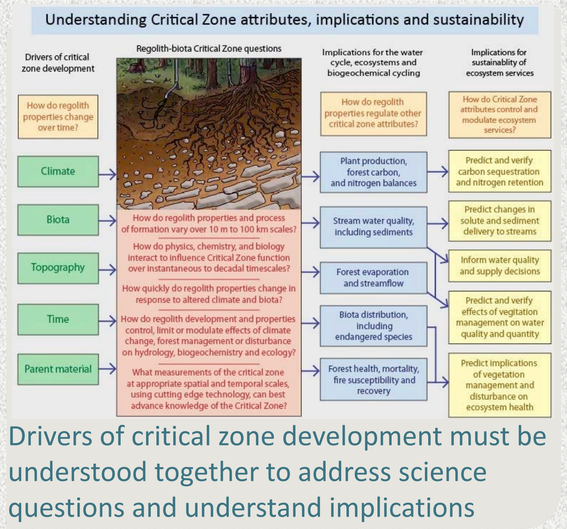
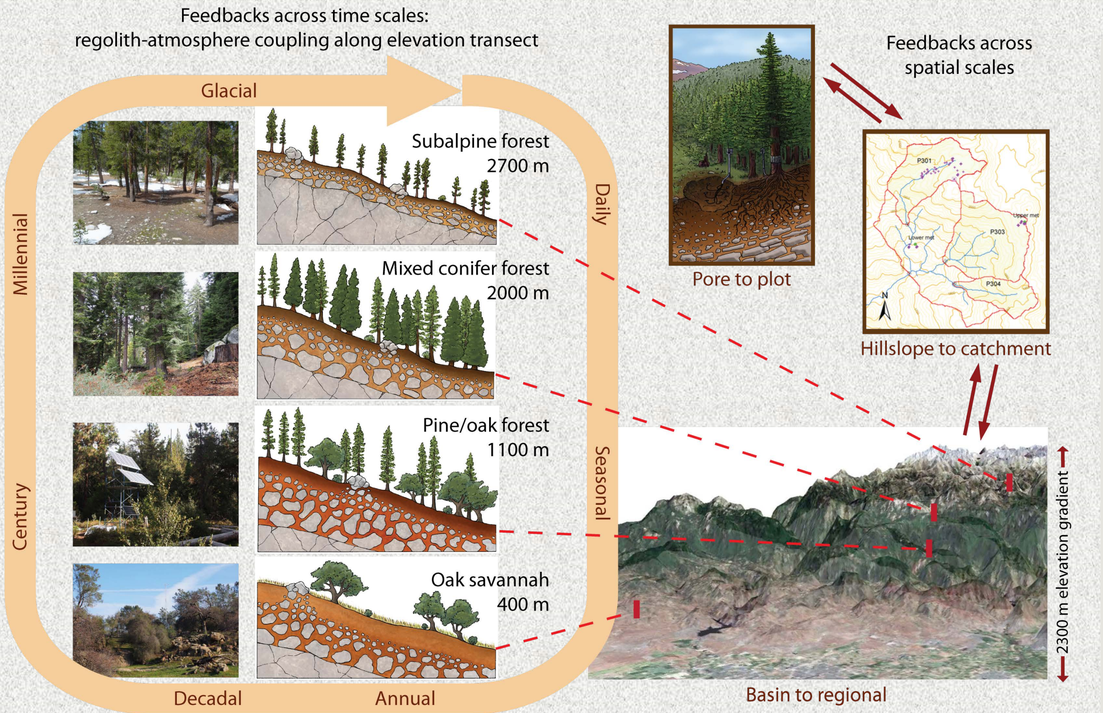
The Southern Sierra CZO (SSCZO) is a community platform for research on critical-zone (CZ) processes along a steep elevation transect where precipitation grades from dominantly rain to dominantly snow and ecosystems range from oak savannah biomes to subalpine forests. Spatial gradients in CZ properties and processes permit substitution of space for time, making the SSCZO an excellent natural laboratory for studying how the CZ responds to disturbance and how the water cycle drives CZ processes. The SSCZOs goals include: i) expand process-based understanding of the CZ in a sensitive, societally crucial ecosystem; ii) establish a foundation for long-term physical, biogeochemical and ecological studies; and iii) develop a framework for improving Earth System Models. KREW is a watershed-level, integrated ecosystem project for headwater streams in the Sierra Nevada. It was developed to: i) quantify the variability in characteristics of stream ecosystems and their associated watersheds in the southern Sierra Nevada; and ii) evaluate the effects of forest management (prescribed fire and uneven-aged, small group tree thinning) on the physical, chemical, and biological components of stream ecosystems. KREW is operated by the USFS, Pacific Southwest Research Station (PSW), which is part of the research and development branch of the USFS. Eight sub-watersheds and two integrating watersheds are fully instrumented to monitor ecosystem changes. The SSCZO includes 4 of the 10 nested KREW catchments. Under a long-term partnership with the Forest Service's Pacific Southwest Region, KREW has been a watershed research site since 2001. Hydrologic research at one of its catchments (Teakettle) began in the 1950's. The SSCZO infrastructure includes a 3000-m transect of flux towers and associated instrumentation, plus the well-instrumented Providence catchments at KREW. At Providence, instrumentation includes 2 meteorological stations, a 60-m flux tower, a 60-node wireless embedded sensor network, 215 EC-TM sensors for volumetric water content, over 110 MPS sensors for matric potential, 60 snow-depth sensors, meadow piezometers and wells, sap-flow sensors, stream gauges and water-quality measurements.



Drivers of critical zone development must be understood together to address science questions and understand implications

Overarching Research Questions:



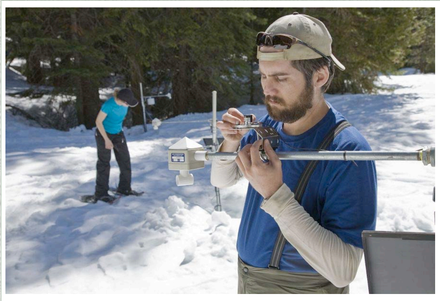
Southern Sierra elevation and climate gradient, with spatial scaling and temporal feedbacks

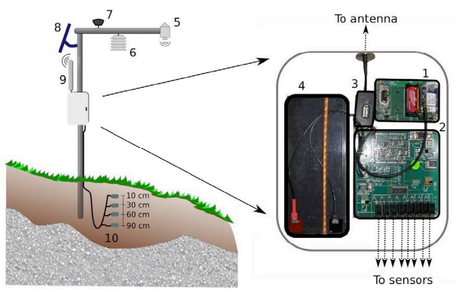
"We investigate how the water cycle drives critical zone processes, focusing on water balance, nutrient cycling, and weathering across the rain-snow transition"

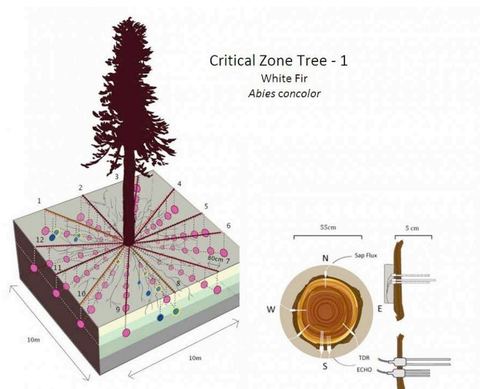
- How does landscape variability control how soil moisture, evapotranspiration and streamflow respond to snowmelt and rainfall?
- How is soil moisture linked to topographic variability, soil formation and weathering?
- What physiological mechanisms are controlling how vegetation distribution and function vary with climate?
- How do vegetation attributes influence cycling of water, energy, and CO_2? What is the link between soil heterogeneity, water fluxes and nutrient availability?
- What is the effect of fire and fuel reduction treatments (i.e., thinning of trees) on the riparian and stream physical, chemical, and biological conditions?
- Does the use of prescribed fire increase or decrease the rate of erosion (long- versus short-term) and affect soil health and productivity?
- How adequate and effective are current stream buffers at protecting aquatic ecosystems?

Our CZO and KREW center on the mixed-conifer slopes of the southwestern Sierra Nevada, over an elevation range associated with the rain-snow transition. Our research across this transition is built around bi-directional links between landscape/climate variability and water/material fluxes.

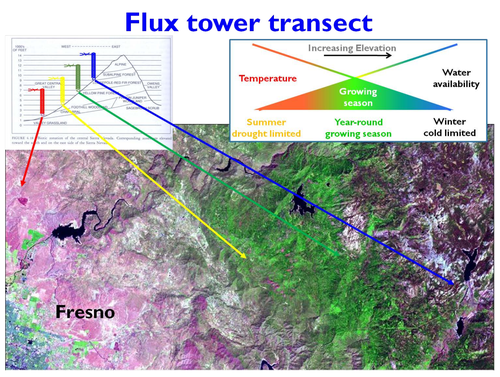
The Water-balance Instrument Cluster at SSCZO/KREW:







Each CZO sensor node interfaces: (1) mote, (2) custom data-logger to interface the sensor array, (3) on-site storage, (4) 12V battery, (5) snow-depth sensor, (6) humidity and temperature sensor, (7) solar radiation sensor, (8) 10W solar panel, (9) external 8dBi antenna, (10) 4 soil moisture, temperature, & matric potential sensors at varying depths.

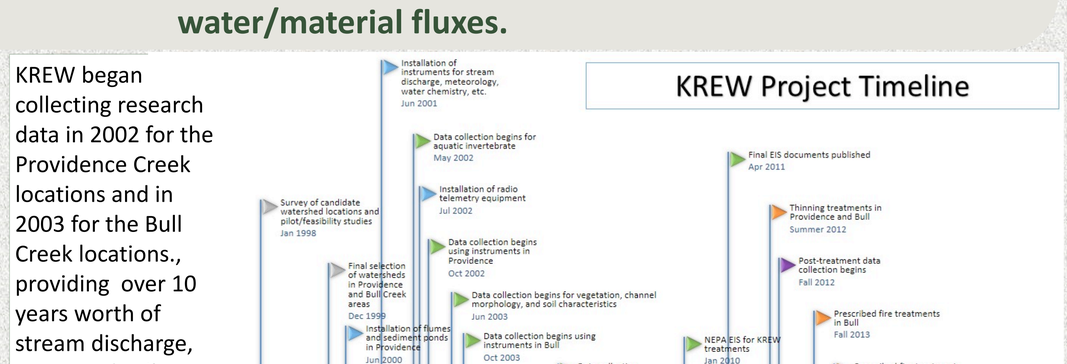


Flux towers are used to analyze the carbon and water balance of the surrounding forest. Various instruments on the flux tower track changes in carbon dioxide, water vapor, temperature, relative humidity, among others.

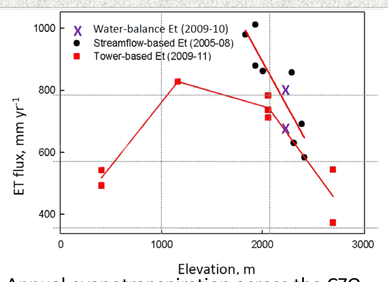
In 2008, the area underneath a white fir was instrumented with numerous soil moisture, matric potential, and sap flux sensors to better understand the water balance of a single tree.

KREW's double flume system, a sediment basin, stream invertebrate sampling during spring, and Yosemite toad with tracking device.

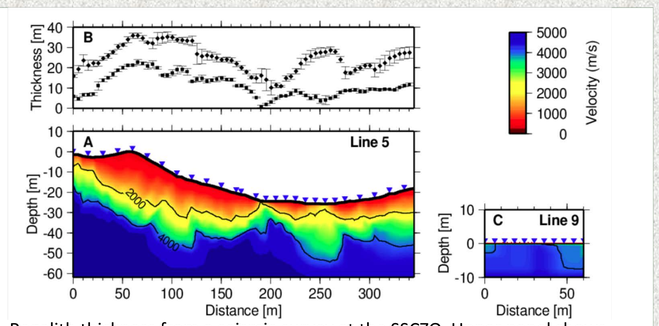
KREW began collecting research data in 2002 for the Providence Creek locations and in 2003 for the Bull Creek locations., providing over 10 years worth of stream discharge, water and soil chemistry, and meteorological data for the eight study watersheds.



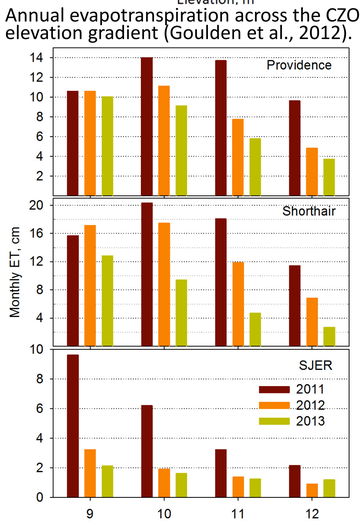
Research Highlights:



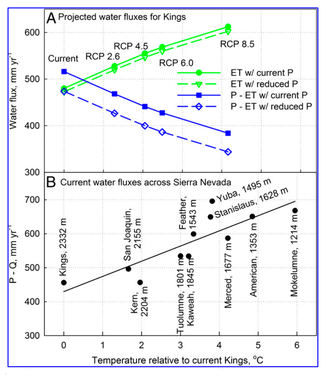
Annual evapotranspiration across the CZO elevation gradient (Goulden et al., 2012).



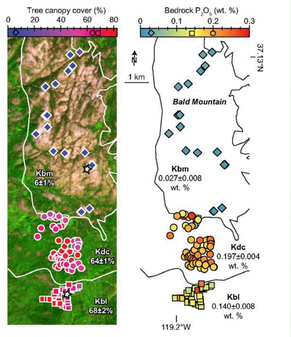
Regolith thickness from a seismic survey at the SSCZO. Upper panel shows thickness to the 2000 and 5000 m s^{-1} velocity profile (Holbrook et al., 2013).



Different drought signals in flux tower data for 3 sites for 2 dry years (2012, 2013) vs. a wet year (2011)



(A) Effect of warming and P reduction on ET and P–ET (B) The observed 1981–2010 relationship between mean T and P – Q across 11 basins on the western Sierra Nevada slope (Goulden and Bales, 2014).



Distribution of vegetation across bedrock with differing phosphorus content (see Hahm et al. 2014 for details)

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