Steering Committee Report on the All-Hands meeting at the Southern Sierra Critical Zone Observatory
September 21-24, 2014

Steering Committee in attendance: Bales, Chadwick, Groffman, Keller, Maher

The September 2014 All Hands Meeting was held at the Tenaya Lodge, just outside Yosemite National Park in California. As with the 2011 All Hands Meeting held at Biosphere 2, the meeting served two functions: a chance for all the participants of the CZOs (Critical Zone Observatories) to present essential material about their sites and to expose their personnel to research at other sites, and an opportunity to evaluate on-going work at the Southern Sierra CZO (SSCZO). This meeting represented a change in direction for the program in that the most important focus was on research integration and on the development of cross-site research to utilize the power of the Critical Zone Exploration Network (CZEN). The network now includes 10 separate observatories. As a consequence about 200 people attended this meeting. The steering committee was impressed by the sense of common purpose and level of excitement exuding from the participants. This is a program that has reached a mature level and is clearly advancing on multiple scientific fronts. In this report we discuss aspects of the meeting itself, the SCCZO, and the program as a whole, particularly as it focuses on cross-site science efforts.

The meeting

The most important goal of the meeting was to foster within and across site research integration. Four thematic areas had been identified as common questions over the summer, and these were addressed through oral presentations: 1) what controls CZ properties and processes, 2) What is the response of CZ structure, stores and fluxes to climate, 3) What is the response of CZ structure, stores and fluxes to land-use change, and 4) How can CZ understanding be used to enhance resilience and sustainability, and restore ecosystem function. Although these questions were posed as equal themes, it became clear from the presentations that knowledge derived from question 1 is required to tackle the other three questions. In a real show of strength for the CZO program, the presentations presented in support of question 1 focused on state-of-the-art knowledge and models and highlighted a number of clear pathways toward understanding the fundamental processes driving CZ evolution. The other three thematic areas utilized aspects of the model approaches summarized in theme 1 to tackle possible outcomes from changes in state conditions such as climate and/or land use, and to specifically highlight ecosystem services provided by CZ and how ecosystem services may be modified by changing land use and climate.

This meeting represents the first network-wide attempt to foster cross-site research. The organizers focused the effort by having breakout groups that corresponded to existing axes of research interest (e.g. origin, storage and fate of organic matter; hydrologic concentration/discharge relations; vegetation-landscape interactions) where practical efforts and outcomes could be identified in support of the thematic areas. The participants enthusiastically embraced the opportunity to develop questions that had clear cross-site implications. Most of the groups suggested that they wanted to have more opportunity to develop their ideas and proposed future workshops to allow greater articulation of questions and honing of methods required.

Although not all the presentations supported the thematic area concept perfectly, the overall effect of the meeting organization was effective in reorienting the science focus from site-specific questions to those that will require data gleaned from several sites. The enthusiasm shown by

breakout group participants and their interest in moving quickly toward common data sets suggests that the momentum developed around the meeting themes can be maintained, particularly if there can be follow up on the most promising aspects via a series of workshops.

The Southern Sierra Critical Zone Observatory

The SSCZO is ideally situated to explore the impact of changing climate on water yield from rainfall and from storage of water in snowpack. Water yield from the Sierra cannot be overestimated as an ecosystem service for the massive agricultural economy of California. For this reason there was a nice meshing of SSCZO science and the themes laid out in the meeting.

The meeting participants were introduced to SSCZO integrated science though an excellent Keynote address by Mike Goulden who highlighted the linkages among net ecosystem exchange as measured using eddy flux approaches and precipitation and water storage within soil, saprolite and fractured bedrock. He highlighted differences in ecosystem functioning and water yield to streams in the different life zones along an elevation transect and tackled the changes that might be expected to occur with changing temperatures and locations of snowpack accumulation. His analysis revealed a significant lack of knowledge about water storage capacities in the different life zones that makes it impossible to predict even the sign of changing water yield with changing climate scenarios. Even though we know quite well how plant water usage interacts with available water in the different elevation zones, we do not know how geological structure and legacies affect the size of the water storage capacity in fractured rock. Later in the meeting Martha Conklin and Roger Bales highlighted the importance of water yield as an ecosystem service for California.

The day-long field trip on Tuesday provided all participants with an opportunity to see the field measurements and the science integration strategies being employed by the SSCZO. There are heroic sampling and monitoring efforts ongoing, ranging from dust-borne microbe collection and characterization to the dynamics of water storage and yield in snowpacks, forests, soils, and groundwater. Although each of the research groups provided a good overview of their measurement and monitoring efforts there was little evident synthesis across the groups. Thus although the flux tower, the "instrumented tree" and the hydrology of the chain of meadows all occur in the same locale it was not made clear to the visitor how those components were being linked into an integrated water yield picture. Surely much of that is happening in order to support Goulden's synthesis and Conklin's ecosystem services efforts but it was not made clear in the site visit.

It is evident that the ability to predict changes in water yield related to potentially complex changes in amount and timing of precipitation is a first order problem and the SSCZO has pinpointed critical zone architecture as one of the most vexing problems in making those predictions. We encourage the SSCZO to respond to this challenge by pressing ahead to estimate water storage capacity within all life zones well enough to allow at least an understanding of the sign of water yield associated with climate change. Uncertainties will remain but the team has the right people and better data than anyone else. They will also generate a compelling target for collaboration that can draw on and demonstrate the power of the network by referencing to similar data collected in the Santa Catalina Mountains and at other sites.

Given the outstanding data collection and modeling efforts directed at hydrologic processes, another opportunity for the SSCZO would be to expand their biogeochemical measurements. Nested soil gas wells, increased measurements of solutes in groundwaters, soil waters and surface waters, etc. would facilitate an analysis of the coupling between hydrologic and biogeochemical processes

that play a central role in CZ function and architecture. In addition, such parameters constitute some of the key inputs or evaluation metrics for hydrologic and reactive transport modeling efforts. The site has created an excellent hydrologic platform for investigating the coupling between hydrologic change and biogeochemical processes such that strategic collaboration to expand the biogeochemical measurements would benefit the site, as well as the entire network. Any investment in additional biogeochemical measurements would be thus extremely valuable.

Opportunities to support cross-site science

As noted by the Steering Committee Report for the Calhoun meeting, there are on-going efforts to identify the most important cross-site questions. These have yielded areas that: 1) address fundamental and exciting scientific questions; 2) are already woven into the fabric of the site mandates and science plans and/or are already underway; 3) are already funded in site budgets or could be funded with relatively modest supplements or reprogramming; and 4) have a high probability of yielding new, transformative, and provocative insights, and testing current models and theory. In some cases natural cross-site efforts can be organized around tools such as the geophysical and "drill-the-ridge" data collection efforts. In other cases, the network will provide appropriate state factor variations such as differences in climate or vegetation as lithology is kept constant, etc.

Also as noted in the Calhoun Steering Committee report resources and leadership are key limitations to moving cross-site work forward. In the short term, the Science Across Virtual Institutes (SAVI) grant that Tim White and Susan Brantley have received can fund a few planning workshops and in the longer term NSF is considering mechanisms to establish a *small grants program that would fund external PIs and postdocs to conduct cross-site research. The steering committee is strongly in favor of such a program* both because it will provide some extra funds but also because it will bring new players into the program. We recommend that the program should not be based with individual CZOs, rather it should be administered via the National Office in order to highlight the importance of synthesis across sites.

There is no doubt that leadership for cross-site science must and will come from the existing CZO scientists. They are charged with managing wide ranging data collection efforts across many disciplines and with synthesizing those data into a full spectrum process understanding of CZ functioning. They know what questions to pose and what data to ask for. Their efforts at coordination are therefore crucial to the development of CZEN as a platform for new views and new inspiration. Toward that end*, the steering committee recommends the following for pressing ahead on cross-site research this fall*. First, the SSCZO meeting conveners should collect and summarize the proposals from the breakout groups. The summaries should be shared with all program PIs and other relevant researchers. After digestion of the summaries, a small group comprised of roughly one PI from each CZO should meet (in person or virtually) to explore common ground on the topic areas. Their discussions could address: 1) what can be done now with existing data, 2) what can be done with existing infrastructure and resources, and 3) what could be done if there were additional funds and/or expertise. Hopefully this can be fit into a timeline that would allow some concrete proposed actions by the time of the spring 2015 meeting.

A substantial barrier to cross-site work has been slow development of the CZO central data management system. It has been very difficult to locate and retrieve relevant data through the CZO data portal. The lack of a functional CDMS was viewed by many researchers and PIs as a key hindrance to cross-network science. Based on Anthony Aufdenkampe's presentation these problems may be solved, however to be sure, the steering committee recommends that data sets

streamlined for rapid release and that firm timelines for deliverables are developed and enforced, possibly under the guidance of the National Office.

Communication is key to the success of the CZO Network. The steering committee strongly supports the PIs suggestions about ways to develop virtual descriptions of on-going research at their sites and to highlight potential cross-site comparisons. Still, there is no substitute for meetings as our experience at SSCZO has again shown. As the network has grown with more people and more ideas, there is greater stress on meeting time. Two possibilities, not mutually exclusive, emerged in conversations: 1) have All-Hands meetings more often. 2) eliminate the field trip from some meetings – perhaps the All-Hands meetings. The drawback of the latter idea, for field-oriented science, is obvious and in fact this year's SSCZO field trip triggered excellent group and one-on-one discussions that may not have happened otherwise.

Steering Committee Recommendations for the CZOs

CZOs require several different measurement approaches, some locally intensive and some spatially distributed. They require different types of expertise ranging from the physical to the biological. Effective synthesis within and among CZOs requires a huge commitment to communication, which in turn requires intellectual involvement in complex problem solving by all the PIs. In some of the more mature CZOs it has perhaps been a while since priorities were set and syntheses were attempted. The steering committee believes that the individual CZOs and the network will only work effectively if the PIs maintain a high level of urgency associated with their tasks. CZOs will not run on a business-as-usual schedule. PIs should keep asking whether their CZO is living up to its interdisciplinary promise – not parallel play, but cross communication among all players with a common set of science goals clearly in mind. For the most part this is happening, but not always and not everywhere. Complacency never sleeps.

There is a universe of potential questions that can be asked for each CZO and for the network. What are the ones that will actually be tackled? Are they the ones that could not be tackled if the network did not exist? The steering committee recommends: 1) focus on questions that can be uniquely solved using the power of the network, 2) identify and exploit timely research (e.g. the spatial distribution and drivers of water storage development), 3) reorient program efforts to go after important questions that may not have been recognized previously, 4) consider inviting new researchers to help plug gaps in existing expertise (e.g. geochronologists specializing in aging water), 5) continue to lobby NSF for a small grant program to support cross-site research efforts, as we recommend above. Although the science questions should be the primary driver for each CZO and the network as a whole, it is important to continue conversations about common measurements (e.g. geophysical profiling, remote sensing, new monitoring technologies, as well as more routine datasets) and to build in plans to support the emerging data platform.