

Annual Report for Period: 09/2009 - 08/2010

Submitted on: 07/21/2010

Principal Investigator: Bales, Roger C.

Award ID: 0725097

Organization: U of Cal - Merced

Submitted By:

Bales, Roger - Principal Investigator

Title:

CZO: Critical Zone Observatory--Snowline Processes in the Southern Sierra Nevada

Project Participants

Senior Personnel

Name: Bales, Roger

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Kirchner, James

Worked for more than 160 Hours: Yes

Contribution to Project:

Co-PI signal analysis, physical weathering

Name: Boyer, Elizabeth

Worked for more than 160 Hours: Yes

Contribution to Project:

Organic carbon in stream water

Name: Tague, Christina

Worked for more than 160 Hours: Yes

Contribution to Project:

Co-PI modeling water and nutrient cycles

Name: Conklin, Martha

Worked for more than 160 Hours: Yes

Contribution to Project:

Co-PI surface-groundwater interaction

Name: Goulden, Mike

Worked for more than 160 Hours: Yes

Contribution to Project:

Flux tower Co-PI, CZO support.

Name: Johnson, Dale

Worked for more than 160 Hours: Yes

Contribution to Project:

Soil nutrients Co-PI. Soil carbon and nutrient analyses, nutrient fluxes, nutrient cycling.

Name: Molotch, Noah

Worked for more than 160 Hours: Yes

Contribution to Project:

Snow surveys and mapping

Name: Houlton, Ben

Worked for more than 160 Hours: Yes

Contribution to Project:

Nitrogen isotopes in streams - planning

Name: Hopmans, Jan**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Co-PI for soil moisture

Name: Riebe, Clifford**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Physical weathering rates

Name: Hart, Steven**Worked for more than 160 Hours:** No**Contribution to Project:**

Forest Ecology

Name: Berhe, Asmeret**Worked for more than 160 Hours:** No**Contribution to Project:**

Soil biogeochemistry

Name: Glaser, Steven**Worked for more than 160 Hours:** Yes**Contribution to Project:**

DUST wireless sensor networks

Post-doc**Name:** Hartsough, Peter**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Experimental design, implementation and ongoing maintenance

Graduate Student**Name:** Malazian, Armen**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Field installation and instrument calibration

Name: Palucis, Marisa**Worked for more than 160 Hours:** Yes**Contribution to Project:**

In preparation for Ph.D. qualifying exam, used stream and suction lysimeter data from the CZO to test a theoretical model for concentration-discharge relationships in porewaters and streams

Name: Alvarez, Otto**Worked for more than 160 Hours:** No**Contribution to Project:**

Data management

Name: Kelly, Anne**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Evapotranspiration and water balance in forest

Name: Musselman, Keith

Worked for more than 160 Hours: Yes

Contribution to Project:

Snow surveys and mapping

Name: Kirchner, Peter

Worked for more than 160 Hours: Yes

Contribution to Project:

Water cycle, soil moisture

Name: Kamai, Timir

Worked for more than 160 Hours: No

Contribution to Project:

Datalogger programming and instrument calibration

Name: Swarowsky, Alex

Worked for more than 160 Hours: Yes

Contribution to Project:

Manufacture, calibration and installation of field instruments

Name: Kerkez, Branko

Worked for more than 160 Hours: Yes

Contribution to Project:

Installation, monitoring, and maintenance of DUST wireless network

Name: Fellows, Aaron

Worked for more than 160 Hours: No

Contribution to Project:

eddy-covariance tower field work

Name: Anderson, Ray

Worked for more than 160 Hours: No

Contribution to Project:

Eddy covariance tower field work

Name: Phelps, Gary

Worked for more than 160 Hours: No

Contribution to Project:

Website Manager

Name: Godsey, Sarah

Worked for more than 160 Hours: Yes

Contribution to Project:

geomorphology, the extensions and contraction of the stream network at the CZO in response to snowmelt

Name: Kandelous, Maziar

Worked for more than 160 Hours: Yes

Contribution to Project:

Field installation and lab calibration of soil moisture instruments

Undergraduate Student

Name: Baumgartner, Thomas

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with field installations

Name: Melendez, Denise

Worked for more than 160 Hours: Yes

Contribution to Project:

Assisted with field installations and data analysis

Name: Kelly, Sean

Worked for more than 160 Hours: Yes

Contribution to Project:

Field research and data analysis

Name: Rojas, Adrian

Worked for more than 160 Hours: Yes

Contribution to Project:

Field research and data analysis

Name: Loy, Garrett

Worked for more than 160 Hours: No

Contribution to Project:

Field research and data analysis

Name: Mckuin, Brandy

Worked for more than 160 Hours: No

Contribution to Project:

Field research and data analysis

Name: Pendleton, John-Marc

Worked for more than 160 Hours: No

Contribution to Project:

Field research and data analysis

Name: Xochihua, Ruth

Worked for more than 160 Hours: No

Contribution to Project:

Field research and data analysis

Name: Zumkehr, Andrew

Worked for more than 160 Hours: Yes

Contribution to Project:

Web site management

Name: Curtis, Chris

Worked for more than 160 Hours: Yes

Contribution to Project:

Field technician

Name: Roudeva, Katja

Worked for more than 160 Hours: No

Contribution to Project:

Field installation and lab calibration of soil moisture instruments.

Name: Ngo, Allen

Worked for more than 160 Hours: No

Contribution to Project:

Field installation and lab calibration of soil moisture instruments.

Name: Huynh, Sylvie

Worked for more than 160 Hours: Yes

Contribution to Project:

Field installation and lab calibration of soil moisture instruments.

Technician, Programmer

Name: Meadows, Matt

Worked for more than 160 Hours: Yes

Contribution to Project:

Research hydrologist in charge of continuing CZO field program

Name: Winston, Greg

Worked for more than 160 Hours: Yes

Contribution to Project:

Flux tower instrumentation

Name: Lucas, Ryan

Worked for more than 160 Hours: Yes

Contribution to Project:

water cycle and meadow research
education, outreach, communication

Name: Liu, Fengjing

Worked for more than 160 Hours: Yes

Contribution to Project:

Geochemical analysis

Name: Tuli, Atac

Worked for more than 160 Hours: No

Contribution to Project:

Field installation of soil moisture instrumentation

Name: Meng, Xiande

Worked for more than 160 Hours: Yes

Contribution to Project:

Data management

Name: Nasta, Paolo

Worked for more than 160 Hours: Yes

Contribution to Project:

Field installation and lab calibration of soil moisture instruments.

Name: Kluitenberg, Gerard

Worked for more than 160 Hours: No

Contribution to Project:

Field installation and lab calibration of soil moisture instruments.

Name: Saintnoy, Albane

Worked for more than 160 Hours: No

Contribution to Project:

Field installation and lab calibration of soil moisture instruments.

Other Participant**Research Experience for Undergraduates**

Name: Holling, Timothy

Worked for more than 160 Hours: No

Contribution to Project:

Undergraduate research project (Summer 2009)

Years of schooling completed: Junior

Home Institution: Other than Research Site

Home Institution if Other: California State University, Stanislaus

Home Institution Highest Degree Granted(in fields supported by NSF): Master's Degree

Fiscal year(s) REU Participant supported: 2009

REU Funding: No Info

Organizational Partners

Pacific SW Research Station, USFS

The CZO is located at the Kings River Experimental watersheds, a set of research catchments operated by the Pacific Southwest Research Station (PSW), U.S. Forest Service.

Lawrence Livermore National Laboratory

Jean Moran and Brad Esser collected samples for isotope analysis as part of the meadow experiment in summer 2008. Initial analysis has been completed; further sampling and analysis may be conducted in order to obtain adequate data for collaboration on papers.

Other Collaborators or Contacts

Decagon Inc. Contact: Colin Campbell

Crossbow Technologies; deployed a prototype wireless sensor network system in Wolverton.

Scott Tyler, UNR; summer 2008 deployed DTS system for meadow water cycle experiment, has provide input and insight on meadow deployment data processing and interpretation

Center for Information Technology Research in the Interest of Society (CITRIS)

The installation, maintenance, and utilization of the Dust Networks wireless sensor platform in the P301 ground-based water balance instrumentation is a collaboration with Steve Glaser and the Civil Systems group at UC Berkeley. This interdisciplinary, and inter-campus collaboration is the first of its kind as part of the newly established CITRUS.

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

See attached

Findings: (See PDF version submitted by PI at the end of the report)

See attached

Training and Development:

We are developing instrument clusters for mountain water cycle measurements, which is a great learning experience for all. This sort of integrated measurement network across a catchment has not been done before in the mountains of the Western U.S., at the rain-snow transition. Students, postdocs and research scientists are learning strategies that will need to be replicated much more widely in the future.

Outreach Activities:

We are sharing technology with colleagues in research and operational agencies. We have provided press releases and conducted newspaper interviews. Talks and presentations given to public audiences and groups are listed below. We organized one day of the Geoscience Information For Teachers (GIFT) workshop during the American Geophysical Union's (AGU) fall meeting. The GIFT session theme was water; the day organized by the SSCZO Education and Outreach presented regional water issues and research conducted by the SSCZO that related to regional water processes. Graduate students from the SSCZO and UC Merced presented their research, its importance relative to climate change and regional water, and a little about their process from being a high school student to graduate education. In June 2010, SSCZO Education and Outreach has participated in the California Institute for Biodiversity's Sierra Nevada Teacher Institute. SSCZO Education and Outreach coordinator, Ryan Lucas, has acted as an instructor for the institute. Ryan led activities focused on physical impacts of climate change to the Sierra Nevada and California, system equilibrium and stability, and led a group of 6th-12th grade teachers in a water quality experiment. We will work with the incoming director of education at the Yosemite Institute (YI) this summer. We will work on collaborating to incorporate SSCZO education and outreach activities in the YI program; specifically we hope to design modules and activities around a mini-instrument system modeled after instrument networks being used in the SSCZO that will be installed at YI's new campus.

Talks and Presentations from SSCZO Education and Outreach:

Lucas, R. 'Climate Change Implications to the Sierra Nevada and the Central Valley' Presentation and Panel Member. Sacramento Valley Forum. October 2009

Lucas, R. 'Critical Zone Observatory ? Researching Hydrologic Processes in the Southern Sierra Nevada' Talk. Merced High School District Excellence in Science. November 2009

Lucas, R. 'Critical Zone Observatory ? Researching Hydrologic Processes in the Southern Sierra Nevada' Talk. American Geophysical Union. Geoscience Information For Teachers. December 2009

Lucas, R. 'Climate Change: A Global Phenomenon with Local Implications' Talk. Central Valley Air Quality Coalition. January 2010

Lucas, R. 'Water Crisis: Where are We Headed?' Talk. University Friends Circle. March 2010.

Bales, R. C. 'Mountain Water Cycles and Instrumentation' Talk. Sierra Nevada Alliance. April 2010

Lucas, R. 'Climate Change: Central Valley Impacts and Implications' Talk. Great Valley Center's Institute for Emerging Area Leaders. April 2010.

Lucas, R. 'Climate Change: Central Valley Impacts and Implications' Talk. Great Valley Center's Institute for Emerging Area Leaders. April 2010.

Lucas, R. 'Studying Water Processes in the Sierra Nevada' Talk. Great Modesto Area Partners in Science. April 2010.

Journal Publications

Johnson, D.W., W.W. Miller, R.B. Susfalk, R.A. Dahlgren, and D.W. Glass, "Biogeochemical Cycling in Forest Soils of the Eastern Sierra Nevada Mountains", Forest Ecology and Management, p. , vol. , (2009). Published, 10.1016/j.foreco.2009.01.018

Anderson, S. A.; R. C. Bales; C. J. Duffy, "Critical Zone Observatories: Building a network to advance interdisciplinary study of Earth surface processes", Mineralogical Magazine, p. 7, vol. 72(1), (2008). Published,

Hunsaker, C.T., Whitaker, T., Bales, R.C., "Water yield and runoff timing across the rain-snow transition in California's southern Sierra Nevada", submitted, p. , vol. , (2010). Submitted,

Johnson, D. W., Glass, D. W., Murphy, J. D., Stein, C. M., Miller, W. W., "Hot Spots and Hot Moments: Another Look at Nutrient Variability in Sierra Nevada Forest Soils", Biogeochemistry, p. , vol. , (2010). Accepted,

Johnson, D.W., Hunsakeer, C.F., Glass, D.W., Rau, B.M., Roath B.A., "Carbon and Nutrient Contents in Soils from the King's River Experimental Watershed, Sierra Nevada Mountains, California", Geoderma, p. , vol. , (2010). Submitted,

Kerkez, B., Glaser, S.D., Dracup, J.A., Bales, R.C., "A hybrid system model of seasonal snowpack water balance", International Conference on Hybrid Systems: Computation and Control, p. , vol. , (2010). Published,

Lui, F., Hunsaker, C.T., Bales, R.B., "Controls of streamflow pathways in small catchments across the snow-rain transition in the Southern Sierra, California", submitted, p. , vol. , (2010). Submitted,

Tague, C., "Assessing climate change impacts on alpine stream-flow and vegetation water use: mining the linkages with subsurface hydrologic processes", Hydrological Processes, p. 1815, vol. 23, (2009). Published,

Books or Other One-time Publications

Johnson, D.W., W.W. Miller, R.B. Susfalk, R.A. Dahlgren, N. Matsuyama and D.W. Glass, "How will a warmer climate affect nutrient cycling in forests of the eastern Sierra Nevada Mountains?", (2008). Conference poster paper, Published
Collection: Fourth Biennial Tahoe Basin Science Conference
Science as a Tool in Lake Tahoe Basin Management: Making Sense of Complexity
Bibliography: Incline Village, Nevada March 17-18, 2008.

Johnson, D.W., W.W. Miller, R.B. Susfalk, R.A. Dahlgren, N. Matsuyama and D.W. Glass, "Biogeochemical Cycling in Forest Soils of the Eastern Sierra Nevada Mountains, USA", (2008). Conference poster presentation, Published
Collection: North American Forest Soils Conference
Bibliography: Blacksburg, VA June 22-26 2008

Tague, C, "Spatial modeling of coupled hydrologic-biogeochemical processes for the Southern Sierra Critical Zone Observatory", (2007). Conference presentation and abstract, Published
Collection: Eos Trans. AGU
Bibliography: 88(52), Fall Meet. Suppl., Abstract H53A-0957

Bales, R; Boyer, B; Conklin, M;
Goulden, M; Hopmans, J;
Hunsaker, C; Johnson, D; Kirchner, J; Tague, C, "Southern Sierra Critical Zone Observatory: integrating water cycle and biogeochemical processes across the rain-snow transition", (2007). Conference presentation and abstract, Published
Collection: Eos Trans. AGU
Bibliography: 88(52), Fall Meet. Suppl., Abstract H13A-0962

Bales, R; Hunsaker, C; Conklin, M; Kirchner, J; Boyer, B; Kirchner, P, " Southern Sierra Critical Zone Observatory (CZO): hydrochemical characteristics, science and measurement strategy", (2007). Conference presentation and abstract, Published
Collection: Eos Trans. AGU
Bibliography: 88(52), Fall Meet. Suppl., Abstract H51K-02

Bales, R; Meadows, M; Hopmans, J; Hartsough, P; Kirchner, P, "Snow and Soil Moisture Response Across Elevation, Aspect and Canopy Variables in a Mixed-conifer Forest, Southern Sierra Nevada", (2008). Conference presentation and abstract, Published
Collection: Eos Trans. AGU
Bibliography: 89(53), Fall Meet. Suppl., Abstract C21A-0496

Bales, R; Hunsaker, C; Kirchner, P; Conklin, M; Lucas, R, "Hydroclimate, ecosystem links & the Southern Sierra Critical Zone Observatory", (2008). Conference presentation and abstract, Published
Bibliography: Southern Sierra Science Symposium

Hartsough, P; Malazian, A; Tuli, A; Kama, T; Kizito, F; Bales, R; Broad, A; Hopmans, J, "Remote Environmental Monitoring of Hydrologic/Biotic Interaction in a Mountain Environment", (2008). Conference presentation and abstract, Published
Collection: Eos Trans. AGU
Bibliography: 89(53), Fall Meet. Suppl., Abstract H51H-0974

Hunsaker, C; Bales, R, "Water Yield and Runoff Timing Across the Rain-snow Transition at the Kings River Experimental Watersheds in California's Southern Sierra Nevada", (2008). Conference presentation and abstract, Published
Collection: Eos Trans. AGU
Bibliography: 89(53), Fall Meet. Suppl., Abstract 13C-0933

Kirchner, P; Bales, R; North, M; Small, E, "Snowmelt infiltration and

evapotranspiration in Red Fir forest ecosystems of the Sierra Nevada", (2008). Conference presentation and abstract, Published Collection: Eos Trans. AGU Bibliography: 89(53), Fall Meet. Suppl., Abstract C21C-0572

Lucas, R; Conklin, M; Tyler, S; Esser, B, "Investigating Meadow Hydrology and Hyporeic Exchange", (2008). Conference presentation and abstract, Published Collection: Eos Trans. AGU Bibliography: 89(53), Fall Meet. Suppl., Abstract H21L-06

Bales, R., "Southern Sierra Critical Zone Observatory: Integrating water cycle & biogeochemical processes across the rain-snow transition", (2008). Conference presentation, Published Bibliography: Poster presentations by Roger Bales at the fall meeting, AGU, San Francisco, CA and WATERS testbed meeting, Baltimore, Md

Bales, R. C., Conlkin, M. H. Kerkez, B., Glaser, S. D., Hopmans, J. W., Hunsaker, C. T., Meadows, M. W., "Sampling strategies in forest hydrology and biogeochemistry", (2010). Book, Submitted Collection: Forest Hydrology Bibliography: Book Chapter

Conklin, M.H., Crook, N.P., Kirchner, P.B., Lucas, R.G., "Seasonal transitions in water and moisture patterns in a mountain meadow, Southern Sierra Nevada", (2009). Conference Presentation, Published Collection: Eos Trans. AGU Bibliography: 90(52), Fall Meet. Suppl., Abstract H41H-01

Hartsough, P.C., Malazian, A., Kama, T., Roudneva, E., Hopmans, J.W., "Soil Moisture/ Tree Water Status Dynamics in a Mid-Latitude Montane Forest, Southern Sierra Critical Zone Observatory, CA", (2009). Conference Presentation, Published Collection: Eos Trans. AGU Bibliography: 90(52), Fall Meet. Suppl., Abstract H33A-0844

Johnson, D. W., Miller, W. W., Meadows, M., Rau, B. R., "Nutrient hotspots and O horizon runoff in a Sierra Nevada Watershed", (2009). Conference presentation, Published

Collection: Eos Trans. AGU
Bibliography: 90(52), Fall Meet. Suppl., Abstract EP52B-04

Johnson, D. W., Richter, D. D., "Short- and Long-term Perspectives of Soil Change: Interactions between Capacity and Intensity", (2009). Book, Published
Collection: Eos Trans. AGU
Bibliography: 90(52), Fall Meet. Suppl., Abstract B34B-01

Johnson, D. W., Miller, W. W.,
Glass, D. W., Murphy, J. D.,
Stein, C. M., Rau, B. R., "Hot Spots and Hot Moments: Another Look at Nutrient Variability in Sierra Nevada Forest Soils", (2009). Conference Presentation, Published
Collection: BIOGEOMON, Finnish Forest Research Institute
Bibliography: Talk

Bales, R.C., Hunsaker, C.T.,
Meadows, M., Kerkez, B., Glaser,
S.D., Liu, F., "Water an geochemical responses to seasonal changes across the rain-snow transition in the Southern Sierra Nevada", (2009). Conference presentation and abstract, Published
Collection: Eos Trans. AGU
Bibliography: 90(52), Fall Meet. Suppl.,
Abstract B32A-06

Johnson, D. W., Miller, W. W.,
Glass, D. W., Murphy, J. D.,
Stein, C. M., Rau, B. R., "Hot Spots and Hot Moments: Another Look at Nutrient Variability in Sierra Nevada Forest Soils", (2009). Book, Published
Collection: Soil Science Society of America
Bibliography: Talk

Kirchner, P.B., Bales, R.C.,
Musselman, K.N., Molotch, N.P., "Multi-scale observations and modeling of the snowpack in a forested Sierra Nevada catchment", (2009). Conference presentation and abstract, Published
Collection: Eos Trans. AGU
Bibliography: 90(52), Fall Meet. Suppl.,
Abstract C23D-08

Krekez, B., Meadows, M., Glaser,
S.D., Bales, R.C., "he Science of Wireless Sensor Networks: Improving engineered systems through scientific analysis", (2009). Conference presentation and abstract, Published
Collection: Eos Trans. AGU
Bibliography: 90(52), Fall Meet. Suppl.,
Abstract IN13C-03

Kelly, A.E., Goulden, M.L., "Climate controls on anomalously high productivity in the mixed conifer forests of the Sierra Nevada", (2009). Conference presentation and abstract, Published Collection: Eos Trans. AGU Bibliography: 90(52), Fall Meet. Suppl., Abstract B33A-0359

Lui, F., Hunsaker, C.T., Bales, R.B., "Controls of Stream Water Chemistry in Small catchments Across Snow/Rain Transition in the Southern Sierra, California", (2009). Conference presentation and abstract, Published Collection: Eos Trans. AGU Bibliography: 90(52), Fall Meet. Suppl., Abstract H33H-0987

Martin, S.E., Hunsaker, C.T., Bales, R.C., "Sediment Sources in four Small Mountain Streams In the Central Sierra Nevada, California", (2009). Conference presentation and abstract, Published Collection: Eos Trans. AGU Bibliography: 90(52), Fall Meet. Suppl., Abstract EP53D-0649

Meadows, M.W., Bales, R.C., Hopmans, J.W., Hartsough, P.C., O?Geen, A.T., Kirchner, P.B., "Soil moisture response to snowmelt and rainfall across elevation, aspect and canopy cover in the Southern Sierra Nevada", (2009). Conference presentation and abstract, Published Collection: Eos Trans. AGU Bibliography: 90(52), Fall Meet. Suppl., Abstract H33A-0856

Musselman, K. N., Molotch, N.P., Margulis, S.A., Kirchner, P.B., Bales, R.C., "A mechanistic approach for estimating snowpack dynamics in a conifer forest", (2009). Conference presentation and abstract, Published Collection: Eos Trans. AGU Bibliography: 90(52), Fall Meet. Suppl., Abstract C23D-07

Riebe, C.S., Hunsaker, C.T., Johnson, D.W., Jessup, B., "Variations in rock-fragment abundance and bulk geochemistry of soils across the Southern Sierra Nevada CZO: Implications for hillslope-channel coupling", (2009). Conference presentation and abstract, Published Collection: Eos Trans. AGU Bibliography: 90(52), Fall Meet. Suppl., Abstract EP51E-02

Son, K., Tague, C., "An Optimized Soil Moisture Sampling Design to Represent the Impact of Climate Variability on Soil Moisture and Vegetation Water Use in Snow-Dominated Watersheds", (2009). Conference presentation and abstract, Published Collection: Eos Trans. AGU Bibliography: 90(52), Fall Meet. Suppl., Abstract H33D-0902

Tague, C, "Modeling eco-hydrology under a changing climate: how much do subsurface drainage patterns matter?", (2009). Conference presentation and abstract, Published Collection: Berkeley Catchment Science Symposium Bibliography: Talk

Web/Internet Site

URL(s):

<https://snri.ucmerced.edu/CZO>
<https://eng.ucmerced.edu/snsjho>

Description:

The first is our main CZO url.
 The second url is our digital library

Other Specific Products

Contributions

Contributions within Discipline:

The CZO provides a multi-disciplinary platform for research. Many of the CZO data are available to the community, and other data to CZO cooperators who agree to data-sharing protocols.

Contributions to Other Disciplines:

The CZO fosters multi-disciplinary research. The site is also a candidate for a NEON investment, which could significantly enhance some of our CZO activities.

Contributions to Human Resource Development:

Several graduate students, undergraduates and recent Ph.D. graduates are involved with the CZO, and are preparing themselves for independent measurement and data analysis work in field hydrology, and modeling.

Contributions to Resources for Research and Education:

The CZO is a research platform, i.e. infrastructure for multidisciplinary research.

Contributions Beyond Science and Engineering:

The high profile of our CZO helps communicate water and other critical zone issues to the public, and helps educate agencies about the need to modernize measurement and decision-making infrastructure.

Conference Proceedings

Special Requirements

Special reporting requirements: None

Change in Objectives or Scope: None

Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Any Product

Any Conference

Activities

The following gives the status of various activities in the work plan. Refer to the section in the work plan of the same title for additional description of activities.

Core CZO measurements, data management and integration. Three of the four planned flux towers have been installed and instrumented. The flux towers are collecting consistent data, which is being telemetered via cellular connections. The ground-based part of the water-balance instrument cluster installation at KREW has been completed (Figure 1). Ground-based water balance instrumentation is producing consistent data around 13 trees, in 3 meadow transects, at 3 aspects and 3 elevations (Figure 2). The Wolverton baseline instrument cluster has continued producing quality data. Xiande Meng has continued to do data management; supplemental data management has been conducted by Matt Meadows, Otto Alvarez, Ryan Lucas, Peter Kirchner, and Gary Phelps. The digital library is functioning and is populated with data. Data are currently being processed to a Level 2 extent for publishing at the national CZO site. The SSCZO website has been developed and maintained by Gary Phelps and Andrew Zumkehr.

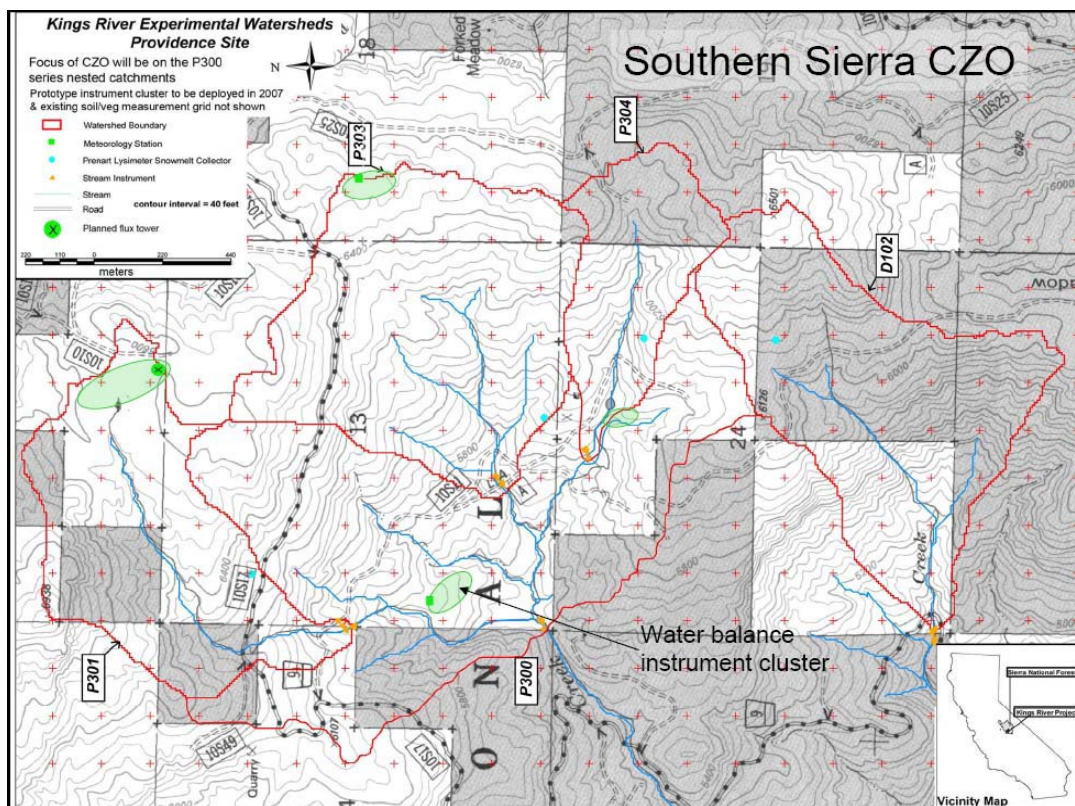


Figure 1—Instrument cluster design at KREW CZO site. Shaded green areas illustrate primary instrument node locations, strategically placed to capture variability in elevation, aspect and vegetation properties.

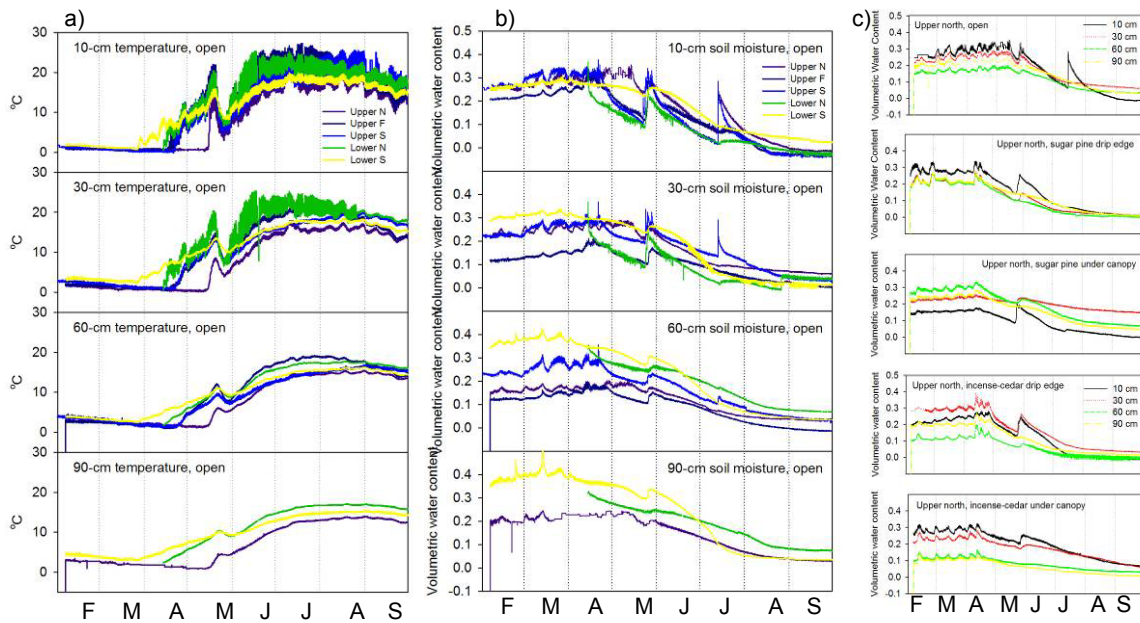


Figure 2—Soil temperature (a) and soil moisture (b) data collected 11 instrument nodes at 3 aspects and 2 elevations in 2008. Vertical soil moisture profiles from nodes located at the upper elevation and north facing aspect (c) in 2008.

The DUST wireless sensor network has continued to operate in the P301 ground-based water-balance instrumentation over the past year. The DUST wireless network is distributed, self-assembling, and self-healing, meaning that if links in the network go down unexpectedly, alternative links form to ensure no data will be lost. The overall system currently consists of 60 motes, and over 250 sensors, a central data hub, and solar assembly for power. The wireless nature of the systems permits for data to be sampled at a large scale, and subsequently to be piped to a central location, and aggregated for easy collection, this would not have been possible with conventional wired setups (Figure 3).

The infrastructure for the system was set up last year on an interim basis to test communications for a robust network. An above-average snowpack and higher than average winds caused some damage to the interim infrastructure and identified weak points in the deployment. The DUST wireless network is undergoing reinforcement and installation of more permanent infrastructure.

Airborne LiDAR was flown for the Providence, Bull, Teakettle, Tokopah, and Wolverton catchbasins, San Joaquin Experimental Range (SJER), Soaproot Saddle, and Shorthair Flux tower sights. Flights were conducted mid-March 2010 near peak snow accumulation for the Providence catch basin. Additional flights will be flown in the summer 2010. LiDAR data will provide spatial distribution of snow depth, leaf area index, canopy structure, and a high resolution digital elevation map

Core KREW measurements and data management. Streamflow, meteorological, turbidity, and sediment data analysis has continued. Collaboration between USFS and SSCZO personnel is ongoing and will continue in the production of the series of manuscripts discussed in the included Workplan. The SSCZO is working with KREW in order to combat USFS budget cuts that have lead to a loss of personnel and a reduction in KREW field activities. See Figure 4ab for a typical stream control section in CZO/KREW catchments.

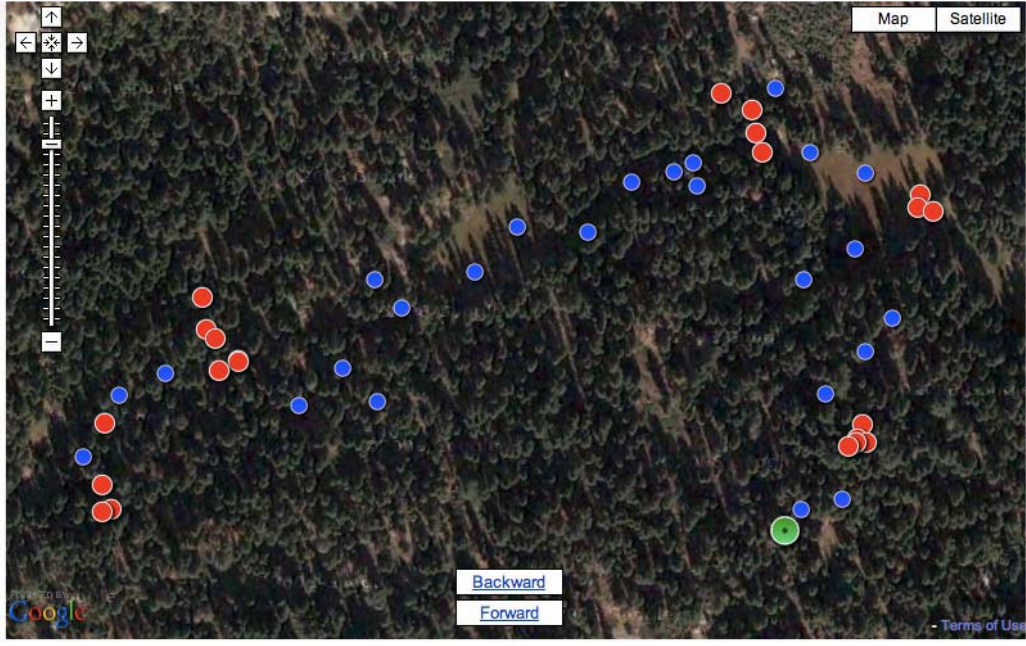


Figure 3 – Locations of DUST wireless network radios. The green dot indicates the mother computer, the red dots indicate sensors, and the blue dots indicate hopper radios.



a)



b)

Figure 4—Looking up (a) and down (b) stream of a typical stream control section in the CZO/KREW catchments.

Modeling of water and nutrient cycles. The RHESSys hydrologic model was calibrated for 4 sub-watersheds in the Southern Sierra CZO. The model was then used to generate spatial-temporal patterns of snow, soil moisture and transpiration under historical and projected future climate. These patterns are then clustered to identify areas

of hydrologic similarity, where similarity will be defined by inter-annual mean and variation of a suite of hydrologic indicators (e.g. seasonal trajectories of snowmelt, root-zone soil moisture storage, and evapotranspiration). Results from this study will demonstrate the utility of such a closely integrated measurement-modeling approach.

A supplemental grant was awarded by the Kearney Foundation to support additional soil sampling as part of the SSCZO. This additional funding will help in validating the results of the model as well as increase the robustness of the model.

Near-surface soil-water processes. The soil moisture arrays at Wolverton continue to operate and have been providing data for 3-4 years. A Crossbow wireless network provides for telemetry of data to enable real-time access. Analysis of data is in progress. The soil moisture/temperature network for the CZO-KREW site has been installed (Figures 1-2). The soil moisture/temperature nodes at the upper and lower meteorological stations are hard-wired to data loggers while the nodes in the P301 ground based water-balance instrument cluster use the DUST wireless network (Figure 3).

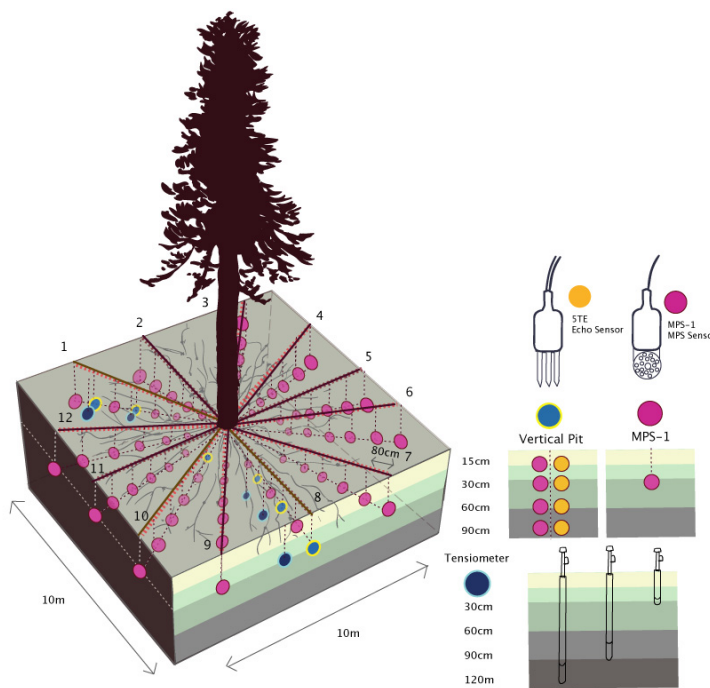


Figure 5-Layout CZT-1 including location of Echo-5TE, MPS, locations, vertical soil moisture/temperature pits, and tensiometers.

The intensively instrumented white fir (*Abies concolor*) tree (CZT-1) in the SSCZO continues to operate, with soil moisture, temperature, matric potential (MPS) sensors and tensiometers (Figure 5). CZT-1 has been operational and collecting data for over 20 months. Sap flux sensors and time domain reflectometry (TDR), for determination of changes in stem water content, have been producing data and shown response to fluctuations in air temperature and solar radiation. A Ground

Penetrating Radar (GPR) survey of the root structure of a similar, nearby white fir tree was conducted in fall 2009 to better determine the point locations of moisture extraction by the tree. The GPR survey produced an initial map of the root structure of a white fir tree (Figure 6).

Continued research into the summer 2010 will include a multi-parameter synoptic soil survey, site selection and instrumentation of a second intensively instrumented tree (CZT-2), and excavation of a white fir tree similar in size and location to CZT-1. The multi-parameter synoptic soil survey will consist of measurements of soil volumetric water content across a grid of over 200 points (this grid will coincide with the synoptic

snow survey conducted in April 2010), tree trunk moisture, and leaf/stem water potential measurements at a subset of the grid points. Excavation of a white fir tree similar in size and location to CZT-1 will commence in September 2010. The excavation will provide

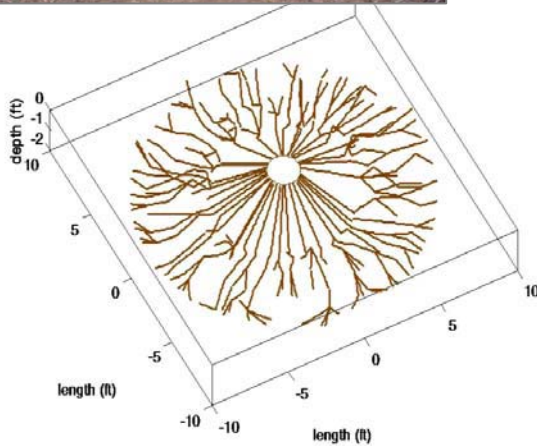


Figure 6—Conducting the GPR survey (above); initial map of a white fir tree root structure produced from the GPR survey (below).

towers have been collecting data for 9 months. We expect to add a fourth tower at the Soaproot Saddle during the summer of 2010.

In order to further understand physical controls on water and carbon in the P301 water shed, the P301 flux tower was instrumented with temperature sensors to measure the vertical gradient of temperature from the forest floor to the atmospheric boundary layer, biomass collection boxes, sap flow sensors, and dendrometers were deployed at several locations.

Surface-groundwater interactions. The meadow transects in the P301 watershed—comprised of soil moisture/temperature, snow depth, and shortwave solar radiation sensors paired with clustered groundwater monitoring wells/piezometers—are almost completed. The remaining the remaining groundwater wells and piezometers will be installed July 2010. Additional piezometers—up to 5—will be installed at the meadow-forest border. We attempt to drill into the sap rock using a gas powered auger engine and concrete coring bits. We hope to gain valuable information about the sap rock contribution to the forest-meadow complex.

the opportunity to produce a detailed root structure map as well as opportunity to sample soil and soil moisture within the root complex.

Physical controls on water and carbon exchange and plant production. Our main accomplishment during the last year was the installation and operation of two additional eddy-covariance towers; one tower was installed at the San Joaquin Experimental Range and one tower was installed at the Shorthair Creek sight. The addition of two towers creates an elevational gradient of measurements from approximately 370 m to 2700 m. The towers transmit a subset of observations hourly, which allows us to keep an eye on how the system is functioning. The complete data set is collected manually approximately every month and is transferred to UCI via the internet. These data are then processed, and posted on the digital library at UCM.

The P301 tower has been collecting data for 1.5 years, the SJER and Shorthair

Water-balance deployments in the P301 will be conducted in the summer 2010 to investigate seasonality of source water contributions to the meadow and P301 stream. We will utilize the wells/piezometers, stream flow measurements, and a chamber evapotranspiration dome to calculate the water balance in July, August, and possibly September 2010.

Meadow stream pools exhibiting anomalous temperature behavior were again investigated in the summer of 2009 by placing Hobo Tidbit temperature loggers in the pools. The Tidbits were placed at varying depth in order to capture meadow stream pool stratification. Additional simulations were run in Fluent, a fluid mechanics modeling software. Initial conditions were set to mirror observed conditions in the Lodgepole-33 pool and meteorological parameters were input from values measured at the micro-meteorological station. Simulations were run with varying input stream velocities. Analysis of the modeled and measured results continues. A manuscript describing meadow pool behavior is in progress and planned for submittal Summer-Fall 2010.

Well and piezometer data from Long Meadow, Sequoia National Park was further analyzed for ET signals and spatial moisture patterns in the meadow. Additional chamber ET measurements were collected in the Fall 2009 to compare seasonal variation in ET. These data were used in conjunction with geophysical measurements, including resistivity and electromagnetic surveys, to investigate spatial and temporal moisture patterns in the meadow.

Nitrogen cycling in soil. Further analysis of soil chemistry data collected in CZO-KREW is being conducted in conjunction with calculating soil contents from bulk density and rock content data and correlating the soil content to watershed parameters like rock content, location, vegetation cover, elevation, aspect, etc.

Analysis of O horizon inter-flow water samples collected summer 2008 through spring 2009, resin nutrient collectors retrieved spring 2009, and O horizon inter-flow and resin samples have undergone analysis. These data and analysis have produced several presentations and 2 journal articles either in press or submitted and returned for revisions (see report).

Deeper soil sampling, by means of an engine powered auger, of the nutrient hotspots will be conducted in summer 2010.

Nitrogen fluxes from soil. Initiation of this project is underway.

Baseline hydrologic, sediment and geochemical characterization. Analysis of the water samples collected bi-weekly at the KREW watershed gauging stations was conducted. In cooperation with PSW, Fenjing Lui completed this analysis. This led to an AGU poster; a manuscript for this data is in progress; expected submittal is July 2010.

Water, geochemical cycles, and upscaling of in-situ measurements. Measurements from the Wolverton basin in Sequoia National Park and the Teakettle Experimental Forest in the Red Fir zone of the southern Sierra Nevada (2,300-2,600 m elevation) were used to evaluate our hypothesis that topography and vegetation cover are the most important variables affecting snowmelt and soil moisture. Our strategy is to combine

synoptic surveys and instrumental data from both sites to describe these processes across broad temporal and spatial scales.

Synoptic snow surveys of a 0.6 sq km area in the Wolverton Basin were conducted in April 2007 and 2008. Annual precipitation was below average in 2007 and above in 2008. Depth and density were measured at 36 grid points, four times under the canopy of the nearest mature Red Fir tree and four times in the closest canopy gap.

Synoptic surveys of soil moisture were carried out in the Teakettle Experimental forest as part of a comprehensive study on forest management. Soil moisture was measured at buried probes at multiple locations seven times over the water year using time domain reflectometry. Analysis of the 2003 survey has been conducted.

Physical weathering rates. Sampling of SSCZO soil and rock materials has been conducted and initial analysis completed. These samples and analysis have been used in conjunction with prior KREW quantitative soil pit, sediment yield trap, and soil survey data. Further sampling and analysis will continue this field season.

Snow processes. The peak accumulation snow survey for the Providence watershed was carried out on April 8 and 9, 2010. The survey consisted of over 200 gridded snow depth measurements and a snow pit analyzed for snow density. A series of snow surveys was carried out in the Wolverton basin for the third consecutive year. Data analysis for both Providence and Wolverton continues.

Organic carbon in streams. Sampling for organic carbon in the KREW streams that commenced in April 2009, has continued. Samples have been collected monthly at the KREW gauging stations; sampling has coincided with the bi-weekly major ion sampling conducted by the PSW field team. Along with the organic carbon samples, water isotope samples have been collected. The collected organic carbon samples have been sent to Elizabeth Boyer at Pennsylvania State University for analysis. Water isotope samples are being stored for future analysis.

Photo credits. Figure 4: Ryan Lucas. Figure 6: Peter Hartsough.

Findings

The following presents findings associated with the various activities in the work plan. Refer to the section in the work plan of the same title for a description of activities.

Core KREW measurements and data management. Measurements of precipitation, snow accumulation and melt, streamflow, soil moisture and meteorological variables from a multi year database have undergone some analysis to assess the hydrologic and geochemical response of rain-dominated versus snow-dominated catchments. Figure 1 shows the measured snow water equivalent (SWE) and cumulative precipitation measured for the upper, snow dominated Bull watersheds and the lower, rain dominated Providence watersheds for 2005 and 2006. For both years, cumulative precipitation is similar for the upper and lower watersheds. Snow at lower elevations exhibits multiple accumulation and melt cycles throughout the cold season. Snow at higher elevations exhibits a single main melt period in spring. The Bull watersheds show a greater fraction of cumulative

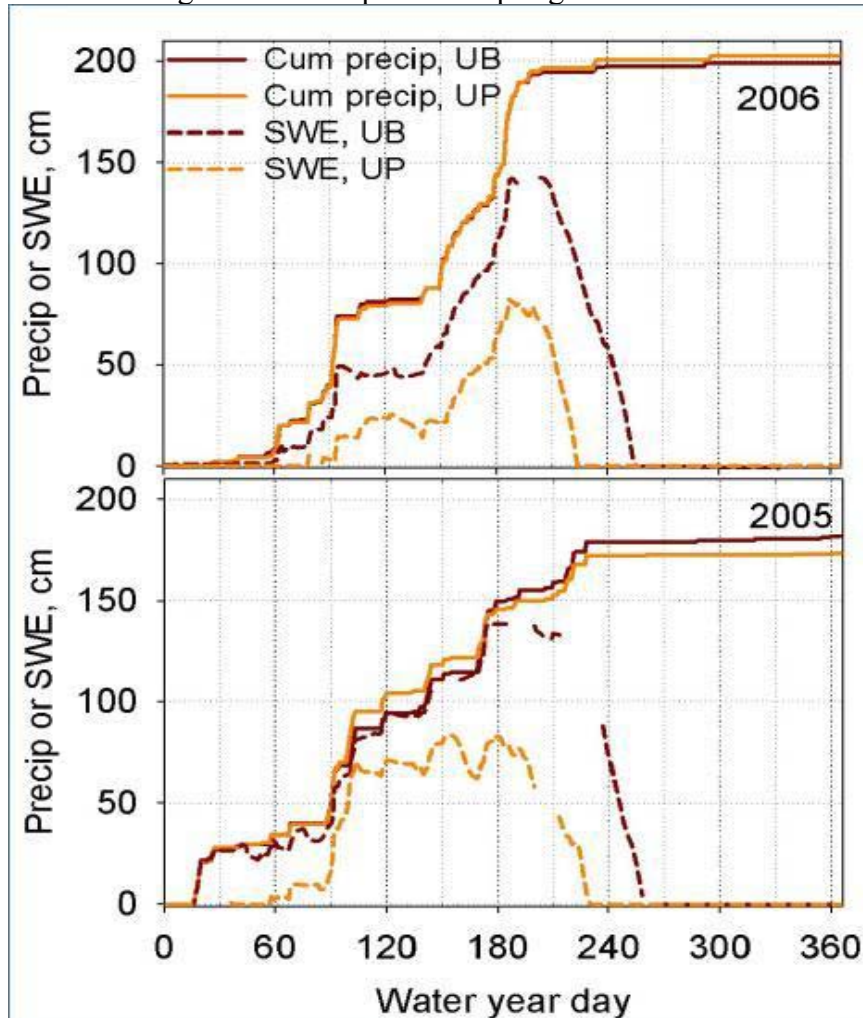


Figure 1 – Cumulative precipitation and SWE for Bull and Providence watersheds.

of cumulative precipitation comes in the form of snow. Figure 2 presents cumulative discharge for all 8 of the KREW watersheds. The lower watersheds, depicted with dashed lines, indicate that mean cumulative discharge occurs earlier than in the upper watersheds, depicted with solid lines, in both the wet and dry precipitation years presented. Earlier runoff in lower elevation catchments reflects the greater proportion of rainfall.

Data from one of the ground-based water balance instrument clusters

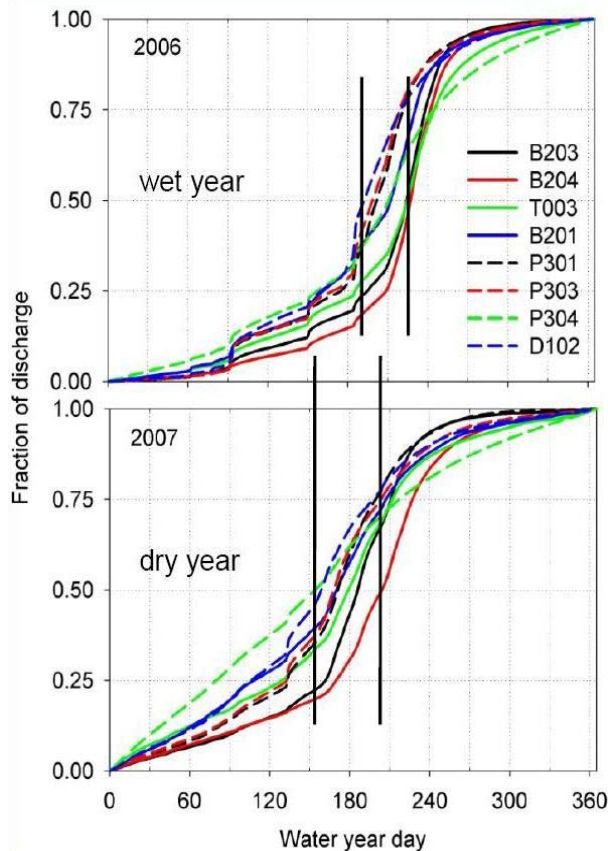


Figure 2 – Cumulative runoff for the upper (solid lines) and the lower (dashed lines) elevation

tree, plot, and watershed scales to test model performance (Figure 4). These patterns were then clustered to identify areas of hydrologic similarity, where similarity will be defined by inter-annual mean and variation of a suite of hydrologic indicators (e.g. seasonal trajectories of snowmelt, root-zone soil moisture storage, and evapotranspiration). Results of model performance at different spatial scales indicate the model performs reasonably well with a Nash-Sutcliffe efficiency of 0.7-0.87 and R^2 values of 0.71-0.91. Hydrologic similarity indicators can be used for cluster analysis. One example of this is presented in Figure 5. Using the mean of snow melt period and the coefficient of variation (CV) of snow melt, the watershed can be divided into classes of snow melt. These classes may potentially be used for strategic location of snow melt monitoring instrumentation.

is presented in Figure 3. This data show snow accumulation and ablation and corresponding effects on soil moisture and soil temperature. Soil moisture declines rapidly in the first week after snowmelt is completed, followed by a more-gradual decline thereafter. Local differences in the timing of snowmelt and soil drying between north versus south aspects and shaded versus open sites are both about one month, comparable to elevation differences in the average response.

Modeling of water and nutrient cycles.

The RHESSys hydrologic model was calibrated for 4 sub-watersheds in the Southern Sierra CZO. The model was initially calibrated to reproduce existing soil moisture, sap-flow and streamflow data. The model was then used to generate spatial-temporal patterns of snow, soil moisture and transpiration under historical and projected future climate. Data were collected at point,

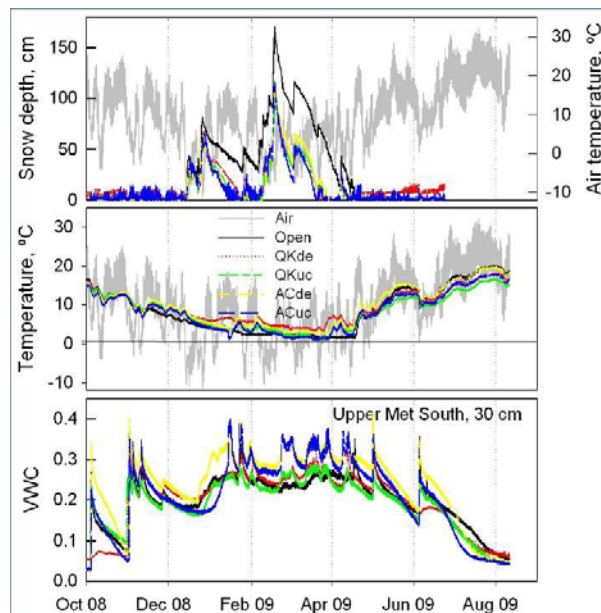


Figure 3 – Example of snow depth, soil temperature, and soil moisture data from a ground-based water balance instrument cluster.

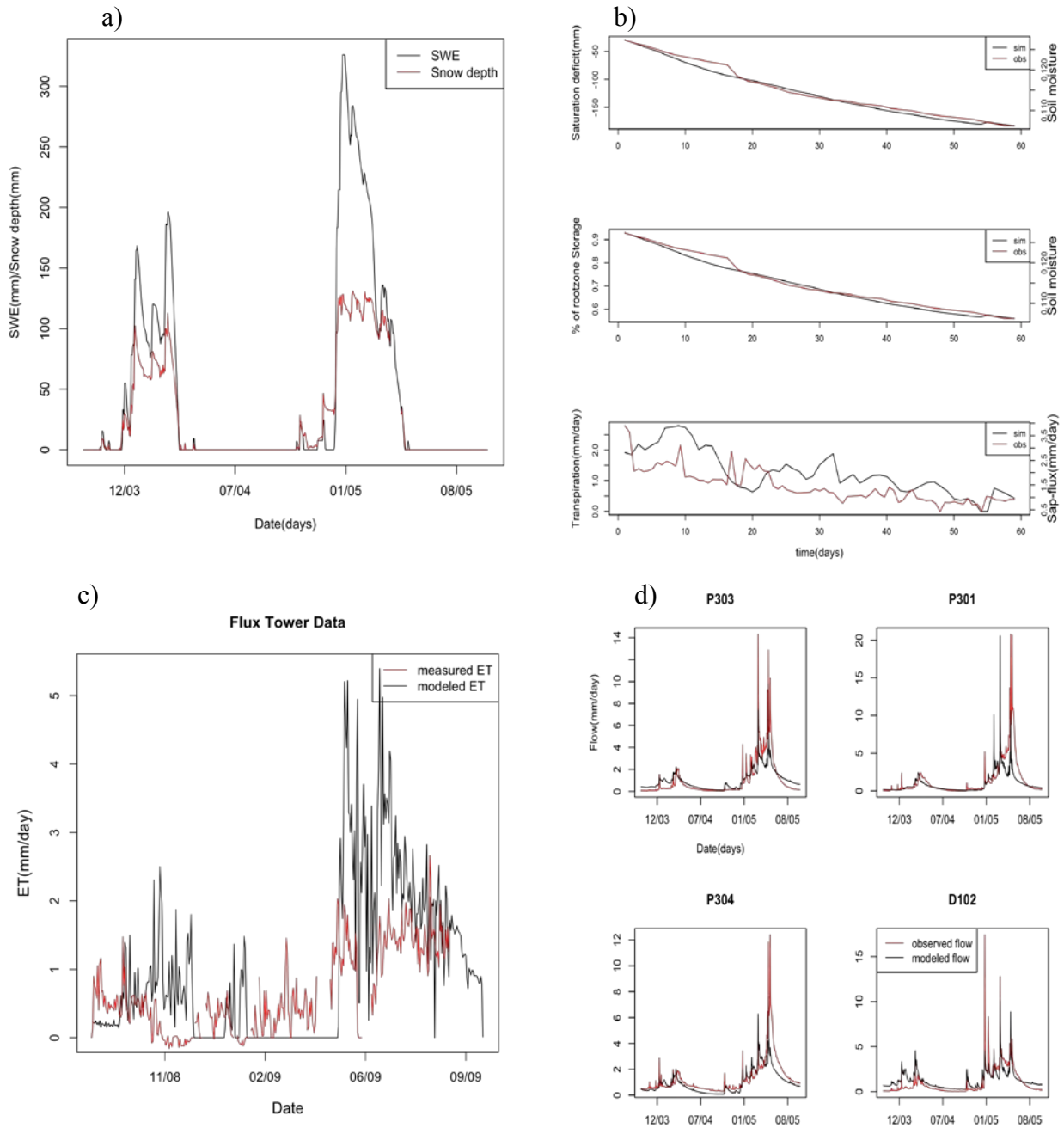
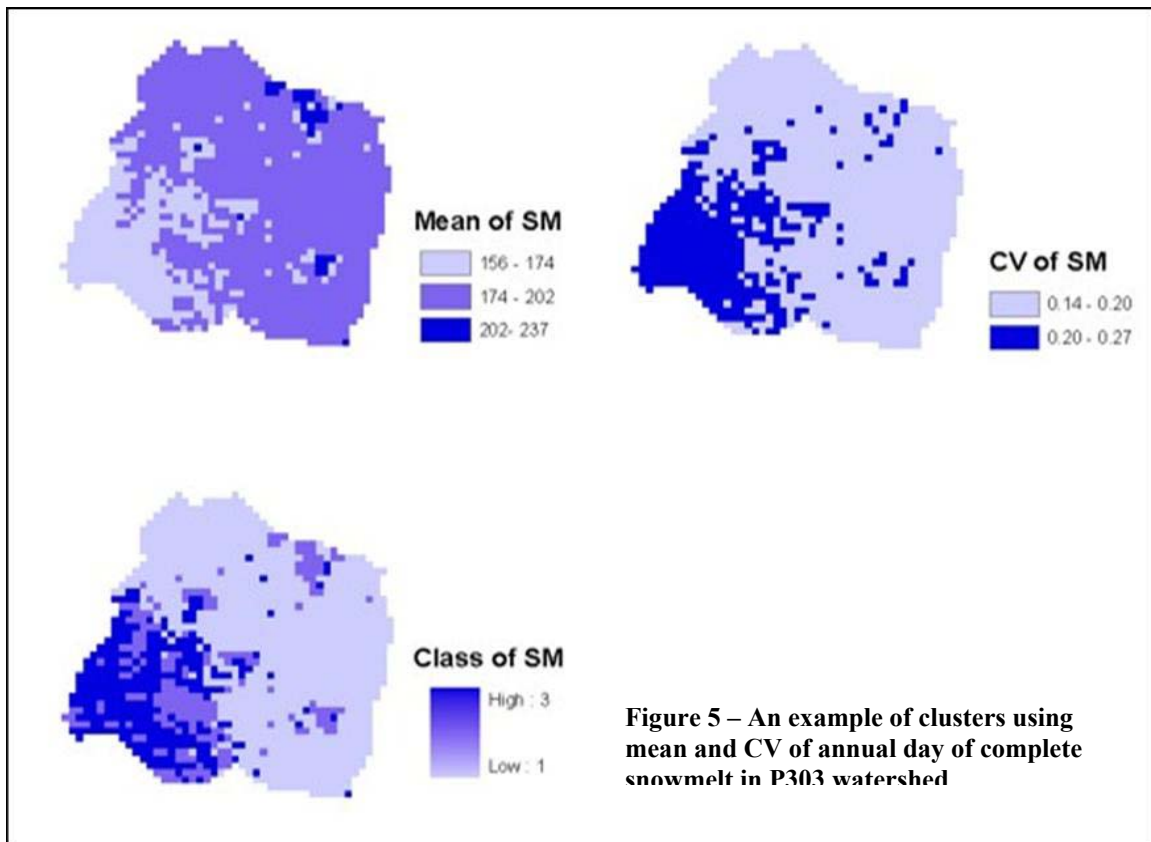


Figure 4 -Measured and modeled data from snow pillow at a point scale (a), soil moisture at a tree scale (b), ET at a plot scale (c), and stream discharge at a watershed scale.



Near-surface soil-water processes. We have captured the dynamics of the soil profile desiccation at various depths beneath the snow pack as it transitioned from saturated to very dry conditions. Tensiometer data within the plot shows the cessation of drainage out of the root zone by early July, leaving an extended period (3+ months) of drying of the soil profile and an estimate of actual ET. (Figure 6). Through monitoring of sap flux and periodic leaf water potential measurements, we tracked the activity of the tree as it responded to changing available moisture in the root zone (Figure 6). Water content, temperature, and soil water potential were measured in six vertical pits across the site. These data are shown over the course of the whole season as well as for a short period in June 09 (Figure 7). Soil water mass balance was used to estimate ET rates using average VWC from the vertical pits. We found remarkable similarity between independent estimates of ET in the trunk and of water removal from the soil.

The sensors were reactive to moisture and temperature variations on multiple timescales. Data show the dynamic response of soil moisture to precipitation, snow melt, and changes in vegetative demand. We demonstrate here the initial year of a multi-year deployment of soil moisture sensors as a critical integrator of hydrologic/ biotic interaction in a forested catchment as part of a wider effort to document ecosystem response to changing environmental inputs.

Sap flux sensors were responsive to fluctuations in air temperature and solar radiation. Leaf water potential values were measured over a 24 hour period, once per

month during the summer drying period, corresponding to changes in available soil water.

Physical controls on water and carbon exchange and plant production. The three completed eddy covariance towers are operating well. Low power following winter storms continues to intermittently interrupt the data stream at the P301 tower. Heavy snow load and strong winds have damaged the guy wires and solar array structure at the Shorthair tower sight.

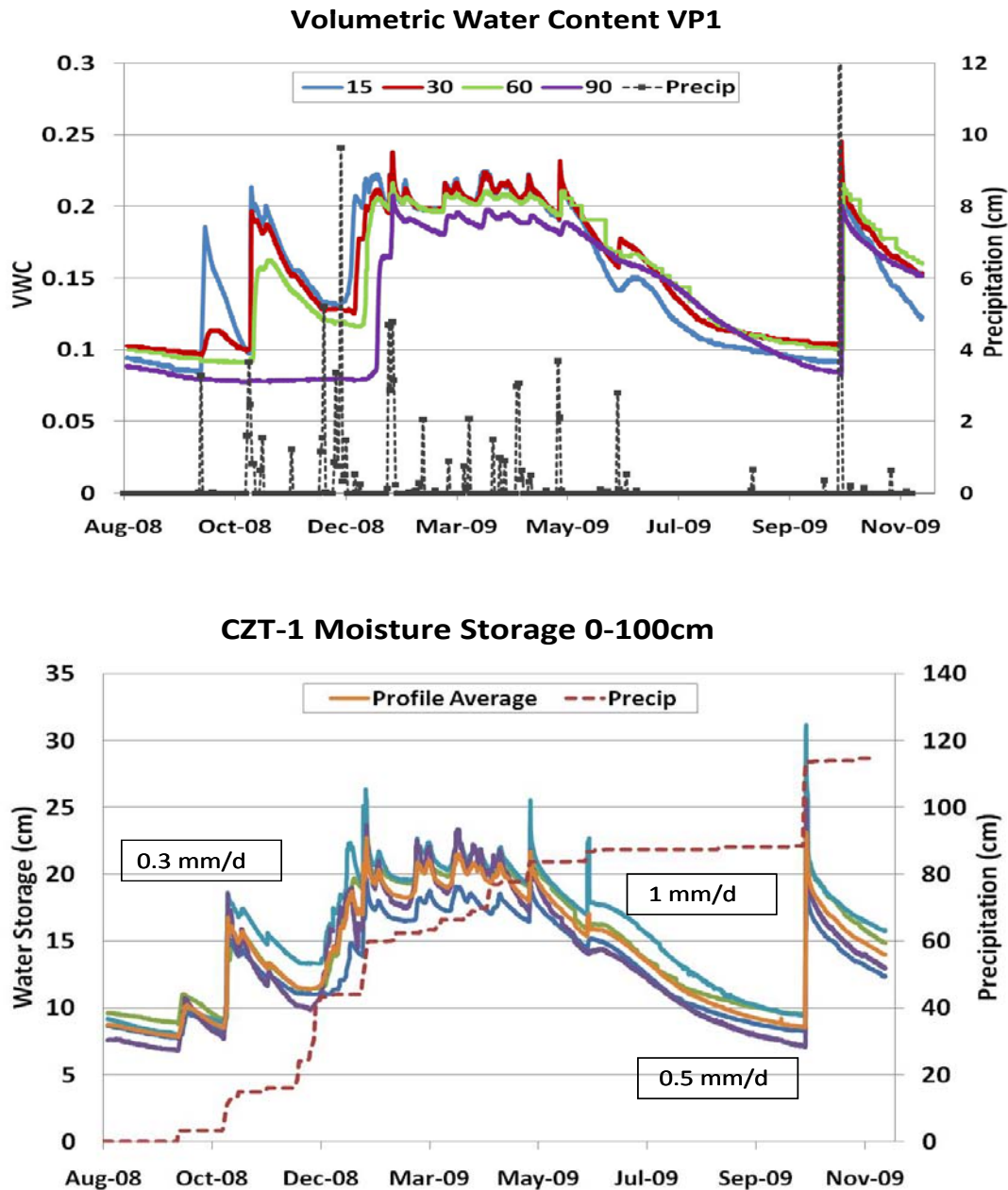


Figure 6 – Soil dessication at various depths beneath the snowpack (above), and Tensiometer data within the plot showing extended 3-month drying out period.

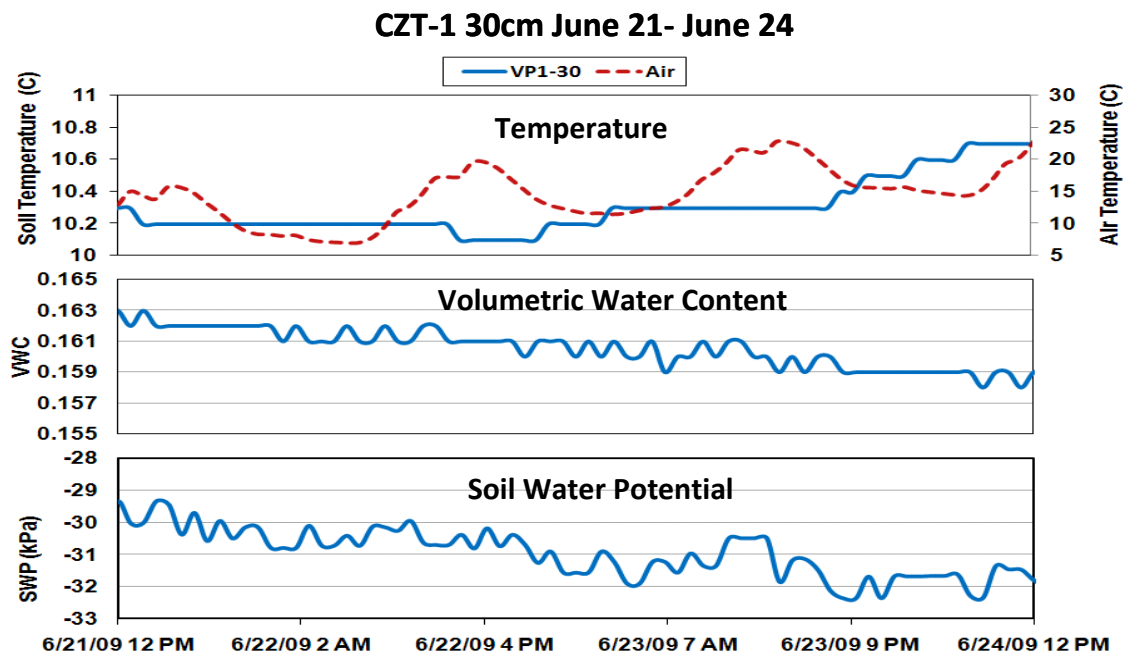
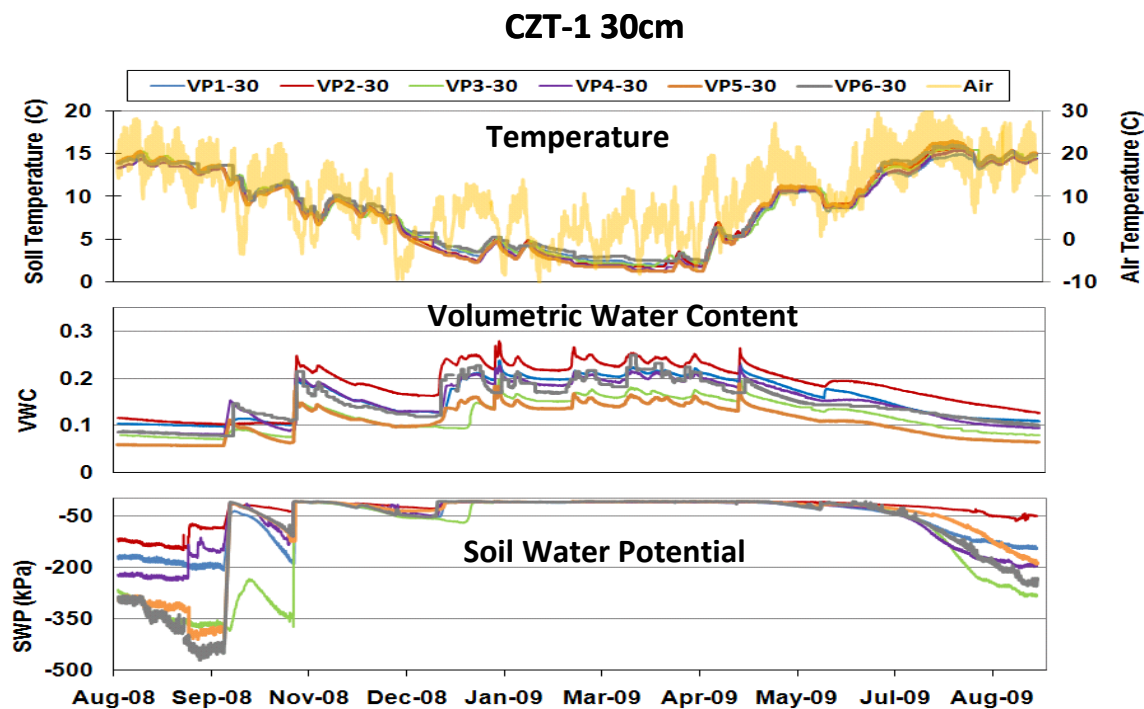


Figure 7 – Water content, temperature and soil water potential measured in six vertical pits across the site. Measurements are shown for a 1-year period (above) and a shorter, 3-day time frame (below).

Consistent with the prior year's data, the P301 tower indicates that forest carbon uptake does not shutdown either in the cold midwinter temperatures or in the late summer drought. Data collected from the Shorthair Creek tower sight indicates that carbon uptake does shutdown in this higher elevation forest due to cold midwinter temperatures. In contrast, data from the San Joaquin Experimental Range Tower shows that the carbon uptake shuts down in this lower elevation forest during the late summer drought. (Figure 8).

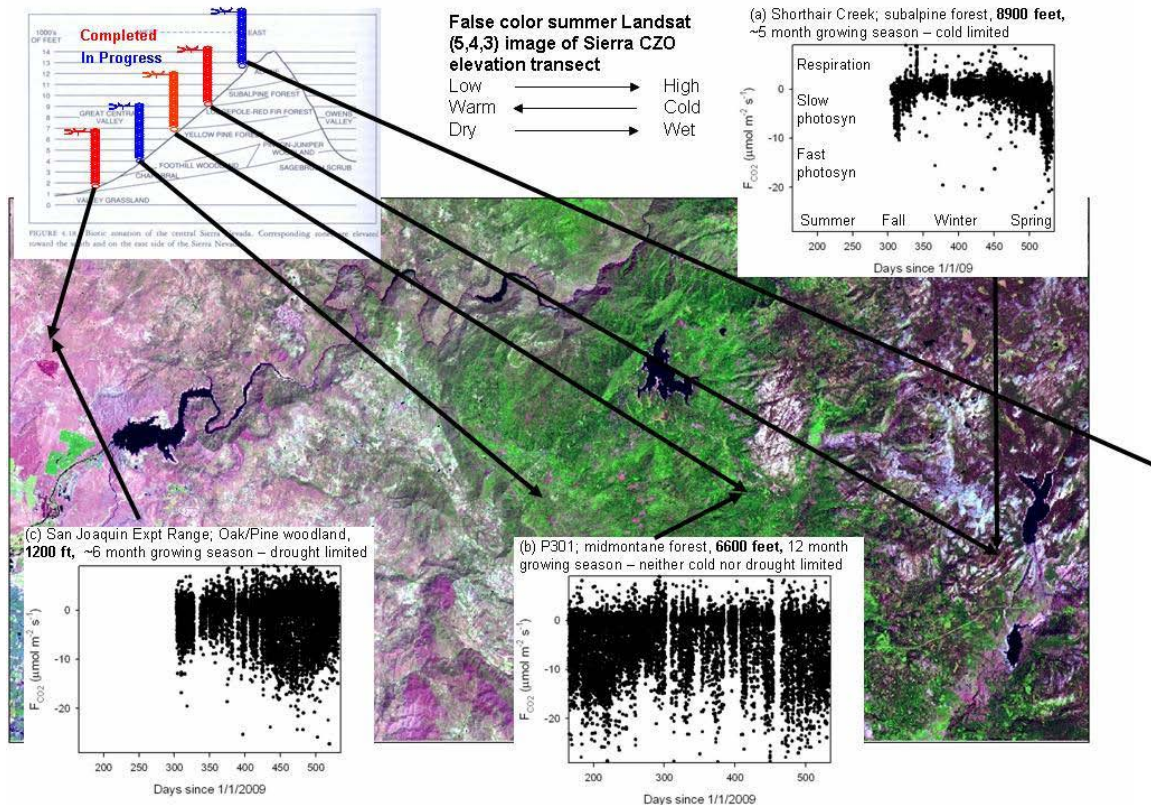


Figure 8 – False color Landsat image with locations of the three completed and 2 planned eddy covariance towers. Plots of seasonal CO₂ uptake at each of the completed towers are included.

Preliminary data from the temperature sensors measuring the vertical gradient of temperature from the forest floor to the boundary layer show that the temperature at 55 m has much less diurnal variation than surface air temperature at our site (Figure 9). This shows that evapotranspiration rates may be diminished during hot summer days and leaf temperatures may be higher during cold winter days than normal meteorological station data would predict.

Sap flow data show a similar pattern to carbon uptake (Figure 10). Cedar has the highest sap flow rates at warmer temperatures, while pines have higher rates at cooler temperatures. This could suggest a difference in adaptive strategies between the functional types.

Meteorological and eddy covariance data show that the mixed conifer forest of the Sierra Nevada can maintain relatively high rates of photosynthesis through cold winter temperatures and midsummer drought. Moderation of the climate at the canopy top compared to the surface may be part of the reason the forest is not as climate-limited as believed. Evapotranspiration rates may be reduced during summer drought due to cooler canopy temperatures, and photosynthesis can continue through winter when the canopy is relatively warm and soils are saturated. The differences between predicted and actual ecosystem productivity highlight the need for better understanding of climate within the forest canopy, especially on daily timescales rather than long-term means. Our primary research site at 2,050 m may exist in a climatological “sweet spot” where photosynthesis can continue throughout the year. This would explain the large forest stature, high

standing biomass, and high productivity of this ecosystem. Measurements of productivity and climate will be further developed along the climate gradient of the western slope. We expect to see significant summer drought limitation at our 1200 m and 300 m elevation sites, and significant cold limitation at our 3,000 m site. Future work will include measurements of soil moisture throughout the year to quantify available water for winter and summer photosynthesis.

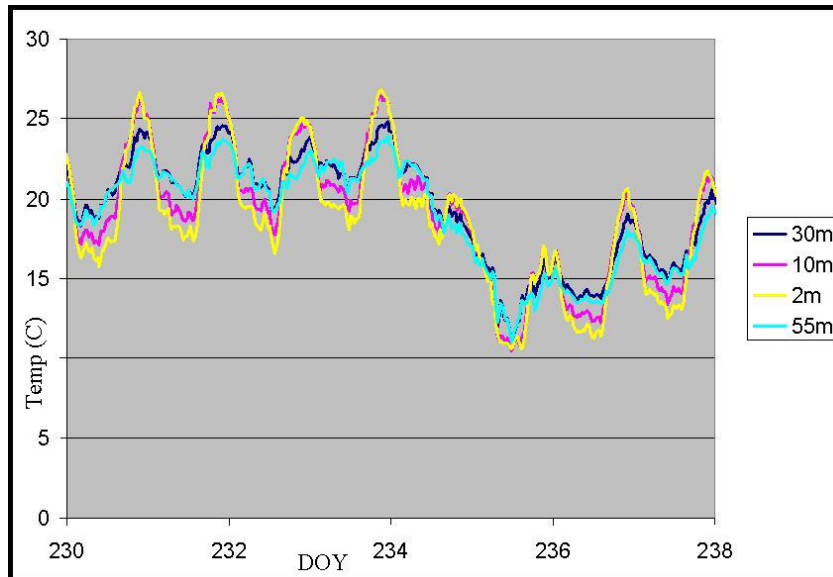


Figure 9 – Temperatures measured along the vertical gradient from the forest floor to the boundary layer.

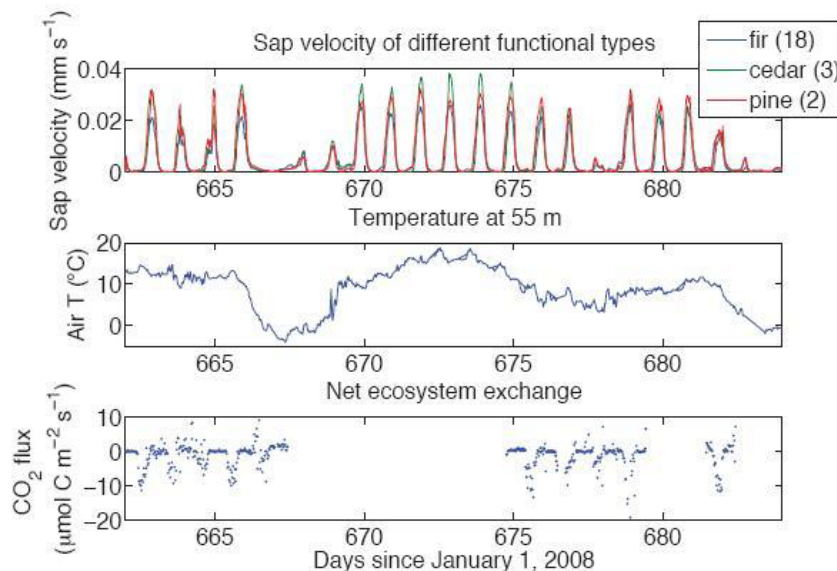


Figure 10 – Sap flow compared to canopy top air temperature and carbon carbon flux for October – November, 2009.

data indicate a strong ET signal is picked up at the treeline and the meadow slope throughout the growing season. Near the meadow stream, the well does not pick up an

Surface-groundwater interactions. Results from an electromagnetic induction (EMI) survey conducted by Nigel Crook, Stanford University, are presented in Figure 11. These initial results indicate that the lower parts of the meadow, in the north, experience more drying between May and June 2008 than the upper parts of the meadow. Drying tends to be more severe at the meadow edges than in the middle of the meadow. The results from the August survey indicate the lower meadow is wetter than when it was observed in May and the upper meadow tends to be drier.

Chamber measurements and well calculations of ET in the lower meadow are presented in Figure 12. These

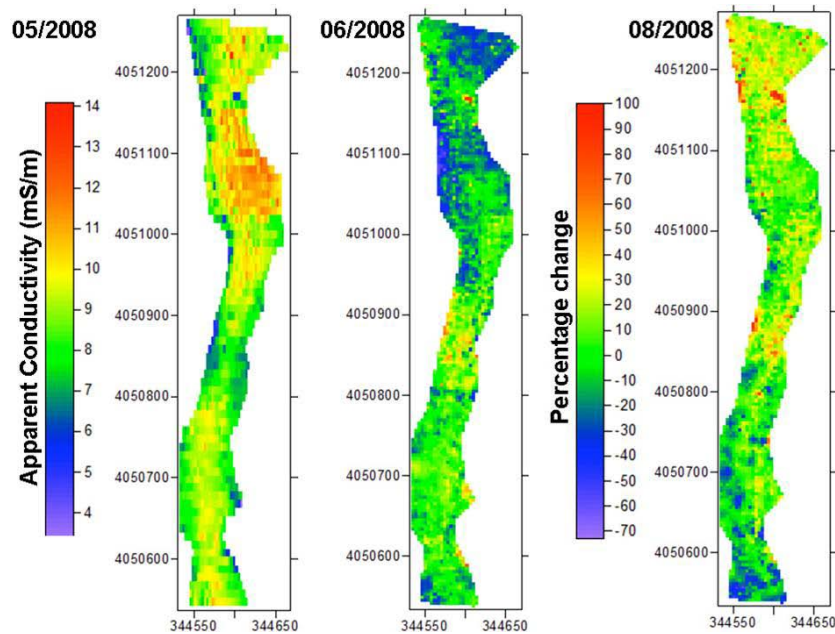


Figure 11 – Results from the EMI survey conducted in Long Meadow

ET signal as strong as that measured by the chamber in July. Low chamber measurements in October are in line with what we would expect to observe as the meadow vegetation had senesced by this point. However the treeline and meadow slope wells still pick up ET signals in October. This suggests that these wells are exhibiting an ET signal from the adjacent forested area. The timing of spatial

moisture patterns and ET signals in the meadow indicate that the groundwater table and soil moisture at the meadow edge and in the lower meadow are heavily influenced by the nearby forest processes.

Results of additional simulations run for the meadow

pools are undergoing analysis.

Example plots from the simulations are presented in Figure 13. Simulations have been run for a variety of stream and groundwater input velocities. Initial analysis of these runs indicates that groundwater input into the bottom of the pools is an important factor in

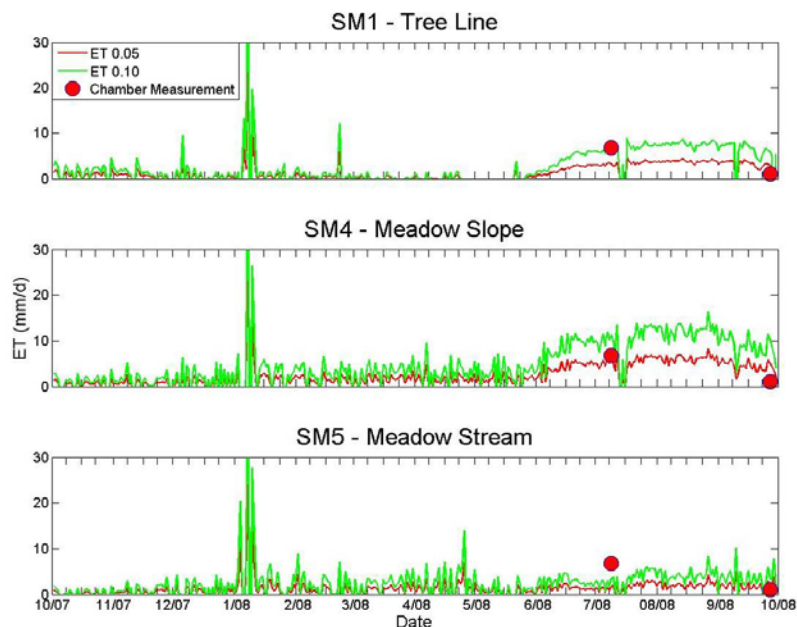


Figure 12 – ET measurements from chamber experiments and meadow wells.

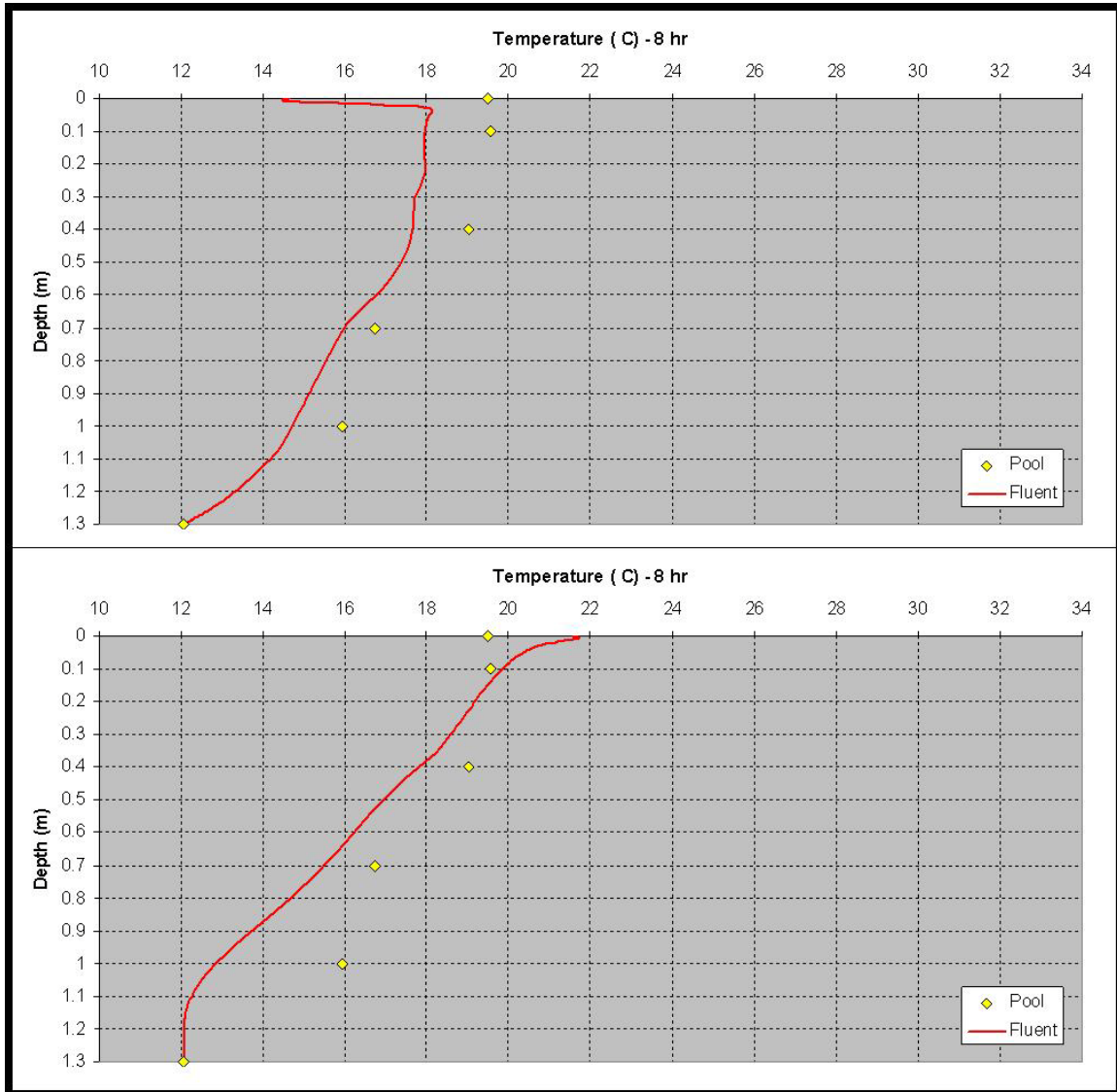


Figure 13 – Example plots from Fluent simulations of thermally stratifying meadow pools. Examples show observed and simulated vertical temperature profiles 8 hours after the model was initiated. The top plot represents results from the model run with 0.01 m/s stream velocity and 0 m/s groundwater velocity; the bottom plot represents results from a simulation run with 0.001 m/s stream velocity and 1 X 10⁻⁵ m/s groundwater velocity.

determining the thermal stratification behavior of the pools. Simulations run with relatively high groundwater input velocity resulted in simulated pool temperatures dominated by the ground water temperatures. Lower groundwater velocity simulations tended to result in temperature profiles closer to the observed values.

Nitrogen cycling in soil . Soils from the KREW watersheds have been analyzed for total C, total N, NH₄⁺ and NO₃⁻; the data from this analysis are presented in Figure 14. Soil NH₄⁺ and mineral N were surprisingly high in both Bull and Providence watersheds and could not be related to any measured soil properties or attributed to known rates of atmospheric deposition. It is possible that NH₄⁺ and mineral N increased between sample

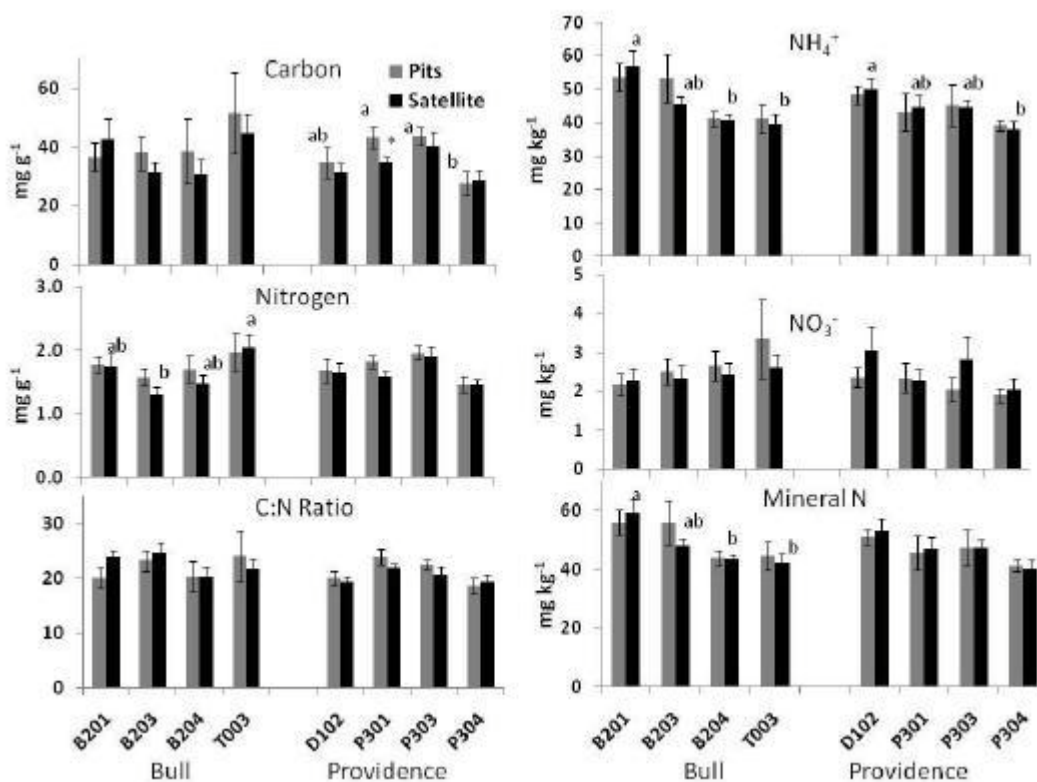


Figure 14 – Carbon, nitrogen, C:N ratio, ammonium, nitrate, and Mineral N concentrations in quantitative pit and satellite samples on the KREW watersheds. Bars not sharing the same letters are significantly different from one another within a site (Bull or Providence).

collection and analysis time, but such is the case with many other data sets collected in the Sierra Nevada mountains which do not show comparably high values. (Johnson 2010)

Nitrogen fluxes from soil. Nothing to report.

Baseline hydrologic, sediment and geochemical characterization. See Figures 1-3 and “Core KREW measurements and data management” for annual-scale analysis of hydrologic data.

Refer to Figure 14 for example of soil geochemical data. Results from soil geochemical analysis other than stated in the *Nitrogen cycling in soil* are described in the summary and conclusions section of Johnson 2010: Quantitative pit and surface soil samples indicated that the higher elevation Bull watersheds had significantly lower extractable P, exchangeable Ca²⁺ and Mg²⁺ and pH were due to differences in leaching rates (greater at snow dominated Bull watersheds). Reasons for the differences in extractable P are not known, but may be due to differences in pH and possibly also sesquioxide contents. Differences in other nutrients occurred in pit and surface soil concentrations, but were not as consistent. There were also significant differences among individual watersheds within Bull and Providence sites that will be taken into account when comparing soil samples from before and after treatments.

Nutrient analyses on samples taken with the bucket auger were comparable to those taken from the same surface horizon depths in nearby quantitative pits when averaged on a watershed or site (Bull and Providence) scale, but quite variable on an individual grid point basis. Elevated Zn values from the quantitative pit samples suggested contamination by field sieving through a galvanized screen. (Johnson et al 2010).

Had quantitative pits not been dug on these watersheds and large rocks within them not accounted for, estimates of fine earth and associated C and nutrient contents would have been overestimated by 16 to 43%; thus, while soil concentration data can provide good indices of differences among sites and watersheds, lack of knowledge about large rock content can cause significant overestimates in soil C and nutrient contents and therefore also their responses to management treatments and climate change. (Johnson et al 2010).

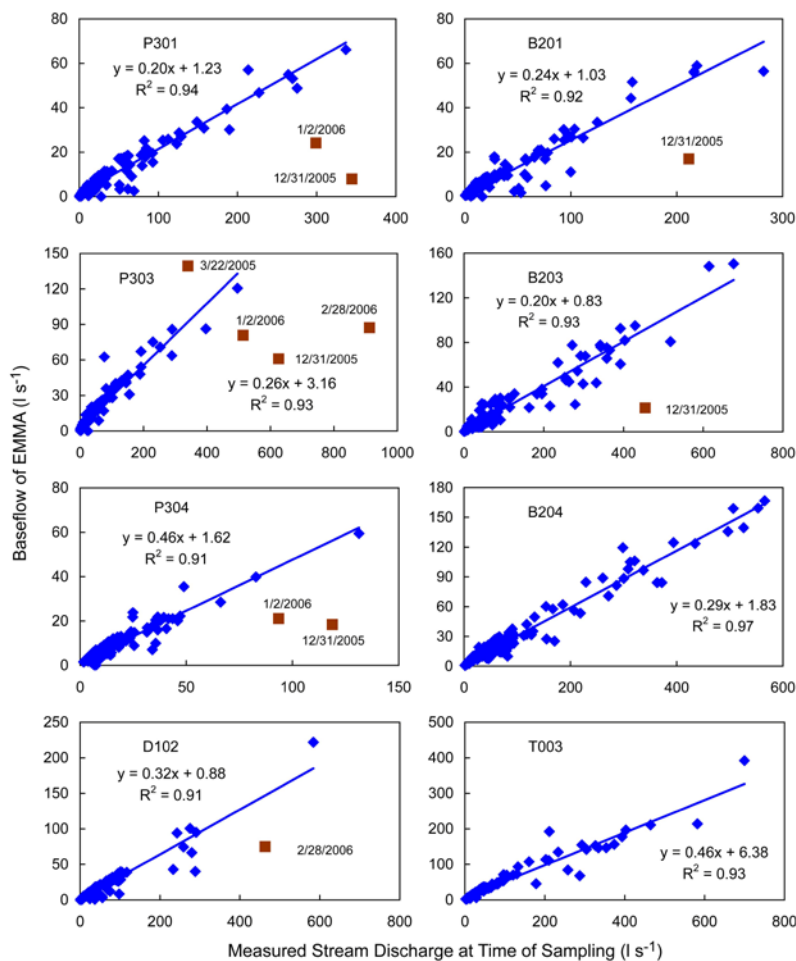


Figure 14 – Correlation between the contribution of baseflow (by flow rate) determined by EMMA using geochemical tracers and stream flow discharge at each catchment.

The bi-weekly major ion samples collected by PSW have been analyzed and used for end-member mixing analysis (EMMA). Some results of the EMMA are presented in Figure 15. Contributions of near-surface runoff (or snowmelt runoff) and baseflow were highly correlated with stream flow discharge by a linear relationship at both Providence and Bull catchments. The R^2 values were 0.92-0.99 and 0.91-0.97 ($p < 0.001$) for near-surface runoff and baseflow, respectively. The slope varied from 0.53 to 0.83 for near-surface runoff and from 0.20 to 0.46 for baseflow. The intercept was all negative for near-

surface runoff, with a magnitude < 7 , and all positive for baseflow, with a value also < 7 . Those samples collected over four water years from 2004 to 2007 covered different climates and annual precipitation.

Water, geochemical cycles, and upscaling of in-situ measurements. Day of snowcover melt out was measured around a north aspect and a southeast aspect Tree in the Wolverton baseline watershed. The range of the day of melt out was 55 days with the mean date 10 days earlier for the aspect tree and than the north aspect tree. (Figure 16). Data from three years of surveys was analyzed for snow depth difference between under

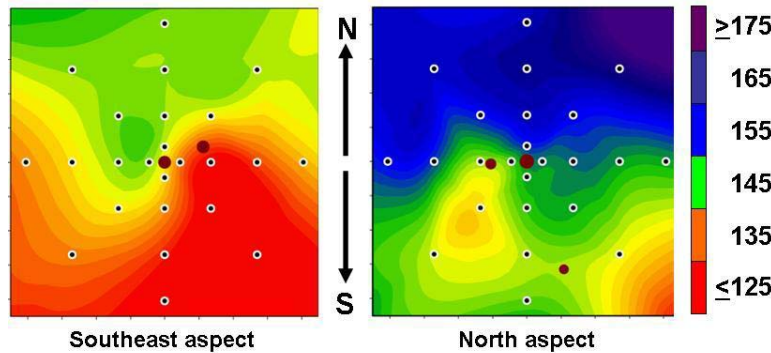


Figure 16 – Day of snowcover melt out around a Southeast aspect tree and a North aspect tree.

canopy and open locations. 270 depths were collected in a 500 by 500 m grid. This data is presented in Figure 17. Similar spatial patterns persist each year. The patterns are most pronounced in the very dry 2007 water year and least pronounced in the wettest water year analyzed (2008).

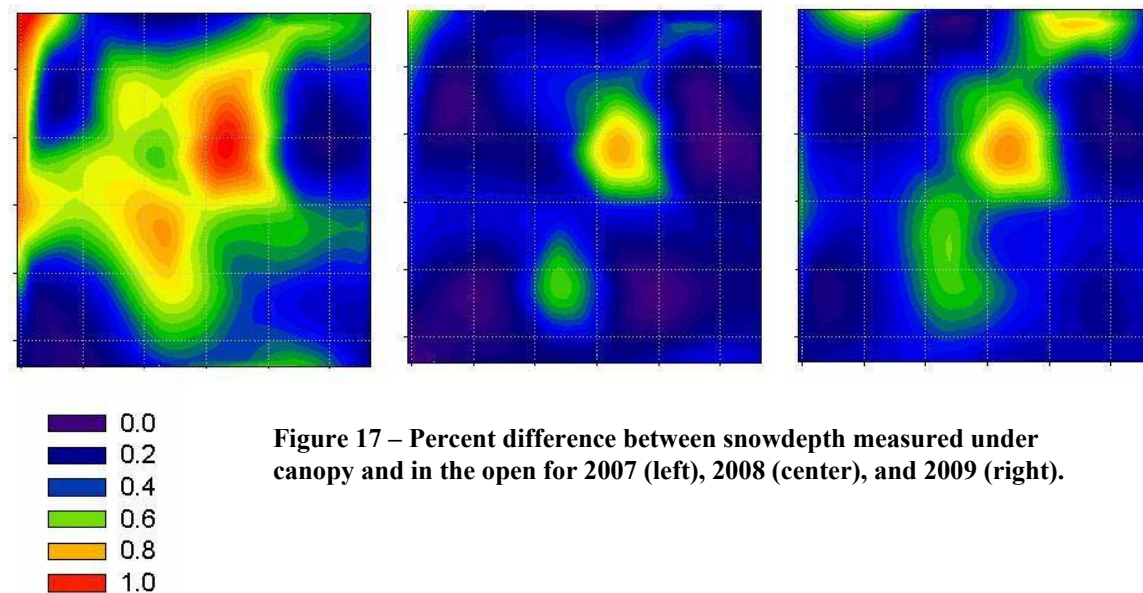


Figure 17 – Percent difference between snowdepth measured under canopy and in the open for 2007 (left), 2008 (center), and 2009 (right).

Physical weathering rates. Results from the Providence and Duff sediment yield traps were compared to long term estimates of sediment yield. These long term estimates were determined from cosmogenic nuclide measurements by Jean Dixon (Dixon et al 2009). This comparison indicates that long-term erosion rates are approximately 10 times higher than the KREW short-term sediment yields (Figure 18). It is important to note that the KREW sediment yield records are too short to include episodic delivery of large packets

of sediment (e.g. from shallow landslides). Analysis of data from the KREW quantitative soil pits and the sediment yield traps indicate that abundance of rock fragment decreases with increased sediment yield (Figure 19). This runs contrary to conventional wisdom. One argument for this may be, again, that the sediment yield record is too short for there to be a significant correlation. Another possibility is that exposed rock outcroppings at the ridgelines—these are quite common in the Providence and Duff water sheds—are supplying a source of rock fragment that is bypassing part of the regolith weathering engine. The watershed that yielded the greatest amount of sediment, in fact, has almost no ridgeline outcropping. Geochemical analysis of rock and soil samples from the Providence and Duff watersheds were used in concert with the cosmogenic nuclide work from Dixon et al 2009 to infer some chemical weathering rates (Table 1). These data indicate high export rates for the Sierra Nevada.

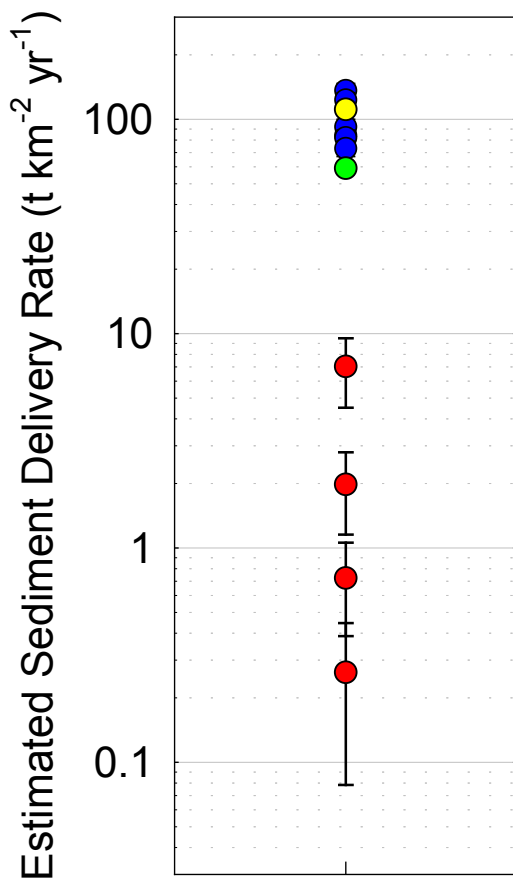


Figure 18 – Erosion rates as determined by KREW sediment traps (red) and by cosmogenic nuclide dating (blue, green, yellow)

Snow processes. Nothing to report.

Organic carbon in streams. Nothing to report.

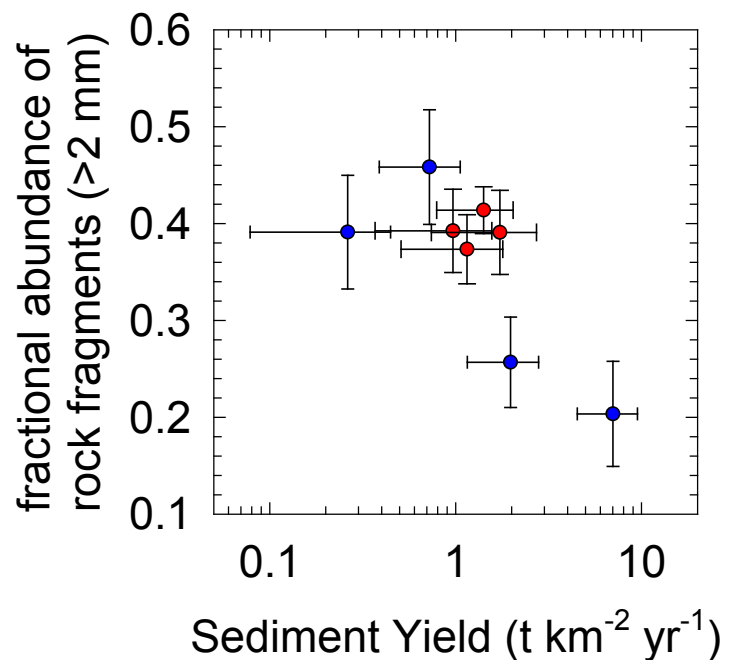


Figure 19 – Fractional abundance of rock fragments versus sediment yield in the Providence and Duff watersheds.

Chemical Weathering Rates (t km⁻² yr⁻¹)		
Element	Total	Saprolite
Si	15.4 ± 1.2	7.6 ± 1.9
Na	1.0 ± 0.1	0.5 ± 0.1
Ca	3.3 ± 0.3	2.1 ± 0.3
Al	2.1 ± 0.3	0.7 ± 0.4

Table 1 – Chemical weathering rates determined from geochemical and cosmogenic nuclide analysis.

References

Johnson, D.W., Hunsaker, C.F., Glass, D.W., Rau, B.M., Roath B.A. Carbon and Nutrient Contents in Soils from the King's River Experimental Watershed, Sierra Nevada Mountains, California. *Geoderma* (submitted and returned for revision)

Dixon, J. L., Heimsath, A. M., Amundson, R. The Critical Role of Climate and Saprolite Weathering in Landscape Evolution. *Earth Surface Processes and Landforms*. v34(11) 1507-1521. 2009