Report of the Critical Zone Observatory (CZO) Network Science Steering Committee (SSC)
Intensively Managed Landscapes (IML)-CZO Site Visit
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The SSC met in conjunction with the IML-CZO PI site visit. This report highlights key points emerging from our discussions over two days, including individual meetings with representatives of NSF, the National Office and the IML CZO. Although the role of the SSC is changing as new review policies are implemented by NSF for the CZO network, and the Committee is no longer expected to provide a detailed site review, we feel it's important to continue the tradition of providing feedback to site PIs to strengthen the program and in anticipation of future formal site reviews.

IML-CZO program

The IML-CZO program clearly is a critical and unique CZO site, emphasizing the role of land use activities in transforming the landscape and critical zone, and has the potential to produce transformative scientific understanding. All of us were impressed by the extent to which human activities, including replacement of tall grass prairie with intensive monoculture (almost exclusively corn and soybean cultivation), and concurrent installation of dense galleries of drainage tiles has changed the landscape. Formerly marshy grasslands rooted in deep organic and nitrogen-rich soils with low drainage densities that developed on Pleistocene moraines, tills, and outwash plains of low relief have been replaced by vast acreages of rich agricultural fields that are intensively farmed, drained, fertilized and repeatedly tilled. As a result, the CZ underlying the Illinois landscape is a palimpsest of a deep depocenter modified by multiple glaciations and overlain by soils recording both the Holocene and Anthropocene. The IML site is thus the most altered site in the CZO portfolio.

The IML CZO team has made impressive strides in understanding the dynamics of this landscape in the short (1+ years) time since the site become part of the CZO network. An overarching hypothesis that the CZ has evolved from being a transformer of sediment and nutrients, particularly carbon and nitrogen, to a transporter and exporter of these constituents is a provocative concept, if not entirely testable. Utilizing a multi-prong attack of deep coring (much of this utilizing Illinois State Geological Survey sites, funded in part by the USGS State Map Program), analysis of river channel change and floodplain sedimentation rates dated with fly ash and cosmogenic isotopes, water quality and sediment provenance studies, as well as erosion process modeling using rainfall simulation experiments and tracers, the team is in the process of assembling narratives of CZ and landscape change over timescales ranging from annual to millennial. Modeling is woven into testing story line components but has not been a primary focus so far. This rich mix of time, space, and process studies has the potential to reveal interesting insights into development of the Illinoisan landscape.

But as with all CZO sites, the most difficult task is integrating the individual studies into a comprehensive and coherent narrative of how the CZ is organized and why and how it is responding to the intense land use pressures, and how these insights be used to guide management of these lands. We see elements of this fundamental story emerging, but many of the dots have not yet been connected. How will results from the rainfall simulation experiments be used to inform the channel sampling and whole basin modeling schemes? How does the CZ "remember" and record its history? These are just examples of the kinds of inter-study connections that will help the audience see how the pieces connect. Clearly, a somewhat unique challenge faced by the team in "connecting the dots" is limited access to the entire flow path because of private land ownership.

Another key issue is the relation between the IML-CZO and the agricultural community, including farmers, landowners, and ag extension. It became clear that the IML team is navigating a fine line with respect to working with private landowners to get access to field sites and establish installations. Trust is an essential component of these relationships, yet the research is targeting "hot button" issues, like nutrient loading, for which there are strongly-held opinions. The SSC sees linking CZ research to the local farming communities as an important aspect of the site, and encourages the IML to continue to reach out to this community, including more visible potential partnerships with agricultural agencies.

Cross-site activities, integration, and data management

In general the Committee was quite encouraged by the level and number of cross-site activities that are moving forward. The proposed SAVI workshops and intended manuscripts are all exciting and forward-looking. **We are particularly enthused about the prospect of a synthesis paper that lays out the core set of linked questions addressed by CZ science and provides compelling examples of research highlights.** This paper could provide a much-needed touchstone for integration issues to come. Further, the workshops are reaching outside the existing CZO community and thus providing portals for others to enter the arena.

More broadly than any one workshop or paper, we believe that the Network needs to be continuously developing an integrated set of frameworks for the network as a whole. These frameworks should highlight and probe both the similarities and differences among sites. One graphic to consider would be a continental map showing the different architectures of the CZ across the population of sites. Common cross-site themes need to be identified and developed. **As an example of a potentially useful cross-site theme, many sites have experienced dramatic dropping of the water table over recent (IML, CAL) to geological (BOU, LUQ) time scales; how does this history affect the organization of the CZ across different landscapes, climates, and rock types?**

We didn't hear a lot about how modeling is being used as an integrative framework for the sites, and it's our impression that the role of models has not been clearly developed and

articulated for the Network as a whole. It would be useful at some point to have a longer discussion about how models are (or are not) being used in the Network, especially once the cross-CZO working groups start to develop integrated views of data and processes.

We emphasize the need for all parties to share responsibility and work together to support the development of the CZO data management structure. In particular we support the efforts by the data management (DM) team to organize webinars and one-on-one site discussions as part of the DM rollout. **Sending members of the team to the various cross-CZO workshops may also be particularly useful as it provides an opportunity to test and evaluate the interface, and fewer webinars and more one-on-one exchanges are likely to be important next steps to widespread engagement and implementation.** As with any product, for the DM system to achieve its full potential, the needs of the end users (*i.e.* both people uploading data and people trying to access data) should start to be woven into the fabric of the system. Given that many of the underlying architectural problems have been addressed, it seems to be an opportune time for the CZO PIs and DM teams to engage in mutual exchanges (*e.g.*, prototyping) to ensure that the final interface meets a variety of needs. Ongoing discussions and prioritization of what data needs to be part of this scheme are expected.

National Office (NO)

The NO is transitioning into its anticipated leadership role, which includes understanding and prioritizing expectations. This can be challenging, because the NO gets tasked by default with all the myriad chores that accompany an enterprise of this magnitude. Fortunately the skill sets of the two principals (Derry and White) are highly complementary, ensuring that both long range planning and taking care of business will get done. Among its many activities, the NO is administering the SAVI cross-site grants, applying for Powell Center funding, tracking the data management issues, arranging site and Network Executive Committee (NEC) meetings, interacting with NSF and external groups, and more. As a result, the NO has a very full plate, meaning that the NO acronym needs to be used! The NEC, which was just recently established and consists of selected PI's, the NO, and the chair of the SSC, has the potential to be a more effective means of decision-making and communication than has been used in the past.

In general, the SSC feels that the National Office leaders have the right set of priorities (i.e., fostering cross-site work). So that everyone understands the role of the NO, **we believe the NO should vet these priorities and associated schedules for task completion with NSF, the NEC, and then clearly communicate to all parties**. Key near-term tasks include **developing ways to highlight research findings from the network to broader audience**s (this would also directly support NSF efforts to elevate the visibility of the CZO network). Further, we feel that the new hires being contemplated by the NO need to be given very careful consideration as to what skills and aptitudes are most needed to ensure that the Office is successful. **Being successful also requires that the NO work collaboratively with the DM team –** we don't need to remind anybody just how vital this component of the Network is. This could mean **more frequent interactions between the DM team**, the NO, and PI's to provide products for review and testing

at more frequent intervals than is currently done and structuring a dialogue that allows for mutual and productive exchange.

NSF

The Committee continues to be impressed by the clear and unwavering support for the CZO program by NSF leadership. NSF explicitly told the Steering Committee that it wants to make the CZOs the star of the Division and Directorate and is committed to seeing that happen. We applaud this and endorse an approach that would continue to fund a network of long-term Observatories that can develop and exploit the prospects and power of the CZ paradigm, the emergence of which was clearly in evidence at this meeting. Within the acknowledged constraints of uncertain future funding, we feel that NSF needs to better communicate its expectations about how they see the longevity of both the CZO program and individual sites. Is this program likely to be around in 10-20 years? Will the number of sites continue to expand or will a different model (i.e., mobile CZO?) become the norm? We know that these are not easy questions to answer but encourage an open discussion as a means of fostering good communication among all parties.

The Network is undergoing a transition as new sites and NO come on line, and the review and accountability process for the sites is changing. Our visit with NSF, which immediately followed their broader and sometimes heated discussion of some of these topics with the PIs, left us feeling that NSF in general understands the work- and reporting load such changes impose upon the sites. In particular, our sense is that within the constraints of certain "must have" reporting and review, there is actually a fair amount of flexibility as to the frequency of meetings and other expectations. As noted above, **we do feel that NSF needs to be clearer in its communications with the sites, particularly with respect to program changes and obligations, including the long-term funding future of the Network.**

All parties (sites, NO, NSF) need to work together to develop high-level, high impact research highlights. These need to be widely communicated in order to help support the Network's exposure and impact. The cross-site products discussed above should help with this. Moreover, NSF is looking down the road to elevating the Network's profile with an NRC review of the CZO program. NSF can have a productive conversation with the CZO community about how the Network might synergistically support the evolving landscape of federally funded observatories (LTER, NEON, etc.). Each of these other observatories exists within a Critical-Zone context, and there may be elements of a CZ approach that can be fruitfully exported/applied to them.

Other Issues

We discussed the SSC charter; everyone is in agreement with some minor editorial changes suggested. These will be shared so that the charter can be posted.

We discussed enlarging the SSC as called for the in the charter and to ensure an informal

quorum for site visits, etc. In general the SSC believes that smaller is better from the standpoint of discussion and productivity. We will consider a few names, but will strive to keep the numbers in the 6-8 range.

As recommended in the past, we felt that the **National Executive Committee should examine how site visits are being conducted and make recommendations to make the process better if warranted.** This theme was echoed by many of the CZO PIs during the meeting. For example, limiting the field trip to one day may ensure that there is ample time for group discussions. There may also be some reconsideration of the timing for other site visits due to schedule conflicts in the fall, 2015.