Preview of Award 1331906 - Annual Project Report

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Cover

Federal Agency and Organization Element to Which Report is Submitted:	4900
Federal Grant or Other Identifying Number Assigned by Agency:	1331906
Project Title:	Critical Zone Observatory for Intensively Managed Landscapes (IML-CZO)
PD/PI Name:	Praveen Kumar, Principal Investigator Alison M Anders, Co-Principal Investigator Elmer Bettis III, Co-Principal Investigator Timothy Filley, Co-Principal Investigator Thanos Papanicolaou, Co-Principal Investigator
Recipient Organization:	University of Illinois at Urbana-Champaign
Project/Grant Period:	12/01/2013 - 11/30/2018
Reporting Period:	12/01/2015 - 11/30/2016
Submitting Official (if other than PD\PI):	N/A
Submission Date:	N/A
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	N/A

Accomplishments

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

The central hypothesis of Critical Zone Observatory for Intensively Managed Landscapes (IML-CZO) is that, through human modification, the critical zone of IMLs has passed a tipping point (or threshold) and has gradually shifted from being a *transformer* of material flux with high nutrient, water, and sediment storage to being a *transporter* of material flux with low nutrient, water and sediment storage. We expect that the *understanding* of *IMLs as systems in disequilibrium whose components are co-evolving under strong human, geological, and climatic drivers and which act as non-linear filters for material transformation and transport* will provide new insights to guide practices and policies for sustaining CZ services in the

Anthropocene. The IML-CZO effort, distributed across two primary sites (Upper Sangamon River Basin [USRB} (~3700 sq. km.) in Illinois and Clear Creek Watershed [CCW] (~270 sq. km.) in Iowa and a partner site Minnesota River Basin [MRB] (~44,000 sq. km) [funded independently through a NSF WSC Grant] is divided into multiple themes to cover a broad range of issues. The present report is organized per these themes and primarily reports on the effort and outcomes from the primary sites (results for the Minnesota River Basin effort is available through the project report associated with the WSC project [NSF Grant # CBET 1209402]);

Theme A: Geologic Timescale Processes-Glacial Legacy to Future Climate Change

Theme A's major goal is to better understand how the glacial and prehistoric legacy recorded in the landscape and deposits of IMLs influence present processes and the trajectory of CZ evolution. Toward this end, four primary research foci are encompassed by this theme: 1) formulation of criteria for and mapping of fundamental landscape units; 2) assessment of the record of anthropogenic landscape disturbance recorded in post settlement alluvial deposits (PSA); and 3) documenting the physical, chemical, and hydrologic characteristics of the weathering profile.

Theme B: Short- and Long-Term Dynamics of Soil Organic Matter

Theme B's major goal is to examine how intensive cultivation has altered soil organic matter fluxes, residence time, and storage using key state variables under the forcings of regional climate and local anthropogenic activity. The key questions in this theme are: What is the dynamic relation between active and stabilized forms of SOM in IMLs and how does that relationship vary in activity centers and activity intervals? What are their effects on biotic and abiotic activities as they relate to SOM storage?

Theme C: Coupled Surface Water – Groundwater Hydrology and Biogeochemistry

The major goal of Theme C is to quantify how intensive management of landscapes affects residence times & aggregate fluxes of water, carbon, nutrient, and sediment at scales ranging from flowpaths to catchments? Four key research questions have been articulated to achieve this goal: (1) How does the coupled interaction of surface water and groundwater control fluxes of water and solutes within the critical zone and their residence times in different elements of the landscape (e.g., vadose zone, stream, aquifer)? (2) How do the signatures of key materials that are exported (e.g., SOM and DOC) relate to those stored in the landscape? (3) How anthropogenic impacts have altered these fluxes, stores, residence times? and (4) How do different materials move through the system, and what are the timescales relevant for their transformation processes?

Theme D: Water, Soil, Sediment and Landscape Connectivity: Short- and Long-Term Budgets

Theme D's major goal is to determine fluxes of water and sediment at different spatial (hillslope, stream, watershed) and temporal (annual, seasonal, event-based) scales within intensively managed landscapes, to establish sediment budgets at the watershed scale, and to determine the role of human and natural factors in water and sediment fluxes. Key question: How are the sources, fluxes, and sinks of sediment in IMLs disributed in space and time? How do geomorphic, biogeochemical, hydrologic, and human processes interact with sediment production, transfer, and storage rates?

Theme E: Integrated Modeling and Critical Zone Services

The major goal of this theme is to lead the development of an integrated modeling system that (1) exploits high resolution data such as those obtained from LiDAR and hyperspectral technologies; (2) represents micro-topographic variability in landscapes, roughness, vegetation and biogeochemical attributes; and (3) characterizes critical zone services in IMLs.

Theme F: Cyberinfrastructure and Services: Creation of an interactive web-portal for storage, retrieval, visualization and analysis of data produced by IML-CZO (measurements and simulations).

Details in the attached Activities Report document.

Theme G: Education/Outreach & Dissemination Plan: building a stakeholder network for dissemination of IML-CZO research through targeted education and outreach activities.

Details Below

Theme H: External Research Partnerships: actively engage IML-CZO in similar large-scale national projects and broadening its international dimensions.

Details below**.**

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

Major Activities:	See attached file "2016-IMLCZO-Annual-Report-Accomplishments.pdf."
Specific Objectives:	See attached file "2016-IMLCZO-Annual-Report-Accomplishments.pdf."
Significant Results:	See attached file "2016-IMLCZO-Annual-Report-Accomplishments.pdf."
Key outcomes or Other achievements:	See attached file "2016-IMLCZO-Annual-Report-Accomplishments.pdf."

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

See attached file "2016-IMLCZO-Annual-Report-Accomplishments.pdf."

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

See attached file "2016-IMLCZO-Annual-Report-Accomplishments.pdf."

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

See attached file "2016-IMLCZO-Annual-Report-Accomplishments.pdf."

Supporting Files

Filename	Description	Uploaded By	Uploaded On
2016-IMLCZO-Annual-Report-Accomplishments.pdf	This document provides details of IMLCZO project activities and accomplishments.	Praveen Kumar	11/04/2016
2016-IMLCZO-TeacherTraining.pdf	Report of K-12 Teacher Training Conducted by IMLCZO	Praveen Kumar	11/04/2016
2015-AnnualReport-Year4-BudgetRequest.pdf	Budget for year 4 and Justification	Praveen Kumar	11/04/2016

Products

Books

Book Chapters

Papanicolaou, A.N., and B.K.B. Abban. (2016). Chapter 65: Channel Erosion and Sediment Transport.. *Handbook of Applied Hydrology.* Chow, V.T.. . Status = PUBLISHED; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes

Inventions

Journals or Juried Conference Papers

Abban, B., A. N. Papanicolaou, M. K. Cowles, C. G. Wilson, O. Abaci, K. Wacha, K. Schilling, and D. Schnoebelen (2016). An enhanced Bayesian fingerprinting framework for studying sediment source dynamics in intensively managed landscapes.. *Water Resources Research*. 52 (6), . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/2015WR018030

Abban, B., A.N. Papanicolaou, M.K. Cowles, C.G. Wilson, O. Abaci, K. Wacha, and K.E. Schilling (2015). Sediment source dynamics in the headwater stream of an intensively cultivated agricultural watershed: A Bayesian fingerprinting study using stable isotopes. *Water Resources Research*. . Status = SUBMITTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Abban, B.K.B., A.N. Papanicolaou, C.P. Giannopoulos, D.C. Dermisis, K.M. Wacha, C.G. Wilson, and M. Elhakeem (). Quantification of change in soil surface roughness at the raindrop detachment zone as a function of rainfall intensity under flatbed preconditions.. *Non-linear Interactions*. . Status = OTHER; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Allison Goodwell and Praveen Kumar (2016). Balance of Unique, Redundant, and Synergistic Information Under Varying Source Dependency. *IEEE Trans. Signal Processing letters*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Allison Goodwell, and P. Kumar (2015). Information theoretic measures to infer feedback dynamics in coupled logistic networks. *Entropy*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Berry, T.D., Filley, T.R., Clavijo A., Bischoff Gray, M., Turco, R.F. (2016). Degradation and Microbial Uptake of Fullerols in Contrasting Agricultural Soils. *Environmental Science and Technology*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Debsunder Dutta, Allison Goodwell, Praveen Kumar, Robert Darmody, James E Garvey, Robert Jacobson, David P. Beretta and Jonathan Greenberg (2015). On the Feasibility of Characterizing Soil Properties from AVIRIS Spectrometer Data. *IEEE Trans. In Geosci. & Remote Sensing*. 53 (9), 5133. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1109/TGRS.2015.2417547

Debsunder Dutta, Kunxuan Wang, Esther Le, Allison Goodwell, Derek Wagner (2015). Characterizing Vegetation Canopy Structure using Airborne Remote Sensing Data. *IEEE Trans*. . Status = OTHER; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Debsunder Dutta, Praveen Kumar, and Jonathan Greenberg (2016). Effect of Spatial Resolution on Characterizing Soil Properties from Imaging Spectrometer Data. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing (JSTARS)*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Dermisis, D., A.N. Papanicolaou, B. Abban, and D. Flanagan (2015). Dynamic approach for predicting soil transport and delivery from fields and small catchments to headwater streams: field experiments and analysis. *Water Resources Research*. . Status = SUBMITTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Dong K Woo and P. Kumar (2015). Impact of Hydrologic Variability on Mean Age Distribution of Soil-Nitrogen. *Water Resources Research*. . Status = SUBMITTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Elag, M., J. Goodall, and P. Kumar (2015). Leveraging Semantics to Improve the Interoperability of Hydrologic Models. *Env. Modeling and Software*. . Status = SUBMITTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Filley, T.R., Li, M.L., Zhuang, J., Yu, G.R.,; Sayler, G., Ouyang, Z.Y., Han, X.G., Zhang, X.D., Jiang, G.B., Zhou, C.H., Wang, F., Bickham, JW. (2015). Bi-national research and education cooperation in the US-China EcoPartnership for Environmental Sustainability.. *Journal of Renewable and Sustainable Energy*. 7 (4), 041512. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Harman, CJ, AS Ward, A Ball (2016). How does reach-scale stream-hyporheic transport vary with discharge? Insights from rSAS analysis of sequential tracer injections in a headwater mountain stream. *Water Resources Reserach*. . Status = ACCEPTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/2016WR018832

Hernandez-Murcia, O.E., D.J. Schnoebelen, A.N. Papanicolaou, and B.K.B. Abban. (). Coupling flow with nutrient dynamics via BioChemFOAM in the Mississippi River.. *Journal of Applied Water Engineering and Research.*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Kaycee N. Reynolds, Terrance D. Loecke, Amy J. Burgin, Caroline A. Davis, Diego Riveros-Iregui, Steven A. Thomas, Martin A. St. Clair, Adam S. Ward (2016). Optimizing Sampling Strategies for Riverine Nitrate Using High-Frequency Data in

Agricultural Watersheds. *Environ. Sci. Technol.,*. 50 (12), 6406. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1021/acs.est.5b05423

Kumar, P. (2015). Hydrocomplexity: Addressing Water Security and Emergent Environmental Risks. *Water Resour. Res.*. 51 . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/2015WR017342

Le, P. V. V., P. Kumar, A. Valocchi, and V. H. Dang (2015). GPU-based high-performance computing for surface – sub-surface conjunctive flow modeling. *Env. Modeling and Software*. 73 . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1016/j.envsoft.2015.07.015

Malzone, J.M., Lowry, C.S., and Ward, A.S. (2016). Response of the hyporheic zone to transient groundwater fluctuations on the annual and storm event time scales. *Water Resources Research*. 52 5301. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/2015WR018056

Papanicolaou, A.N. Dermisis, D., B.K.B. Abban, D. Flanagan, and J. Frankenberger. (). Capturing the dynamic effects of hillslope heterogeneity on overland flow using a shock-capturing numerical scheme: a 1-D approximation in the downslope direction.. *Water Resources Research.*. . Status = OTHER; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Papanicolaou, A.N., C.G. Wilson, A.G. Tsakiris, T. Sutarto, S. Dey, F. Bertrand, and M. Rinaldi. (). Quantifying bank fluvial erosion rates using Photo Electronic Erosion Pins and in-situ flume: an improved methodology for estimating key properties of fluvial erosion.. *Earth Surface Processes and Landforms.*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Papanicolaou, A.N., K.M. Wacha, B.K. Abban, C.G. Wilson, J. Hatfield, C. Stanier, and T. Filley (2015). From Soilscapes to Landscapes: A landscape-oriented approach to simulate soil organic carbon dynamics in Intensely Managed Landscapes. *Journal of Geopysical Research Biogeosciences*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Papanicolaou, A.N., M. Elhakeem, D. Chang, C.G. Wilson, K. Schilling, D. Schnoebelen (2015). hydoscape to soilscape- A remote sensing approach to quantify flow paths and ponding regions in Iowa. *CATENA*. . Status = OTHER; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Parsons, K., E.A. Bettis, C.G. Wilson, A.N. Papanicolaou (2015). Spatial Patterns and Rates of Historic Sediment Accumulation in a Small Midwestern Catchment. *Geomorphology*. . Status = OTHER; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Qina Yan, Toshiki Iwasaki, Andrew J. Stumpf, Gary Parker, Patrick Belmont, and Praveen Kumar (). Hydrogeomorphological understanding of alluvial river valley development in glaciated landscapes. *Earth Surface Processes and Landforms*. . Status = SUBMITTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Quijano, J., and P. Kumar (2015). Numerical Simulations of Hydraulic Redistribution Across Climates: The Role of the Root Hydraulic Conductivities. *Water Resour. Res.*. 51 . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/2014WR016509

Reshmina William, Allison Goodwell, Meredith Richardson, Phong V. V. Le, Praveen Kumar, Ashlynn S. Stillwell (2016). An environmental cost-benefit analysis of alternative green roofing strategies. *Ecological Engineering*. 95 1. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1016/j.ecoleng.2016.06.091

Rhoads, B.L., Lewis, Q., and Andresen, W. (2016). Historical changes in channel network extent and channel planform in an intensively managed landscape: natural versus human-induced effects.. *Geomorphology*. 17. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI:

Schilling, K.E., M.T. Streeter, K.J. Hutchinson, C.G. Wilson, B. Abban, K.M. Wacha, and A.N. Papanicolaou (2015). Evaluating the effects of land cover on streamflow variability in a small Iowa watershed: Toward development of sustainable and resilient landscapes. *American Journal of Environmental Science*. . Status = ACCEPTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Schmadel, N.M., Ward, A.S., Lowry, C.S., and Malzone, J.M. (2016). Hyporheic exchange controlled by dynamic hydrologic boundary conditions. *Geophysical Research Letters*. 43 4408. Status = PUBLISHED; Acknowledgment of Federal Support =

Yes ; Peer Reviewed = Yes ; DOI: 10.1002/2016GL068286

Schmadel, NM, AS Ward, MJ Kurz, JH Fleckenstein, JP Zarnetske, DM Hannah, T Blume, T Datry, M Vieweg, C Schmidt, PH Blaen, MJ Klaar, J Knapp, P Romeijn, T Keller, S Folegot, A Marruedo, S Krause (2016). Spatio-temporally variable controls confound transport process interpretation of stream solute tracers. *Water Resources Research*. 52 3227. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/2015WR018062

Srinivasan V., P. Kumar, and S. Long (2016). Fewer Not More Leaves – Key to Obtaining the Needed Jump in Crop Yield Potential. *Global Change Biology*. . Status = ACCEPTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI:

Thomas, J.T., A.N. Papanicolaou, C.G. Wilson, E.A. Bettis, and M. Elhakeem. (2015). Mechanisms of knickpoint migration in a channelized western Iowa stream.. *Earth Surface Processes and Landforms..* . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes

Wacha, K.M., A.N. Papanicolaou, B.K.B. Abban, C.G. Wilson, J.L. Hatfield, T. Filley, and T. Hou. (). Aggregate Stability Dynamics within Intensely Managed Landscapes: Methods and controls.. *Soil & Tillage Research..* . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Ward, A.S., Schmadel, N.M., Wondzell, S.M., Harman, C., Gooseff, M.N., and Singha, K. (2016). Hydrogeomorphic controls on hyporheic and riparian transport in two headwater mountain streams during base flow recession. *Water Resources Research*. 52 1479. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/2015WR018225

Ward, AS (2016). The evolution and state of interdisciplinary hyporheic research. *WIREs Water*. 83. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/wat2.1120

Wilson, C.G., A.N. Papanicolaou, K.M. Wacha, C.O. Stanier, and A. Jamroensan. (). Differences in Net Ecosystem Exchange for an intensely managed watershed using a lumped, regional model and a mechanistic, hillslope-scale model.. *Global Biogeochemical Cycles..* . Status = OTHER; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Wilson, C.G., K.M. Wacha, A.N. Papanicolaou, H.A. Sander, V.B. Freudenberg, B.K.B. Abban, and C. Zhao. (2016). Assessing sustainability of current management practices in an intensively managed landscape. In Press.. *Journal of Contemporary Water Research & Education..* 148. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI:

Woo, D. K., and P. Kumar (2016). Mean age distribution of inorganic soil-nitrogen. *Water Resour. Res.*. 52 . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/2015WR017799

Yu, M. and Rhoads, B.L. (). Sources of fine sediment in a headwater watershed in the agricultural Midwest: the impact of grazing.. *Geomorphology,*. . Status = OTHER; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI:

Licenses

Other Conference Presentations / Papers

Gonzalez-Pinzon, R, AS Ward , C Hatch , AN Wlostowski , K Singha , MN Gooseff , R Haggerty , JW Harvey , OA Cirpka and JT Brock (2015). *A field comparison of techniques to quantify surface water- groundwater interactions*. American Geophysical Union Fall Meeting. . Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Allison Goodwell and Praveen Kumar (2016). *A network approach to evaluate ecosystem vulnerability*. EGU. Vienna, Austria. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Wilson, C.G. K.M. Wacha, V. Freudenberg, and A.N. Papanicolaou (2016). *Assessing the sustainability of current management practices in an intensively managed landscape.*. 16th Annual Meeting of the American Ecological Engineering Society.. Knoxville, TN.. Status = ACCEPTED; Acknowledgement of Federal Support = Yes

Kunxuan Wang, Praveen Kumar and Debsunder Dutta (2015). *Biomass Estimation for Individual Trees using Waveform LiDAR*. AGU Fall Meeting. San Francisco, California. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

A. Dere, E.A. Bettis III, K. Goff and S. Parcher (2016). *COMPARING THE EFFECTS OF AGRICULTURAL LAND DISTURBANCE ON WEATHERING AND SOIL DEVELOPMENT IN LOESS SOILS OF EASTERN IOWA AND NEBRASKA*. Geological Society of America Annual Meeting. Denver, CO. Status = ACCEPTED; Acknowledgement of Federal Support = Yes

Giannopoulos, C.P., B.K.B. Abban, and A.N. Papanicolaou. (2016). *Characteristic time scales of sediment at the catchment scale: implications to stream ecology.*. 16th Annual Meeting of the American Ecological Engineering Society.. Knoxville, TN.. Status = ACCEPTED; Acknowledgement of Federal Support = Yes

Efi Foufoula-Georgiou, Jonathan A Czuba, Patrick Belmont, Peter R Wilcock, Karen B Gran and Praveen Kumar (2015). *Climate and Humans as Amplifiers of Hydro-Ecologic Change: Science and Policy Implications for Intensively Managed Landscapes*. AGU Fall Meeting. San Francisco, California. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Meredith Richardson and Praveen Kumar (2015). *Critical Zone Services as a Measure for Evaluating the Trade-offs in Intensively Managed Landscapes*. AGU Fall Meeting. San Francisco, California. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Esther Lee, Praveen Kumar, Greg Barron-Gafford, Russell L Scott, Sean Hendryx and Enrique P. Sanchez-Canete (2015). *Determining the Role of Hydraulic Redistribution Regimes in the Critical Zone*. AGU Fall Meeting. San Francisco, California. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Burgin, AJ, TD Loecke, CA Davis, AS Ward, M St. Clair, D Riveros-Iregui, SA Thomas (2013). *Drought-induced enrichment of soil nitrogen leads to record high nitrate loading to agricultural river networks*. American Geophysical Union Fall Meeting. . Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Allison Goodwell and Praveen Kumar (2014). *Ecosystem Network Shifts As Indicators of Climate Response*. AGU, Fall Meet. . Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Debsunder Dutta and Praveen Kumar, (2015). *Effect of Spatial Resolution for Characterizing Soil Properties from Imaging Spectrometer Data*. AGU Fall Meeting. San Francisco, California. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Mostafa Elag, Praveen Kumar, Luigi Marini, Margaret Hedstrom, James D Myers and Beth A Plale (2014). *Emergent Data-Networks from Long-Tail Collections*. AGU, Fall Meet. . Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Wacha, K.M., A.N. Papanicolaou, B.K. Abban, C.G. Wilson, T.R. Filley, T. Hou, and J. Boys (2015). *Enrichment ratio and aggregate stability dynamics in intensely managed landscapes*. American Geophysical Union 2015 Fall Meeting. San Francisco. Status = OTHER; Acknowledgement of Federal Support = Yes

Praveen Kumar, Mostafa Elag, Peishi Jiang and Luigi Marini, (2015). *Envisioning a Future of Computational Geoscience in a Data Rich Semantic World*. AGU Fall Meeting. San Francisco, California. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Praveen Kumar (2016). *Envisioning a Future of Hydroinformatics in a Data Rich Semantic World*. Plenary Lecture, 12th International Conference on Hydroinformatics. Incheon, South Korea. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Abban, B.K.B., A.N. Papanicolaou, D. Dermisis, and C.P. Giannopoulos. (2016). *Evaluating the Effects of Grassed waterways at the Watershed Scale Using a Coupled Hillslope and Instream Model.*. 16th Annual Meeting of the American Ecological Engineering Society.. Knoxville, TN.. Status = ACCEPTED; Acknowledgement of Federal Support = Yes

Phong Le and Praveen Kumar (2014). *Extreme Resolution Ecohydrologic Modeling for Understanding Micro-topographic Controls*. AGU, Fall Meet. . Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Praveen Kumar, Phong V Le, Dong Kook Woo, Debsunder Dutta, Kunxuan Wang, Esther Lee, Allison Eva Goodwell, Qina Yan and Derek Wagner (2015). *Extreme Resolution Modeling of Integrated Critical Zone Processes,*. AGU Fall Meeting. San Francisco, California. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Cullin, JA, AS Ward, DM Cwiertny, LB Barber, DW Kolpin, PM Bradley, SH Keefe, LE Hubbard (2014). *Field predictions of the fate and transport of a photolytic contaminant of emerging concern at Fourmile Creek in Ankeny, Iowa*. Fourth International Conference on Occurrence, Fate, Effects, & Analysis of Emerging Contaminants in the Environment. . Status = OTHER; Acknowledgement of Federal Support = Yes

Derek Wagner, Phong V Le, Praveen Kumar and Dongkook Woo (2015). *High Resolution Modeling of Tile-Drained Controls on Ecohydrologic Dynamics in Intensively Managed Landscapes*. AGU Fall Meeting. San Francisco, California. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Reynolds, KN, TD Loecke, AJ Burgin, CA Davis, D Riveros-Iregui, SA Thomas, AS Ward, M St. Clair (2014). *High-frequency Water Quality Monitoring to Quantify Uncertainties of Sampling Strategies in Agricultural Watersheds*. The Future of Big Data: From Data to Knowledge. Nebraska Innovation Campus Conference Center. Status = OTHER; Acknowledgement of Federal Support = Yes

Hou, T., T. Filley, M. Hughes, Y. Tong, A.N. Papanicolaou, K.M. Wacha, C.G. Wilson, B.K.B. Abban, U. Hester. (2016). *Hill slope and erosional controls on soil organic geochemistry in intensely managed landscapes.*. Goldschmidt 2016.. Yokohama, Japan.. Status = ACCEPTED; Acknowledgement of Federal Support = Yes

Hou, T., T.R. Filley, A.N. Papanicolaou, K.M. Wacha, B.K. Abban, C.G. Wilson, and J. Boys (2015). *Hillslope and erosional controls on soil organic geochemistry in intensely managed landscapes*. American Geophysical Union. San Francisco. Status = OTHER; Acknowledgement of Federal Support = Yes

Qina Yan and Praveen Kumar (2014). *Human Impact Intertwined with Glacial Legacy: Hydro-Geomorphologic Exploration using LiDAR data*. AGU, Fall Meet. . Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Gold, A, D Riveros-Iregui, CA Davis, AS Ward, AJ Burgin, TD Loecke, SA Thomas, MA St. Clair (2015). *Hydrologic and morphologic controls of nitrate concentrations in Iowa, USA*. Climate Change Symposium. University of North Carolina at Chapel Hill. Status = OTHER; Acknowledgement of Federal Support = Yes

Praveen Kumar and Dong Kook Woo (2014). *Impact of Hydrologic Variability on Nutrient Age Distribution in Intensively Managed Landscapes*. AGU, Fall Meet. . Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Dong Kook Woo and Praveen Kumar (2015). *Impact of Hydrologic and Micro-topographic Variabilities on Spatial Distribution of Mean Soil-Nitrogen Age*. AGU Fall Meeting. San Francisco, California. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Muste, M., Cheng, Z., Firoozfar, A.R., Tsai, H-W., Loeser, T. and Xu, H. (2016). *Impacts of Unsteady Flows on Monitoring Stream Flows*. River Flow Conference, International Association for Hydro-environment Engineering and Research (IAHR). St Louis, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Prior, K, AS Ward, CA Davis, AJ Burgin, TD Loecke, DA Riveros-Iregui, SA Thomas, MA St. Clair. (2014). *In-stream Nitrogen Processing and Dilution in an Agricultural Stream Network*. American Geophysical Union Fall Meeting. . Status = OTHER; Acknowledgement of Federal Support = Yes

AS Ward, KE Dalrymple, SN Spak (2015). *In-stream nitrate responses integrate human and climate systems in an intensively managed landscape*. Water Sustainability and Climate Annual Meeting, National Science Foundation. . Status = OTHER; Acknowledgement of Federal Support = Yes

Ward, AS, CA Davis, A Burgin, T Loecke, D Riveros-Iregui, D Schnoebelen, C Just, S Thomas, L Weber, M St. Clair, S Spak, K Dalrymple, Y Li, K Prior (2015). *In-stream nitrate responses integrate human and climate systems in an intensively managed landscape*. American Geophysical Union Fall Meeting. . Status = OTHER; Acknowledgement of Federal Support = Yes

Allison Goodwell and Praveen Kumar (2016). *Information sharing in eco-hydrologic systems: synergy, redundancy, and uniqueness*. Information Theory in Geosciences Workshop. Garmisch, Germany. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Praveen Kumar (2016). *Intensively Managed Landscapes: Anthropocence in Action*. Wolman Lecture, CUAHSI Biennial Meeting. Shepherdstown, WV. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Bainbridge, S, AS Ward (2014). *Inter- and Intra-annual Nitrate Dynamics in Clear Creek During 2012 and 2013*. Summer Undergraduate Research Conference. . Status = OTHER; Acknowledgement of Federal Support = Yes

Filley, T., D. Guo, R. Filley, P. Kumar, and A.N. Papanicolaou. (2016). *Keynote: The legacy of intensively managed agricultural landscapes written in the soil organic carbon of the critical zone*. Goldschmidt 2016.. Yokohama, Japan.. Status = ACCEPTED; Acknowledgement of Federal Support = Yes

N. Blair, A. Ward, J. Moravek, Y. Zeng, D. Cooperberg, A. Bettis, K. Prior,, C. Davis (2015). *Landscape Response to a Storm Event in the Clear Creek, IA watershed*. Goldschmidt Conference. Prague. Status = OTHER; Acknowledgement of Federal Support = Yes

Qina Yan and Praveen Kumar (2015). *Low-relief landscape modeling with human activities*. AGU Fall Meeting. San Francisco, California. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Phong V. V. Le and Praveen Kumar (2015). *Microtopographic control on ecohydrologic dynamics resulting from vegetation acclimation response to elevated atmospheric CO2*. AGU Fall Meeting. San Francisaco, California. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Phong V Le and Praveen Kumar (2015). *Microtopographic hydrologic variability change resulting from vegetation acclimation response to elevated atmospheric CO2*. AGU Fall Meeting. San Francisco, California. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Ward, AS, DM Cwiertny, EP Kolodziej (2014). *Product-to-parent reversion processes: Stream-hyporheic spiraling increases ecosystem exposure and environmental persistence*. American Geophysical Union Fall Meeting. . Status = OTHER; Acknowledgement of Federal Support = Yes

Bettis, E.A., K. Parsons, C.G. Wilson, A.N. Papanicolaou, and D. Grimely. (2016). *Rate, magnitude and impact of legacy sediment accumulation on a headwaters watershed in eastern Iowa.*. Geological Society of America, North-Central Section - 50th Annual Meeting.. Urbana, IL.. Status = ACCEPTED; Acknowledgement of Federal Support = Yes

Ward, AS, JA Cullin, DM Cwiertny, LB Barber, DW Kolpin, PM Bradley, SH Keefe, LE Hubbard (). *Reach-scale predictions of the fate and transport of contaminants of emerging concern at Fourmile Creek in Ankeny, Iowa*. Fourth International Conference on Occurrence, Fate, Effects, & Analysis of Emerging Contaminants in the Environment. . Status = OTHER; Acknowledgement of Federal Support = Yes

J. Lopez, E.A. Bettis III, S. Parcher, K. Goff (2016). *Seasonal Water Table Behavior in an Agricultural Landscape*. Iowa EPSCoR Annual investigators meeting. Ceadr Rapids, Iowa. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

J. Lopez, E.A. Bettis III, S. Parcher, K. Goff (2016). *Seasonal water table behavior in An Agricultural Landscape*. Iowa Undergraduate Research Symposium. Iowa City, Iowa. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Abban, B., A.N. Papanicolaou, C.G. Wilson, O. Abaci, K. Wacha, and D.E. Schnoebelen (2015). *Sediment Fingerprinting in Intensively Managed Landscapes: Application of an Enhanced Bayesian Un-mixing Framework that accounts for Spatiotemporal Heterogeneity to Study Intra-Seasonal Trends in Source Contributions*. Fall American Geophysical Union. . Status = OTHER; Acknowledgement of Federal Support = Yes

Darren Drewry, Praveen Kumar and Steve Long (2014). *Simultaneous Improvement in Water Use, Productivity and Albedo Through Crop Structural Modification*. AGU, Fall Meet. . Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Dongkook Woo, Juan Quijano, Praveen Kumar, Sayo Chaoka and Carl Bernacchi (2014). *Threshold Dynamics in Soil Carbon Storage for Bioenergy Crops*. AGU, Fall Meet. . Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Abban, B.K.B., A.N. Papanicolaou, M.K. Cowles, C.G. Wilson, O. Abaci, and K.M. Wacha. (2016). *Towards a holistic model for simulating sediment dynamics at watershed scales: partitioning of sediment sources and uncertainty quantification.*. European Geophysical Union General Assembly 2016.. Vienna, Austria.. Status = ACCEPTED; Acknowledgement of Federal Support = Yes

Yu, M., Rhoads, B.L. and Stumpf, A. (2016). *Tracing suspended sediment sources in the upper Sangamon River basin using fingerprinting techniques.*. 112th Annual Meeting of the Association of American Geographers,. San Francisco, CA. Status =

ACCEPTED; Acknowledgement of Federal Support = Yes

Yu, M., Rhoads, B.L., Stumpf, A. (2016). *Tracing suspended sedment sources in the upper Sangamon River basin using conservative and non-conservative tracers.*. AGU Fall Meeting.. San Francisco, CA. Status = ACCEPTED; Acknowledgement of Federal Support = Yes

Qina Yan, Iwasaki Toshiki, Praveen Kumar, Gary Parker (2015). *Understanding the Characteristics of River Valley Topography with Extreme Flooding Events*. GSA North-Central Meeting. San Francisco, California. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Freudenberg, V.B., A.N. Papanicolaou, and C.G. Wilson. (2016). *Using a life cycle assessment model to demonstrate the intricate relationship between the quality of soil and the quantities of food and water.*. 16th Annual Meeting of the American Ecological Engineering Society.. Knoxville, TN.. Status = ACCEPTED; Acknowledgement of Federal Support = Yes

Xu, H., Hameed, H., Demir, I., Muste, M. (2016). *Visualization Platform for Collaborative Modeling*. 2016 American Water Resources Association, Summer Specialty Conference on GIS. Sacramento, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

S.K. Parcher, E.A, Bettis III, K..R. Goff, J. Lopez (2016). *Water Table behavior in an Agricultural Landscape*. Annual Iowa EPSCoR investigators meeting. Cedar Rapids, Iowa. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Dalrymple, KE, J Krajewski, AS Ward, SN Spak (2015). *We are what we drink: Examining public perceptions of water quality in the agricultural Midwest*. Water Sustainability and Climate Annual Meeting, National Science Foundation. . Status = OTHER; Acknowledgement of Federal Support = Yes

K. Goff and E.A. Bettis III (2016). *Weathering Profiles of Quaternary Sedimentary materials of East-Central Iowa*. North-Central Section geological Society of America. Champaign, IL. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Other Products

Audio or Video Products.

A video that portrays an artistic rendition of Critical Zone Observatory for Intensively Managed Landscapes has been developed as an E&O tool. See https://www.youtube.com/watch?v=FkR495FJNGo&feature=youtu.be

Audio or Video Products.

Investigator and student interviews: http://criticalzone.org/iml/news/

Audio or Video Products.

video production highlighting Teacher workshop http://criticalzone.org/iml/news/story/critical-zone-observatory-environmental-science-workshop/

Other Publications

Kelleher, S. (2016). *Conservation Farming Shown to Protect Carbon in Soil. EOS: Earth & Space Science News.*. https://eos.org/research-spotlights/conservation-farming-shown-to-protect-carbon-in-soil.. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Obrien, M. (2016). *Critical Zone Observatories help U.S. plan for the future. NSF Science Nation.*. http://www.nsf.gov/news/special_reports/science_nation/criticalzones.jsp. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Unknown (2016). *Did Dust Bowl's ravages end in the 1940s? New study says no. NSF Science 360 News.*. http://news.science360.gov/obj/story/763a5273-5f7a-4732-b655-92b29e7f0c2d/dust-bowls-ravages-end-1940s-new-study.. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

David A. Grimley, Alison M. Anders, and Andrew J. Stumpf with contributions by Ryan Arnott, Sebastien Huot, Xiaodong Miao, Christopher J. Stohr, Nicholas P. Schneider, and Jia J. Wang (2016). *Quaternary Geology of the Upper Sangamon River Basin: glacial, postglacial and post-settlement history in: 1967-2016 - Celebrating 50 Years of Geoscience in the Mid-*

Continent ISGS Guidebook 43. Background information, data, and stop locations for a field trip run at the NC-GSA meeting in Urbana, IL in April 2016. Peer-reviewed within ISGS.. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Cheryl Dybas, NSF; Liz Ahlberg Touchstone, University of Ilinois (2016). *What's good for crops not always good for the environment*. http://www.nsf.gov/news/news_summ.jsp?cntn_id=139263&WT.mc_id=USNSF_51&WT.mc_ev=click. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Patents

Technologies or Techniques

"Dhara", an integrated modeling platform using hybrid computing (CPU+GPU) has been developed and made available as open source modeling platform. See https://hydrocomplexity.github.io/Dhara/.

Thesis/Dissertations

Debsunder Dutta. *Data Driven Estimation Of Soil And Vegetation Attributes Using Airborne Remote Sensing*. (2016). University of Illinois. Acknowledgement of Federal Support = Yes

Wacha, K.M.. *From Soilscapes to Landscapes: A Landscape Oriented Approach to Stimulate Soil Organic Carbon Dynamics in Intensely Managed Landscapes.*. (2016). University of Iowa,. Acknowledgement of Federal Support = Yes

Phong V. V. Le. *Predicting Malaria Dynamics Under Climate Change*. (2016). University of Illinois. Acknowledgement of Federal Support = Yes

Haowen Xu. *Prototyping Hydroinfromatics-based Systems for Supporting Decision Making*. (2015). The University of Iowa. Acknowledgement of Federal Support = No

Websites

"Dhara" Modeling Framework
https://hydrocomplexity.github.io/Dhara/

An open source modeling framework for Critical Zone science

Geosemantic Framework for Model-Data Integration
http://hcgs.ncsa.illinois.edu/

EarthCube supported project for developing GeoSemantic Framework for model-data integration leverages and builds on IMLCZO data system.

IMLCZO Activities Report Tool
http://s-iihr32.iihr.uiowa.edu/pro/artool/

Website for internal tracking of activities and outcomes across different teams based on work breakdown structure.

IMLCZO Data
http://data.imlczo.org/geodashboard/

A GUI based interface to IMLCZO data

IMLCZO Data System
http://data.imlczo.org/clowder/

A collaborative environment for IMLCZO data

Participants/Organizations

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked

Kumar, Praveen	PD/PI	1
Anders, Alison	Co PD/PI	3
Bettis III, Elmer	Co PD/PI	2
Filley, Timothy	Co PD/PI	1
Papanicolaou, Thanos	Co PD/PI	1
Belmont, Patrick	Co-Investigator	1
Blair, Neal	Co-Investigator	1
Burkholder, Barbara	Co-Investigator	0
Chaubey, Inderjeet	Co-Investigator	1
Foufoula-Georgiou, Efi	Co-Investigator	1
Garcia, Marcelo	Co-Investigator	0
Jacobson, Andrew	Co-Investigator	1
Krajewski, Witold	Co-Investigator	0
Laura, Keefer	Co-Investigator	2
Lin, Henry	Co-Investigator	1
Marini, Luigi	Co-Investigator	2
Packman, Aaron	Co-Investigator	1
Parker, Gary	Co-Investigator	1
Peschel, Joshua	Co-Investigator	0
Phillips, Andrew	Co-Investigator	1
Schnoebelen, Douglas	Co-Investigator	2
Ward, Adam	Co-Investigator	1
Weber, Larry	Co-Investigator	0
Dere, Ashley	Faculty	1
Flynn, Leslie	Faculty	1

Freudenberg, Violet	Faculty	1
Grimley, David	Faculty	2
Kumar, Charu	Faculty	0
Leithold, Elana	Faculty	1
Lewis, Quinn	Faculty	1
Michalski, Greg	Faculty	1
Rhoads, Bruce	Faculty	1
Elag, Mostafa	Postdoctoral (scholar, fellow or other postdoctoral position)	8
Hernandez, Oscar	Postdoctoral (scholar, fellow or other postdoctoral position)	2
Le, Phong	Postdoctoral (scholar, fellow or other postdoctoral position)	12
Li, Yuwei	Postdoctoral (scholar, fellow or other postdoctoral position)	6
Lu, Nanxi	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Quijano, Juan	Postdoctoral (scholar, fellow or other postdoctoral position)	0
Schmadel, Noah	Postdoctoral (scholar, fellow or other postdoctoral position)	2
Tsakiris, Achilles	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Yu, Mingjing	Postdoctoral (scholar, fellow or other postdoctoral position)	6
Hochstedler, Mary	Other Professional	1
Keefer, Donald	Other Professional	1
Larson, Timothy	Other Professional	1
Lin, Yu-feng	Other Professional	1
Stumpf, Andrew	Other Professional	1
Angelo, Brock	Technician	4
Stoeffler, Thomas	Technician	1
Muste, Marian	Staff Scientist (doctoral level)	1
Wilson, Christopher	Staff Scientist (doctoral level)	2

Abban, Benjamin	Graduate Student (research assistant)	12
Amir, Abbas	Graduate Student (research assistant)	4
Arnott, Ryan	Graduate Student (research assistant)	11
Balson, Tyler	Graduate Student (research assistant)	1
Berry, Timothy	Graduate Student (research assistant)	11
Boys, John	Graduate Student (research assistant)	11
Burns, Adam	Graduate Student (research assistant)	11
Cain, Molly	Graduate Student (research assistant)	3
Childress, Laurel	Graduate Student (research assistant)	4
Culotti, Alessandro	Graduate Student (research assistant)	11
Dutta, Debsunder	Graduate Student (research assistant)	6
Ettema, Will	Graduate Student (research assistant)	11
Farber, Brianna	Graduate Student (research assistant)	11
Fillyaw, L.	Graduate Student (research assistant)	2
Giannopoulos, Christos	Graduate Student (research assistant)	12
Goff, Kathleen	Graduate Student (research assistant)	10
Goodwell, Allison	Graduate Student (research assistant)	12
Hameed, Haider	Graduate Student (research assistant)	2
Handa, Saki	Graduate Student (research assistant)	11
Hester, Ulyssa	Graduate Student (research assistant)	11
Jiang, Peishi	Graduate Student (research assistant)	12
Lai, Jingtao	Graduate Student (research assistant)	8
Lee, Esther	Graduate Student (research assistant)	12
Leonard, Michael	Graduate Student (research assistant)	11
Li, Zheng	Graduate Student (research assistant)	11

Maciel, Fernanda	Graduate Student (research assistant)	11
Merook, Adam	Graduate Student (research assistant)	1
Muhammad, Umar	Graduate Student (research assistant)	1
Parsons, Kelli	Graduate Student (research assistant)	11
Prior, Kara	Graduate Student (research assistant)	1
Richardson, Meredith	Graduate Student (research assistant)	12
Roots, Paul	Graduate Student (research assistant)	11
Schmalle, Kayla	Graduate Student (research assistant)	11
Stevenson, Leigh	Graduate Student (research assistant)	2
Tokuhisa, Rai	Graduate Student (research assistant)	11
Wacha, Kenneth	Graduate Student (research assistant)	12
Wagner, Derek	Graduate Student (research assistant)	5
Wang, Kunxuan	Graduate Student (research assistant)	12
Woo, Dongkook	Graduate Student (research assistant)	12
Xu, Haowen	Graduate Student (research assistant)	1
Yan, Qina	Graduate Student (research assistant)	12
Abuyazid, Nabiel	Undergraduate Student	2
Ainsley, Benjamin	Undergraduate Student	4
Brown, Scott	Undergraduate Student	1
Coker-Gunnick, Sophia	Undergraduate Student	4
Cooperberg, Danna	Undergraduate Student	4
Daugherty, Michael	Undergraduate Student	1
DeBartolo, Gia	Undergraduate Student	4
Dunn, Jesse	Undergraduate Student	2
Gamblin, David	Undergraduate Student	4

Hughes, Madison	Undergraduate Student	4
Kazmierczak, Breanna	Undergraduate Student	6
Kirton, Erin	Undergraduate Student	4
Lopez, Jazmin	Undergraduate Student	2
Magnuson, Angela	Undergraduate Student	2
Mettenberg, Daniel	Undergraduate Student	4
Moravek, Jessie	Undergraduate Student	2
Parcher, Sarah	Undergraduate Student	2
Patterson, Kaity	Undergraduate Student	1
Quan, Wei	Undergraduate Student	4
Sevilla, Tiffany	Undergraduate Student	4
Shen, Bomo	Undergraduate Student	4
Wang, Jia Jia	Undergraduate Student	1
Williams, Joshua	Undergraduate Student	2
WInters, Jake	Undergraduate Student	4
Yu, Zhihan	Undergraduate Student	1
Zhou, Nina	Undergraduate Student	3
Gasparini, Nicole	Consultant	0
Bauer, Erin	Other	4
Fetty, Nicholas	Other	2
Hodson, Tim	Other	6
Seek, Lara	Other	2
Storsved, Brynne	Other	6
Zeng, Yue	Other	1

Full details of individuals who have worked on the project:

Praveen Kumar
Email: kumar1@uiuc.edu
Most Senior Project Role: PD/PI
Nearest Person Month Worked: 1

Contribution to the Project: Project Director

Funding Support: NSF

International Collaboration: Yes, China
International Travel: Yes, China - 0 years, 0 months, 10 days

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Alison M Anders
Email: amanders@uiuc.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 3

Contribution to the Project: Assisted with collection of samples. Interpretation and analysis of data. GIS analysis of PSA locations. Manuscript preparation. Guidance and help in developing numerical model components for LandLab

Funding Support: IML-CZO/ UIUC/summer support from IML-CZO

International Collaboration: No
International Travel: No

Elmer Bettis III
Email: art-bettis@uiowa.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 2

Contribution to the Project: lead investigator project design core collection- Primary investigator and project supervisor in CC. Data collection and analysis -- CC Manuscript Preparation

Funding Support: NFS IML-CZO/NSF, EPSCoR

International Collaboration: No
International Travel: No

Timothy Filley
Email: filley@purdue.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 1

Contribution to the Project: Co-PI

Funding Support: NSF

International Collaboration: Yes, China
International Travel: Yes, China - 0 years, 0 months, 10 days

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Thanos Papanicolaou
Email: tpapanic@utk.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 1

Contribution to the Project: Co-director of IML-CZO; Lead Co-Themes B&D

Funding Support: n/a

International Collaboration: No
International Travel: No

Patrick Belmont
Email: patrick.belmont@usu.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

Contribution to the Project: geomorphology, sediment transport, fluvial systems

Funding Support: Utah State University

International Collaboration: No
International Travel: No

Neal Blair
Email: n-blair@northwestern.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

Contribution to the Project: Co-Lead Theme C, carbo-cycling processes, biogeochemistry of organic carbon

Funding Support: Northwestern University

International Collaboration: No
International Travel: No

Barbara Burkholder
Email: bkb0811@umn.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 0

Contribution to the Project: E&O

Funding Support: None

International Collaboration: No
International Travel: No

Inderjeet Chaubey
Email: ichaubey@purdue.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

Contribution to the Project: ecohydrology, watershed modeling, soil erosion

Funding Support: Purdue University

International Collaboration: No
International Travel: No

Efi Foufoula-Georgiou
Email: efi@umn.edu

Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

Contribution to the Project: geomorphic transport, scaling in river basins

Funding Support: University of Minnesota

International Collaboration: No
International Travel: No

Marcelo H Garcia
Email: mhgarcia@illinois.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 0

Contribution to the Project: river mechanics and environmental hydraulics

Funding Support: University of Illinois

International Collaboration: No
International Travel: No

Andrew D Jacobson
Email: adj@earth.northwestern.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

Contribution to the Project: aqueous and isotopic geochemistry

Funding Support: Northwestern University

International Collaboration: No
International Travel: No

Witold Krajewski
Email: witold-krajewski@uiowa.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 0

Contribution to the Project: hydrometeorology, radar rainfall estimation

Funding Support: University of Iowa

International Collaboration: No
International Travel: No

Keefer Laura
Email: lkeefer@illinois.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 2

Contribution to the Project: Upper Sangamon River Basin Site & Facilities Co-coordinator, Fluvial Geomorphology, Hydraulics/Hydrology

Funding Support: NSF (IMLCZO) & University of Illinois, Illinois State Water Survey

International Collaboration: No
International Travel: No

Henry Lin
Email: henrylin@psu.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

Contribution to the Project: Co-Lead Theme E, Cross-site studies, hydropedology, sub-surface flow

Funding Support: Pennsylvania State University

International Collaboration: Yes, China
International Travel: Yes, China - 0 years, 0 months, 12 days

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Luigi Marini
Email: lmarini@illinois.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 2

Contribution to the Project: Co-Lead Cyber, large-scale data management system, cyber collaborator, CZOData Information Management Committee

Funding Support: NSF (IMLCZ) & University of Illinois/NCSA

International Collaboration: No
International Travel: No

Aaron Packman
Email: a-packman@northwestern.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

Contribution to the Project: environmental transport processes, stream ecology

Funding Support: Northwestern University

International Collaboration: No
International Travel: No

Gary Parker
Email: parkerg@illinois.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

Contribution to the Project: morphodynamics and fluvial processes

Funding Support: University of Illinois

International Collaboration: No
International Travel: No

Joshua Peschel
Email: peschel@illinois.edu

Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 0

Contribution to the Project: USRB Site & Facilities Co-coordinator, unmanned aerial system, robotics

Funding Support: University of Illinois/CEE

International Collaboration: No
International Travel: No

Andrew Phillips
Email: phillips@isgs.illinois.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

Contribution to the Project: quaternary landscape evolution

Funding Support: Illinois State Geological Survey

International Collaboration: No
International Travel: No

Douglas Schnoebelen
Email: douglas-schnoebelen@uiowa.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 2

Contribution to the Project: E&O Co-Coordinator, nutrient and sediment transport, CZO Network Web manager group

Funding Support: NSF (IMLCZO) & University of Iowa

International Collaboration: No
International Travel: No

Adam Ward
Email: adamward@indiana.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

Contribution to the Project: Co-Lead Theme C, solute movement, biogeochemical transport across steam-landscape-aquifer connectivity

Funding Support: NSF (IMLCZO) & Indiana University

International Collaboration: No
International Travel: No

Larry Weber
Email: larry-weber@uiowa.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 0

Contribution to the Project: environmetal hydraulics, tile drainage.

Funding Support: University of Iowa

International Collaboration: No
International Travel: No

Ashley Dere
Email: adeere@unoomaha.edu
Most Senior Project Role: Faculty
Nearest Person Month Worked: 1

Contribution to the Project: collaborating on weathering zone study across climatic gradient from Nebraska to Iowa

Funding Support: Univeresity of Nebraska

International Collaboration: No
International Travel: No

Leslie Flynn
Email: leslie-flynn@uiowa.edu
Most Senior Project Role: Faculty
Nearest Person Month Worked: 1

Contribution to the Project: taught methods class focusing on CZO science in U of Iowa Department of Education
Organized teacher workshop

Funding Support: NSF IML-CZO

International Collaboration: No
International Travel: No

Violet Freudenberg
Email: vfreuden@vols.utk.edu
Most Senior Project Role: Faculty
Nearest Person Month Worked: 1

Contribution to the Project: Life Cycle Assessment for Clear Creek

Funding Support: funded from other sources

International Collaboration: No
International Travel: No

David Grimley
Email: dgrimley@illinois.edu
Most Senior Project Role: Faculty
Nearest Person Month Worked: 2

Contribution to the Project: Supervised collection of cores. Trained students in measurement of fly ash. Analysis and interpretation of PSA data. First author of manuscript.

Funding Support: ISGS

International Collaboration: No
International Travel: No

Charu Kumar
Email: cgkumar@illinois.edu

Most Senior Project Role: Faculty
Nearest Person Month Worked: 0

Contribution to the Project: metagenomics

Funding Support: University of Illinois

International Collaboration: No
International Travel: No

Elana Leithold
Email: leithold@ncsu.edu
Most Senior Project Role: Faculty
Nearest Person Month Worked: 1

Contribution to the Project: Prof. Leithold oversaw the Lake Decatur core analyses at LacCore and performed grain size measurements on the same

Funding Support: None for salary. This project provided support for the analyses.

International Collaboration: No
International Travel: No

Quinn Lewis
Email: qlewis2@illinois.edu
Most Senior Project Role: Faculty
Nearest Person Month Worked: 1

Contribution to the Project: Assisted with field work

Funding Support: funded from other sources

International Collaboration: No
International Travel: No

Greg Michalski
Email: gmichalski@purdue.edu
Most Senior Project Role: Faculty
Nearest Person Month Worked: 1

Contribution to the Project: geochemistry

Funding Support: Purdue University

International Collaboration: No
International Travel: No

Bruce Rhoads
Email: brhoads@illinois.edu
Most Senior Project Role: Faculty
Nearest Person Month Worked: 1

Contribution to the Project: Co-lead Theme D

Funding Support: n/a

International Collaboration: No
International Travel: No

Mostafa Elag
Email: mostafaelag@gmail.com
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 8

Contribution to the Project: Development of semantic technologies and integration of IMLCZO data.

Funding Support: NSF (SEAD project)

International Collaboration: No
International Travel: No

Oscar Hernandez
Email: oscar-hernandezmurcia@uiowa.edu
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 2

Contribution to the Project: E&O, modeling

Funding Support: INRC and LACMRERS funds/NSf (IML-CZO)

International Collaboration: No
International Travel: No

Phong Vu Viet Le
Email: phongle1@illinois.edu
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 12

Contribution to the Project: Development of "Dhara" model for Critical Zone processes.

Funding Support: NSF (WSC REACH project)

International Collaboration: No
International Travel: Yes, China - 0 years, 0 months, 10 days

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Yuwei Li
Email: yuwei.lee03@gmail.com
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 6

Contribution to the Project: Agro-IBIS modeling

Funding Support: IU

International Collaboration: No
International Travel: No

Nanxi Lu
Email: nanxi.lu@northwestern.edu
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 1

Contribution to the Project: Biogeography of environmental microbiome at the IML-CZO

Funding Support: Other

International Collaboration: No
International Travel: No

Juan C Quijano
Email: quijano2@illinois.edu
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 0

Contribution to the Project: ecohydrologic & nutrient dynamics modeling

Funding Support: University of Illinois

International Collaboration: No
International Travel: No

Noah Schmadel
Email: noahschm@indiana.edu
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 2

Contribution to the Project: solute tracer timeseries analysis, COMSOL modeling

Funding Support: IU

International Collaboration: No
International Travel: No

Achilles Tsakiris
Email: atsakiri@utk.edu
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 1

Contribution to the Project: Assisted with field work

Funding Support: finded from other projects

International Collaboration: No
International Travel: No

Mingjing Yu
Email: myu18@illinois.edu
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 6

Contribution to the Project: Sediment sourcing in USRB

Funding Support: partially funded from this project

International Collaboration: No
International Travel: No

Mary E Hochstedler
Email: beth-hochstedler@uiowa.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: organized and coordinated State Hygienic laboratory with teacher workshop

Funding Support: State of Iowa

International Collaboration: No
International Travel: No

Donald Keefer
Email: dkeefer@illinois.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: glacial deposit mapping, shallow groundwater flow

Funding Support: ILLINOIS STATE GEOLOGICAL SURVEY

International Collaboration: No
International Travel: No

Timothy Larson
Email: thlarson@illinois.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: geophysics

Funding Support: Illinois State Geological Survey

International Collaboration: No
International Travel: No

Yu-feng Lin
Email: yflin@illinois.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: geograhic information systems

Funding Support: Illinois State Geological Survey

International Collaboration: Yes, China
International Travel: Yes, China - 0 years, 0 months, 10 days

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Andrew Stumpf
Email: astumpf@illinois.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: stratigraphy -USRB core analysis USRB

Funding Support: State of Illinois

International Collaboration: No
International Travel: No

Brock Angelo
Email: jba@illinois.edu
Most Senior Project Role: Technician
Nearest Person Month Worked: 4

Contribution to the Project: large-scale data management system, cyber collaborator

Funding Support: NSF (IMLCZO) & University of Illinois/NCSA

International Collaboration: No
International Travel: No

Thomas Stoeffler
Email: thomas-stoeffler@uiowa.edu
Most Senior Project Role: Technician
Nearest Person Month Worked: 1

Contribution to the Project: sensor installation

Funding Support: NSF-IML-CZO

International Collaboration: No
International Travel: No

Marian Muste
Email: marian-muste@uiowa.edu
Most Senior Project Role: Staff Scientist (doctoral level)
Nearest Person Month Worked: 1

Contribution to the Project: Design of the Annual Report Tool and overseeing workflow developments for the IML-CZO geo-portal

Funding Support: NSF (IMLCZ) & University of Iowa

International Collaboration: No
International Travel: No

Christopher Wilson
Email: christopher-wilson@uiowa.edu
Most Senior Project Role: Staff Scientist (doctoral level)
Nearest Person Month Worked: 2

Contribution to the Project: site manager/ data manager Clear Creek watershed participates in Themes A, B, D

Funding Support: Partial support from CZO project

International Collaboration: No
International Travel: No

Benjamin Abban
Email: babban@vols.utk.edu

Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 12

Contribution to the Project: Enrichment ratio experiments and sediment sourcing

Funding Support: partial funded from this project

International Collaboration: No
International Travel: No

Abbas Ali Amir
Email: abbasali-amir@uiowa.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 4

Contribution to the Project: Was involved in an exploration task for figuring out a web-based project management tool

Funding Support: NSF (IMLCZO) & University of Iowa/Other

International Collaboration: No
International Travel: No

Ryan Arnott
Email: arnott2@illinois.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 11

Contribution to the Project: Spatial and Temporal Variability in Floodplain Sedimentation during Individual Hydrologic Events on a Lowland, Meandering River: Allerton Park, Monticello, Illinois

Funding Support: University of Illinois at Urbana-Champaign/NSF(IML-CZO)

International Collaboration: No
International Travel: No

Tyler Balson
Email: tbalson@indiana.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 1

Contribution to the Project: Agro-IBIS modeling

Funding Support: IU

International Collaboration: No
International Travel: No

Timothy Berry
Email: berry10@purdue.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 11

Contribution to the Project: 13C content of lignin phenols in IML

Funding Support: EPA/NSf (IML-CZO)

International Collaboration: No
International Travel: No

John Boys
Email: jboys@utk.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 11

Contribution to the Project: How does management affect the various pools of SOM? What are the key mechanisms affecting changes in SOM storage potential in IMLs? What are the effects of tillage, pH, and N-fertilizer applications on aggregates, SOM decay and respiration rates?

Funding Support: University of Tennessee, Knoxville/NSF(IML-CZO)

International Collaboration: No
International Travel: No

Adam Burns
Email: burns7@illinois.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 11

Contribution to the Project: A Mobile High-Resolution Phenotyping Robot

Funding Support: Gates Foundation; Peschel

International Collaboration: No
International Travel: No

Molly Cain
Email: cainmr@umail.iu.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 3

Contribution to the Project: modeling of agricultural floodplains

Funding Support: CZO

International Collaboration: No
International Travel: No

Laurel Childress
Email: lbchildr@u.northwestern.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 4

Contribution to the Project: Provided assistance with isotope analyses and supervision of undergraduates

Funding Support: This project and NSF GeoPrisms project 1144483

International Collaboration: No
International Travel: No

Alessandro Culotti
Email: aculotti@u.northwestern.edu

Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 11

Contribution to the Project: How does IML land use and water drainage influence the diversity and composition of microbial communities

Funding Support: Water Research Foundation

International Collaboration: No
International Travel: No

Debsunder Dutta
Email: debsunderdutta@gmail.com
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 6

Contribution to the Project: Development of a novel approach for use of hyperspectral, lidar and other remote sensing data for Critical Zone studies

Funding Support: NASA Fellowship

International Collaboration: No
International Travel: No

Will Ettema
Email: william-ettema@uiowa.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 11

Contribution to the Project: What role does intensive management of the landscape by humans plays in connectivity of water and sediment fluxes and corresponding budgets? Which controlling variables govern watershed response in terms of runoff and sediment fluxes? What are the feedback mechanisms between hydrological processes and the landscape, and how do these affect runoff and sediment distribution and fluxes on the landscape?

Funding Support: University of Iowa/NSF(IML-CZO)

International Collaboration: No
International Travel: No

Brianna Farber
Email: bdfarber13@gmail.com
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 11

Contribution to the Project: E &O, Science/Farming

Funding Support: University of S. Carolina/NSF (IML-CZO)

International Collaboration: No
International Travel: No

L. Roy Fillyaw
Email: lfillyaw@indiana.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 2

Contribution to the Project: storm data analysis

Funding Support: IU

International Collaboration: No
International Travel: No

Christos Giannopoulos
Email: cgiannop@vols.utk.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 12

Contribution to the Project: Enrichment Ratio experiments and travel times

Funding Support: Partial funding from this project

International Collaboration: No
International Travel: No

Kathleen Goff
Email: kathleen-goff@uiowa.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 10

Contribution to the Project: assisted with well installation data collection data analysis data collection data analysis literature research

Funding Support: NSF-IML-CZO NSF- EPSCoR

International Collaboration: No
International Travel: No

Allison Eva Goodwell
Email: goodwel2@illinois.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 12

Contribution to the Project: Development of information theory approach to understanding process network dynamics.

Funding Support: NASA Fellowhip

International Collaboration: No
International Travel: Yes, China - 0 years, 0 months, 10 days

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Haider Hameed
Email: haider-hameed@uiowa.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 2

Contribution to the Project: Designer and developer of the Annual Report Tool for IML-CZO

Funding Support: IML_CZO

International Collaboration: No
International Travel: No

Saki Handa
Email: shanda3@illinois.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 11

Contribution to the Project: Human-Machine Interaction for Unmanned Surface Systems

Funding Support: Gates Foundation; Peschel

International Collaboration: No
International Travel: No

Ulyssa Hester
Email: uhester@purdue.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 11

Contribution to the Project: stabilization of plant C and N in microbial Biomass and mineral surfaces

Funding Support: Purdue Diversity Scholarship/NSF (IML-CZO)

International Collaboration: No
International Travel: Yes, China - 0 years, 0 months, 10 days

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Peishi Jiang
Email: pjiang6@illinois.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 12

Contribution to the Project: Use of IMLCZO data for semantic technology based model-data integration.

Funding Support: NSF (Geosemantics project)

International Collaboration: No
International Travel: No

Jingtao Lai
Email: jlai11@illinois.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 8

Contribution to the Project: model development and testing

Funding Support: IML-CZO

International Collaboration: No
International Travel: No

Esther Lee
Email: elee98@illinois.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 12

Contribution to the Project: Development of MLCan model for application in a semi-arid region; supported collaboration with Catalina-Jamez CZO.

Funding Support: NSF

International Collaboration: No
International Travel: No

Michael Leonard
Email: mileonar@umail.iu.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 11

Contribution to the Project: Groundwater-surface water interaction

Funding Support: Other

International Collaboration: No
International Travel: No

Zheng Li
Email: zhengli6@illinois.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 11

Contribution to the Project: Nonisothermal Vapor Diffusivity in Soils

Funding Support: ORD; Peschel

International Collaboration: No
International Travel: No

Fernanda Maciel
Email: maciely2@illinois.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 11

Contribution to the Project: Spatially Distributed Bioaccumulation Risk Analysis: A GIS-Based Tool and a Case Study of Polychlorinated Biphenyls in the Great Lakes

Funding Support: Fulbright; Peschel; NGRREC/NSF(IML-CZO)

International Collaboration: No
International Travel: No

Adam Merook
Email: amerook@vols.utk.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 1

Contribution to the Project: assisted with field work

Funding Support: Supported from other projects

International Collaboration: No
International Travel: No

Umar Muhammad
Email: umar83@illinois.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 1

Contribution to the Project: assisted with GIS and field work

Funding Support: funded from other sources

International Collaboration: No
International Travel: No

Kelli Parsons
Email: kelli-parsons@uiowa.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 11

Contribution to the Project: how has agricultural aland management affected sediment dynamics in a headwater basin

Funding Support: University of Iowa/NSF(IML-CZO)

International Collaboration: No
International Travel: No

Kara Prior
Email: kprior@umail.iu.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 1

Contribution to the Project: field data collection and analysis

Funding Support: CZO, IU startup

International Collaboration: No
International Travel: No

Meredith Richardson
Email: mlricha2@illinois.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 12

Contribution to the Project: Development of Critical Zone Services for Intensively managed Landscapes

Funding Support: NSF (IMLCZO)

International Collaboration: No
International Travel: No

Paul Roots
Email: pkroots@gmail.com
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 11

Contribution to the Project: stream sediment analysis

Funding Support: NSF (IML-CZO)

International Collaboration: No
International Travel: No

Kayla Schmalle
Email: kayla-schmalle@uiowa.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 11

Contribution to the Project: How does the late glacial history of large valleys in glaciated regions affect their response to glacial/interglacial climate transitions

Funding Support: NSF (EPSCoR), NSF (IML-CZO)

International Collaboration: No
International Travel: No

Leigh Stevenson
Email: leesteve@umail.iu.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 2

Contribution to the Project: data analysis for storm events

Funding Support: IU

International Collaboration: No
International Travel: No

Rai Tokuhisa
Email: rai-tokuhisa@uiowa.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 11

Contribution to the Project: Urban Stream/biocells

Funding Support: University of Iowa/NSF (IML-CZO)

International Collaboration: No
International Travel: No

Kenneth Wacha
Email: Ken.Wacha@ARS.USDA.GOV
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 12

Contribution to the Project: Enrichment ratio experiments; aggregate stability

Funding Support: Funded from this project

International Collaboration: No
International Travel: No

Derek Wagner
Email: dcwagner5@hotmail.com

Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 5

Contribution to the Project: Development of model for flow through tiles; Installation and management of field facilities.

Funding Support: NSF (IMLCZO)

International Collaboration: No
International Travel: No

Kunxuan S. Wang
Email: kswang3@illinois.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 12

Contribution to the Project: Study of vegetation characteristics using waveform lidar data.

Funding Support: NSF (BrownDog project)

International Collaboration: No
International Travel: Yes, China - 0 years, 0 months, 10 days

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Dongkook Woo
Email: dwoo5@illinois.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 12

Contribution to the Project: Development of a model to identify the age of nutrients in agricultural land.

Funding Support: NSF (IMLCZO & BrownDog projects)

International Collaboration: No
International Travel: Yes, China - 0 years, 0 months, 10 days

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Haowen Xu
Email: haowen-xu@uiowa.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 1

Contribution to the Project: Workflows and tools for the IML-CZO Clear Creek

Funding Support: USACE's Institute for Water Resources

International Collaboration: No
International Travel: No

Qina Yan
Email: qinayan2@illinois.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 12

Contribution to the Project: Characterization of alluvial valleys in IMLCZO and modeling of landscape evolution to understand carbon transport due to human impact.

Funding Support: NSF (IMLCZO and EarthCube projects)

International Collaboration: No
International Travel: No

Nabiel Abuyazid
Email: abuyazi2@illinois.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 2

Contribution to the Project: Developed algorithms for the use of Lidar data in modeling.

Funding Support: Self funded

International Collaboration: No
International Travel: No

Benjamin Ainsley
Email: BenjaminAinsworth2019@u.northwestern.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 4

Contribution to the Project: stream sediment analysis

Funding Support: Northwestern

International Collaboration: No
International Travel: No

Scott M Brown
Email: ScottBrown2017@u.northwestern.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 1

Contribution to the Project: Embedded journalism student documenting the contributions of undergraduates to the CZO project.

Funding Support: none

International Collaboration: No
International Travel: No

Sophia Coker-Gunnick
Email: sophia-cokergunnick@uiowa.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 4

Contribution to the Project: undergrad research green storm water infrastructure

Funding Support: Other

International Collaboration: No
International Travel: No

Danna Cooperberg
Email: DannaCooperberg2016@u.northwestern.edu

Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 4

Contribution to the Project: stream sediment analysis

Funding Support: Other

International Collaboration: No
International Travel: No

Michael Cronin Daugherty
Email: MichaelDaugherty2018@u.northwestern.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 1

Contribution to the Project: Biomarker analysis of Lake Decatur sediments

Funding Support: None for salary. This project provided support for the analyses.

International Collaboration: No
International Travel: No

Gia DeBartolo
Email: giamarie-debartolo@uiowa.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 4

Contribution to the Project: undergrad research green storm water infrastructure

Funding Support: Other

International Collaboration: No
International Travel: No

Jesse Dunn
Email: jesse-dunn@uiowa.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 2

Contribution to the Project: undergrad research shallow groundwater

Funding Support: other

International Collaboration: No
International Travel: No

David Gamblin
Email: gamblind@purdue.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 4

Contribution to the Project: Other

Funding Support: Other

International Collaboration: No
International Travel: No

Madison Hughes
Email: hughes80@purdue.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 4

Contribution to the Project: Undergrad research: Isoscapes in CCW baseline

Funding Support: Other

International Collaboration: No
International Travel: No

Breanna Marie Kazmierczak
Email: BreannaKazmierczak2016@u.northwestern.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 6

Contribution to the Project: Sample processing, data management, training

Funding Support: This project

International Collaboration: No
International Travel: No

Erin Kirton
Email: ErinKirton2015@u.northwestern.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 4

Contribution to the Project: stream sediment analysis

Funding Support: Northwestern URG

International Collaboration: No
International Travel: No

Jazmin Lopez
Email: jazmin-lopez@uioowa.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 2

Contribution to the Project: assisted with well installation data collection data analysis

Funding Support: NSF-EPSCoR

International Collaboration: No
International Travel: No

Angela Magnuson
Email: amagnus2@illinois.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 2

Contribution to the Project: Expanded the work of Qina Yan on hydrogeomorphologic characterization of river valleys to include other CZOs.

Funding Support: NSF (IMLCZO)

International Collaboration: No
International Travel: No

Daniel Mettenberg
Email: daniel-mettenberg@uiowa.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 4

Contribution to the Project: undergrad research soil sediment dynamics

Funding Support: U of Iowa

International Collaboration: No
International Travel: No

Jessie Moravek
Email: jessiemoravek@gmail.com
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 2

Contribution to the Project: stream sediment analysis

Funding Support: Other

International Collaboration: No
International Travel: No

Sarah Parcher
Email: sparcher015@gmail.com
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 2

Contribution to the Project: assist well installation data collection data analysis

Funding Support: NSF-EPSCoR

International Collaboration: No
International Travel: No

Kaity Patterson
Email: kpatte21@vols.utk.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 1

Contribution to the Project: Assisted with sample prep and analysis

Funding Support: funded from other projects

International Collaboration: No
International Travel: No

Wei Quan
Email: quanweisdu@gmail.com
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 4

Contribution to the Project: Developed a GIS based approach for developing vegetation indices from Landsat data.

Funding Support: CEE REU Support

International Collaboration: No
International Travel: No

Tiffany Sevilla
Email: tiffanysevilla2015@u.northwestern.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 4

Contribution to the Project: How does IML land use and water drainage influence the diversity and composition of microbial communities

Funding Support: Northwestern Murphy Fellowship

International Collaboration: No
International Travel: No

Bomo Shen
Email: shen-bomo@uiowa.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 4

Contribution to the Project: Cyberinfrastructure

Funding Support: NSF/(IML-CZO)

International Collaboration: No
International Travel: No

Jia Jia Wang
Email: jiawang2@illinois.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 1

Contribution to the Project: Collection of cores. Fly ash measurements. Data interpretation. Assistance with NC-GSA field trip.

Funding Support: ISGS

International Collaboration: No
International Travel: No

Joshua John Williams
Email: JoshuaWilliams2016@u.northwestern.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 2

Contribution to the Project: Developed an age model for the Lake Decatur sediment cores

Funding Support: none

International Collaboration: No
International Travel: No

Jake WInters
Email: winters9@purdue.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 4

Contribution to the Project: Undergrad research: soil DOC

Funding Support: Other

International Collaboration: No
International Travel: No

Zhihan Yu
Email: ZhihanYu2014@u.northwestern.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 1

Contribution to the Project: Biomarker analyses of stream organic C

Funding Support: None for salary. This project provided support for the analyses.

International Collaboration: No
International Travel: No

Nina Zhou
Email: NinaZhou2019@u.northwestern.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 3

Contribution to the Project: Processed water samples and made FTIR measurements for carbonate determination, and isotopic measurements of C and N. has been involved in data management.

Funding Support: This Project

International Collaboration: No
International Travel: No

Nicole Gasparini
Email: ngaspari@tulane.edu
Most Senior Project Role: Consultant
Nearest Person Month Worked: 0

Contribution to the Project: Dr. Gasparini has generously shared her expertise in helping us develop new LandLab components and providing guidance in testing/debugging LandLab models

Funding Support: none

International Collaboration: No
International Travel: No

Erin Bauer
Email: ebauer@illinois.edu
Most Senior Project Role: Other
Nearest Person Month Worked: 4

Contribution to the Project: Other

Funding Support: Illinois Department of Natural Resources

International Collaboration: No
International Travel: No

Nicholas Fetty
Email: nick-fetty@uiowa.edu
Most Senior Project Role: Other
Nearest Person Month Worked: 2

Contribution to the Project: conducted interviews, produced video, wrote summaries of research and outreach efforts

Funding Support: NSF IML-CZO

International Collaboration: No
International Travel: No

Tim Hodson
Email: tohodson@gmail.com
Most Senior Project Role: Other
Nearest Person Month Worked: 6

Contribution to the Project: Other

Funding Support: NSF (IML-CZO)

International Collaboration: No
International Travel: No

Lara Seek
Email: laraseek@illinois.edu
Most Senior Project Role: Other
Nearest Person Month Worked: 2

Contribution to the Project: Other

Funding Support: Illinois Department of Natural Resources

International Collaboration: No
International Travel: No

Brynne Storsved
Email: storsve2@illinois.edu
Most Senior Project Role: Other
Nearest Person Month Worked: 6

Contribution to the Project: Other

Funding Support: NSF (IML-CZO)

International Collaboration: No
International Travel: No

Yue Zeng
Email: yuezeng2017@u.northwestern.edu
Most Senior Project Role: Other
Nearest Person Month Worked: 1

Contribution to the Project: Analysis of high frequency events observed in Lake Decatur cores.

Funding Support: None for salary. This project provided support for the analyses

International Collaboration: No
International Travel: No

What other organizations have been involved as partners?

Name	Type of Partner Organization	Location
City of Coralville,	State or Local Government	Iowa
Illinois State Water Survey, Prairie Research Institute	State or Local Government	Urbana, Illinois
Purdue University	Academic Institution	West Lafayette, Indiana
United States Geological Survey	State or Local Government	Urbana, Illinois
University of Iowa	Academic Institution	Iowa City, Iowa
University of Minnesota	Academic Institution	Minneapolis, MN
University of Tennessee,Knoxville	Academic Institution	Knoxville, Tennesse
University of nebraska-Omaha	Academic Institution	Omaha Nebraska
Utah State University	Academic Institution	Logan, Utah
Illinois State geological Survey-Prairie research Institute	Academic Institution	Champaign,Illinois
Indiana University	Academic Institution	Bloomington, Indiana
Iowa-Cedat Watershed Interagency Coordination Team	State or Local Government	Iowa
LacCore	Academic Institution	University of Minnesota
North Carolina State University	Academic Institution	Raleigh, NC
Northwestern University	Academic Institution	Evanston, Ilinois
Pennsylvania State University	Academic Institution	State College, Pennsylvania

Name	Type of Partner Organization	Location
Prairie Research Institute	State or Local Government	Urbana, Illinois

Full details of organizations that have been involved as partners:

City of Coralville,

Organization Type: State or Local Government
Organization Location: Iowa

Partner's Contribution to the Project:
Facilities

More Detail on Partner and Contribution: assisted with Watershed Improvement Research Board Tour in Clear Creek Watershed Financial support for buses

Illinois State Water Survey, Prairie Research Institute

Organization Type: State or Local Government
Organization Location: Urbana, Illinois

Partner's Contribution to the Project:
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

Illinois State geological Survey-Prairie research Institute

Organization Type: Academic Institution
Organization Location: Champaign,Illinois

Partner's Contribution to the Project:
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

Indiana University

Organization Type: Academic Institution
Organization Location: Bloomington, Indiana

Partner's Contribution to the Project:
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

Iowa-Cedat Watershed Interagency Coordination Team

Organization Type: State or Local Government
Organization Location: Iowa

Partner's Contribution to the Project:
In-Kind Support
Facilities

More Detail on Partner and Contribution: Workflows for specific tasks in the Clear Creek IML-CZO were developed through a funded project for the Interagency Team by the Institute for Water Resources of USACE.

LacCore

Organization Type: Academic Institution
Organization Location: University of Minnesota

Partner's Contribution to the Project:
Facilities

More Detail on Partner and Contribution: The LacCore facility was used to analyze Lake Decatur cores for magnetic susceptibility, porosity and color.

North Carolina State University

Organization Type: Academic Institution
Organization Location: Raleigh, NC

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: Prof. Leithold's group at NCSU assisted with the Lake Decatur sedimentology.

Northwestern University

Organization Type: Academic Institution
Organization Location: Evanston, Ilinois

Partner's Contribution to the Project:
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

Pennsylvania State University

Organization Type: Academic Institution
Organization Location: State College, Pennsylvania

Partner's Contribution to the Project:
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

Prairie Research Institute

Organization Type: State or Local Government
Organization Location: Urbana, Illinois

Partner's Contribution to the Project:
In-Kind Support
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution: Illinois State Geological Survey and Illinois State Water Survey, which are part of PRI, are strong partners in the IMLCZO effort. Several personnel from PRI are directly or indirectly engaged in IMLCZO effort in field activities and scientific investigations.

Purdue University

Organization Type: Academic Institution
Organization Location: West Lafayette, Indiana

Partner's Contribution to the Project:
Facilities
Personnel Exchanges

More Detail on Partner and Contribution:

United States Geological Survey

Organization Type: State or Local Government
Organization Location: Urbana, Illinois

Partner's Contribution to the Project:
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

University of Iowa

Organization Type: Academic Institution
Organization Location: Iowa City, Iowa

Partner's Contribution to the Project:
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

University of Minnesota

Organization Type: Academic Institution
Organization Location: Minneapolis, MN

Partner's Contribution to the Project:
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

University of Tennessee,Knoxville

Organization Type: Academic Institution
Organization Location: Knoxville, Tennesse

Partner's Contribution to the Project:
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

University of nebraska-Omaha

Organization Type: Academic Institution
Organization Location: Omaha Nebraska

Partner's Contribution to the Project:
Financial support

More Detail on Partner and Contribution:

Utah State University

Organization Type: Academic Institution
Organization Location: Logan, Utah

Partner's Contribution to the Project:
Facilities
Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

What other collaborators or contacts have been involved?
Nothing to report

Impacts

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

Task A.3.1: Site weathering zone study locality in USB
We trained two female undergraduate students (one underrepresented group) and one female graduate student. Engaged faculty of satellite university (UNO) with Tier-1 research university.

Task A.4: Model Quaternary landscape development of the IML-CZO

The landscape of the glaciated Midwest is common and has received little study from a process geomorphology standpoint. We are developing the first model to consider the development of drainage networks post-glaciation and the link between this evolution and anthropogenic change. Our model highlights the importance of hydrological connectivity for landscape evolution and takes advantage of the unusually slow pace of landscape change to understand more about the processes that develop connectivity.

Task B:

The baseline sampling and ER experiments that took place the USRB will help us tease out how IMLs respond under different management practices and hydrologic forcings for locations with representative soil and water content. The monitoring of dynamic enrichment ratios is key to quantifying the lateral transport of carbon, which is a neglected term in many carbon budgets. IMLs have the potential of storing high amounts carbon, but first the lateral fluxes must be determined accurately. Moreover, the enrichment ratio can help us capture the connectivity issue between the landscape and the stream as well as address the key question related to SOM transport dynamics. Due to the unique correspondence of the enrichment ratio with soil texture, bulk density, the enrichment ratio has been used as a method to determine sources of organic matter and for performing event-based dynamics of carbon budgets across sites.

Task C.2: Biogeochemical reaction and transport -mechanisms and scales

Despite almost a century of agricultural research, we are discovering that C-cycling and transport processes are poorly understood and not well appreciated outside of the immediate community. The impacts of landscape and hydrologic engineering on C and N biogeochemistry are global in scope and will only increase in scale with time. The project will mainstream the observations.

Task D: Local- and watershed scale sediment budgets

The findings from this theme allow scientists and modelers to conceptualize and implement models for estimating water, sediment, and nutrient fluxes at different spatial and temporal scales. The influence of roughness evolution at the grain scale, as well fluxes at the plot scale under different management practices and hillslope location/characteristics can be better represented and linked based on the plot experiment results. Travel times from plot to watershed scales, as well as the origin of flux material, can also be taken into account in when determining changes in flux propagation along a flow path from a point to the watershed outlet. These are also based on the outcomes of the plot, radionuclide, sourcing and flux monitoring experiments. The findings so far provide an aggregated measure of the connectivity between the different parts of the landscape, as well as between the landscape and the channel. These can be incorporated into the estimation of the sediment delivery ratio as a function of not only drainage area (space) but also a function of time. The sediment delivery ratio can be seen as a reflection of the connectivity on the landscape. The changes in travel times and sediment delivery ratio over the course of a growing season, as we have found, both reflect the amount of places along the landscape where water, sediment, and nutrients can be retained. Other scaling laws and rating curves can benefit from the findings by incorporating the influences of travel times and sediment delivery.

Task H.1: Broadening research engagement

Alison Anders along with Nicole Gasparini and Nicole West proposed and chaired a session on Landscape evolution from a Critical Zone Perspective at the annual AGU meeting in Dec. 2015. The session was very successful with 25 posters and 16 talks presented including participation from 6 CZOs. The sessions were well attended and brought together people from different disciplines and from within and outside the CZO network. ESPL (Earth Surface Processes and Landforms) special issue on Landscape Evolution from a Critical Zone perspective grew out of an invitation by Stuart Lane (Editor) that was extended to Alison Anders, Nicole Gasparini and Nicole West after the success of their AGU session in December 2015. Currently we are collecting manuscripts and sending them out for review - we anticipate closing the call for papers in Oct. 2016. This special issue will bring together an interdisciplinary group to explore landscape evolution and cz science from a range of perspectives. The special issue should generate more publicity for CZOs and stimulate cross-CZO research.

Task I: Microbial Data…

This effort is one of the first to explicitly determine distributions and connectivity of microbial communities within the critical zone, as well as to link these communities to other relevant critical zone information such as land use, ecosystem connectivity, and soil organic matter composition. The cross-CZO and CZO-NEON effort we initiated also provide data and metadata standards that are essential to broad synthesis of information in the critical zone. Therefore this effort represents an important contribution to holistic understanding of the critical zone, particularly interdependencies between landscape patterns of land management, water (re)distribution, biogeochemistry, and microbial ecology.

What is the impact on other disciplines?

Task A.4: Model Quaternary landscape development of the IML-CZO

The evolution of the landscape strongly influences the development of weathering profiles and soils, so this work provides crucial context for understanding weathering in the IML-CZO

Task B: Short- and Long-Term Dynamics of Soil Organic Matter

The CZO program is interdisciplinary by nature. Two central components are the following: (1) to develop a unifying theoretical framework that integrates new understanding of coupled hydrological, geochemical, geomorphological, sedimentological and biological processes; and (2) to develop, couple and validate system-level models to predict how the critical zone responds to external forces such as anthropogenic, climatic, and/or tectonic processes. In the upcoming years of the IML-CZO the goal will be to unite the information gathered in the individual themes to address the overall transformer-transporter hypothesis. The processes driving the water-sediment-nutrient budgets are co-evolving but have really only been examined in isolation. But using this information that has been collected so far, along with limited “connectivity experiments” described above, we hope to identify those cause-effect relationships that have not been recognized in the discipline-specific measurements/ studies.

Task D: Local- and watershed scale sediment budgets

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What is the impact on the development of human resources?

Task A.1: Define and map fundamental landscape units

Trained two female undergraduates (one underrepresented group) and one female graduate student in field hydrogeomorphic methods and data analysis

Task A.3.1: Site weathering zone study locality in USB

We trained two female undergraduate students (one underrepresented group) and one female graduate student. We engaged faculty of satellite university (Univ. of Northern Iowa) with Tier-1 research university.

Task A.4: Model Quaternary landscape development of the IML-CZO

A PhD student is gaining crucial skills in the development and testing of a numerical model.

Task B: Short- and Long-Term Dynamics of Soil Organic Matter

Due to the interdisciplinary nature of the CZO program, students are working on research topics with co-mentoring across departments and institutions. A good example are the regular meetings between the Papanicolaou and Filley groups. These meetings are allowing the students to see the co-evolution of short-term (event-based) mechanisms like erosion and management affect the long-term (decades) stabilization mechanism of soil carbon. This exposure to other schools of thought will open new avenues to explaining how systems of interrelated processes with multiple feedbacks function.

Task D.1: Local- and watershed-scale sediment budgets

Due to the interdisciplinary nature of the CZO program, students are working on research topics with co-mentoring across departments and institutions. Co-Director Papanicolaou works to get his students involved in the science meetings of the IML-CZO. This exposure working with other schools of thought will open new avenues to explaining how systems of interrelated processes with multiple feedbacks function.

Task E: Integrated Modeling. Key Questions: What is CZ resilience to external large-scale drivers? What perturbations result in internal changes that trigger long-term or permanent transition to a qualitatively different dynamic regime? What are the hierarchy of scales within CZ dynamics and the associated interactions at different stages of soil/sediment evolution?
IMLCZO has contributed and is contributing to the interdisciplinary development of two undergraduate, nine graduate students, and two postdocs. Further it has facilitated significant interdisciplinary interaction between established disciplinary scientists.

Task I: Microbial Data…

By providing training and professional development to dozens of graduate students and postdoctoral researchers, associated with this project and the CZOs, we have significantly developed human resources in science, engineering and technology. In particular, we have taught domain scientists about important new CyberInfrastructure tools, including those associated with CZO, EarthCube, and SESAR (IGSNs). We have also provided important networking opportunities for these early career researchers through these three workshops.

The Table below summarizes the distribution of people engaged in IMLCZO effort.

Participant Category	Number	Gender		Disciplinary Background
		Male	Female	
Total participants	100	64	36	Other (10), Civil and Environmental Engineering (60), Earth and Planetary Sciences (1), Geology (8), Earth and Environmental Science (11), Hydroscience & Engineering – University of Iowa (1), Geography (8), Computer Science (1)
Undergrad students	18	5	13	Other (5), Civil and Environmental Engineering (11), Geology (2)
Graduate students	48	32	16	Earth and Planetary Sciences (1), Geology (1), Earth and Environmental Science (6), Other (1), Civil and Environmental Engineering (32), Geography (6), Computer Science (1)
External participants	6	1	5	Other (3), Geology (2), Hydroscience & Engineering – University of Iowa (1)
Main Personnel	20	18	2	Geology (3), Earth and Environmental Science (3), Other (1), Civil and Environmental Engineering (11), Geography (2)
Postdoctoral	4	4	0	Civil and Environmental Engineering (2), Earth and Environmental Science (2)

What is the impact on physical resources that form infrastructure?

Task B: Short- and Long-Term Dynamics of Soil Organic Matter
A number of observational platforms have been deployed at the primary test field in the CCW to help perform the connectivity experiments. These include an eddy tower (with climate and soil moisture/temperature probes) to capture fluxes through soil-crop-atmosphere interface. A downslope transect of water table monitoring wells track not only water and dissolved constituents across the surface-subsurface interface, but also through the soil matrix. Advanced Radio-frequency ID and isotopic tracers can track the particulate movement across the surface and through a series of Alternative Tile Intakes along the hillslope from the surface to the subsurface. A monitoring camera has been installed at the outlet of this tile system to measure the fluxes through the subsurface drainage system. Finally an integrated stage-sediment-water quality monitoring system is installed just downstream of the field. This set up allows us to track the water drop, sediment particle, carbon

molecule from the top of the hillslope through the channel in one experiment. This deployment and associated datasets are likely to have a lasting impact on the science of intensively managed landscapes.

Task D: Local- and watershed scale sediment budgets
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Task E: Integrated Modeling. Key Questions: What is CZ resilience to external large-scale drivers? What perturbations result in internal changes that trigger long-term or permanent transition to a qualitatively different dynamic regime? What are the hierarchy of scales within CZ dynamics and the associated interactions at different stages of soil/sediment evolution?
IMLCZO has established a network of monitoring systems across landscapes and streams to provide valuable measurements to support interdisciplinary research.

What is the impact on institutional resources that form infrastructure?
Nothing to report.

What is the impact on information resources that form infrastructure?

Task B: Short- and Long-Term Dynamics of Soil Organic Matter
The monitoring of dynamic enrichment ratios is key to quantifying the lateral transport of carbon, which is a neglected term in many carbon budgets. The measured ER values are central for the modeling of carbon in IMLs. Carbon loss through erosion is poorly quantified and hence represented in carbon budget modeling. In several studies, the ER is assumed to be near unity but our studies have shown ER values during some events can reach up to 4.IMLs have the potential of storing high amounts carbon, but first the lateral fluxes must be determined accurately.

Task D.1: Local- and watershed-scale sediment budgets
The enhanced Bayesian framework provides a robust means to assess the degree of connectivity within the watershed and the associated variabilities in contributions, travel times, and storage of material in the watershed. The method is independent of scale.

Task E: Integrated Modeling. Key Questions: What is CZ resilience to external large-scale drivers? What perturbations result in internal changes that trigger long-term or permanent transition to a qualitatively different dynamic regime? What are the hierarchy of scales within CZ dynamics and the associated interactions at different stages of soil/sediment evolution?
IMLCZO data system is part of and is informing a number of Cyberinfrastructure development efforts. These include SEAD Datanet (http://sead-data.net/), Earthcube Geosemantics (http://hcgs.ncsa.illinois.edu/), and Browndog DIBBS (http://browndog.ncsa.illinois.edu/).

Task I: Microbial Data…

This project has registered more than 300 International GeoSample Numbers (IGSNs) with SESAR. Microbial metagenomic sequences and associated metadata obtained through this project are deposited in the public data archive MG-RAST. In addition, 2014 data are also deposited in the Earth Microbiome Project archive. We anticipate that all microbial, ecological, biogeochemical, and workflow data and information from this project will be publically available on multiple relevant websites and repositories upon publication, within the next two years.

What is the impact on technology transfer?
Nothing to report.

What is the impact on society beyond science and technology?

Task A.3.1: Site weathering zone study locality in USB

Improved understanding of weathering processes that may impact atmospheric chemistry and climate change. Improved understanding of connectivity across the landscape that impacts water quality of surface and ground waters

Task B: Short- and Long-Term Dynamics of Soil Organic Matter

Conservation programs have helped slow and in some cases reverse the trend of IMLs becoming transporters. The IML-CZO can provide a more comprehensive scientific underpinning of the management strategies geared toward preserving or rebuilding SOM. This study can lead to the development of watershed management plans that promote sustainable agriculture and ecosystem services through teaching, training, and learning towards environmental literacy and land stewardship.

Task D.1: Local- and watershed-scale sediment budgets

Conservation programs have helped slow and in some cases reverse the trend of IMLs becoming transporters. The IML-CZO can provide a more comprehensive scientific underpinning of the management strategies geared toward preserving or rebuilding SOM. This study can lead to the development of watershed management plans that promote sustainable agriculture and ecosystem services through teaching, training, and learning towards environmental literacy and land stewardship.

Task E: Integrated Modeling.

IMLCZO has developed an artistic rendition of the CZ science using remote sensing data that is accessible to the broader audience (see https://www.youtube.com/watch?v=FkR495FJNGo&feature=youtu.be).

Task G.1: Virtual engagement: website and social media

We brought IML-CZO activities to the attention of local government, citizens, consultants and state legislators

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Changes/Problems

Changes in approach and reason for change

Comparison of expenditures versus budget by program area/activity (with explanation of cost overruns), and indication of leveraging from other sources.

The attached budget provides details of the allocation and spent (and encumbrances) in the various categories. During the year 3, our expenses (and encumbrances) are only slightly below that budgeted. We will be carrying forward $529,824. This carry forward is attributed to the following:

- We have not had any cost overruns.

- Since the start of the project was off cycle, we were unable to hire people immediately resulting in significant carry forward during year 1.

- Our team in Northwestern Univ. has had difficulty in attracting a graduate student to the project. Effort is underway to remedy this situation. In the meantime undergraduate students are actively contributing to the laboratory analyses.

- Laboratory analyses of samples is underway and not all costs have been incurred or encumbered.

- We are underspent in field equipment because of our ability to leverage existing equipment through repairs. This provides us with flexibility in new deployments during the coming year.

- We are carrying forward Participant Support Cost to meet the needs of the coming year, so we are requesting a budget neutral reallocation to student/postdoc salary to increase momentum on the data-model integration effort (details are in budget justification).

- We have increased the support to field technician effort during year 3 through reallocation. This has helped us address some pinch points with equipment maintenance and data collection. We expect that this will continue in year 4.

- Illinois State Water Survey and Illinois State Geological Survey continue to provide strong partnership through the involvement of several scientists at no cost to the project, as well services and support on a cost reimbursable basis.

- The development of IMLCZO Data System has continued to benefit significantly from synergistic contribution of NSF DIBBS grant for Browndog project, and NSF Earthcube grant for GeoSemantics project.

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

A plan for remedial action where project milestones in the CZOMP have been significantly impacted.

Task A: Define and map fundamental landscape units
We originally planned to map the functional landscape units during the first two years of the project. After year 1 we realized that our knowledge of the hydropedology and hydrogeomorphology of the IML-CZO was insufficient to successfully accomplish this task without gathering further information. The past three year's activities have allowed us to fill our knowledge gap sufficiently to now map functional landscape units in these watersheds.

Task B: Short- and Long-Term Dynamics of Soil Organic Matter

Northwestern Univ. has had some difficulty in attracting a graduate student to the project. As a resulting undergraduate students have been hired to fill the gap resulting in some underspending. Effort is underway to recruit other graduate students.

Task D: Local- and watershed-scale sediment budgets
Attempts to conduct detailed field studies of connectivity pathways in the USRB that can be linked to results of sediment tracing studies have been frustrating due to withdrawal of landowner permissions to access several important field sites. This withdrawal reflects changes in decision-making authority within landowner families, namely, the death of heads of households. We are seeking alternative field sites that can appropriately represent the site to which we no longer have access.

Problems likely to delay accomplishment of annual, strategic goals:

Dr. Doug Schnoeblen, coordinator of our E&O program left for a new position of the Director of USGS office in San Antonio starting Jan 2016. Dr. Art Bettis has taken the lead of the E&O effort the involvement of Dr. Leslie Flynn, who is a Clinical Assistant professor in the Department of Education. Dr. Flynn has provided significant engagement with training of K-12 Science Teachers in CZ Science. A report from this effort is attached. We expect Dr. Flynn will take on a position elsewhere. Ted Neal, Clinical Instructor of Science Education in the Department of Teaching and Learning Univ. of Iowa will lead E&O activities instead. We are also expecting to get momentum in engaging the Extension program at UIUC. We have already had several conversations, but the Extension program is impacted due to the state budget of Illinois with cutbacks and downsizing of programs through which we could interface. We are expecting to get increased momentum this year.

Changes that have a significant impact on expenditures

We have carry forward budget of $18,255 in our Participant Support Cost at Univ. of Illinois. This is sufficient to meet the needs for the 4th year of the project. We would therefore like to request that the funds ($28,500) originally budgeted as Participant Support Cost for Year 4 be reallocated to support a post-doctoral research associate. Similarly, we request that $20,000 allocated to Purdue Univ. and $8000 allocated to Penn State Univ. as Participant Support Cost be rebudgeted to equivalent support for students and/or postdoctoral research associate at the respective institutions. We expect to meet the original goals of Cross CZO synthesis and attracting external scientists to the site through our carry forward funds in this category. The need for synthesizing across experimental and modeling effort is significant and this allocation will help us support this crucial activity at this stage of the project.

Significant changes in use or care of human subjects
Nothing to report.

Significant changes in use or care of vertebrate animals
Nothing to report.

Significant changes in use or care of biohazards
Nothing to report.

What are the Major Activities

Task A.1: Define and map fundamental landscape units

We characterized soil hydrogeomorphic associations in CC watershed; installed and monitored water levels in shallow water table wells; monitored agricultural tile discharge; collected water samples from wells and tiles for water chemistry analysis; performed resistivity survey of headwaters landscape in CC.

Task A.2 Post-settlement alluvium analysis using stream bank surveys, coring, fly ash screening, and radionuclide dating

We completed grain size and clay mineralogy measurements on USRB cores, and grain-size, organic carbon analyses on CC cores and outcrops. We collected shells from the base of cores in the main stem Sangamon flood plain and radiocarbon dated them to estimate the pre-settlement sedimentation rates. We Obtained 137-Cs and 210-Pb dates on post-settlement alluvium in a transect of CC cores. We showcased USRB field sites and results in a field trip for the NC-GSA meeting in April 2016 and CC sites in a Watershed Improvement Research Board field tour in June, 2016.

Task A.3: Site weathering zone study locality in USB

We collected geochemical data on cores from CC and USRB cores; collected core from research site in central Iowa (COBBS) owned by Iowa State University; collected grain-size and geochemistry data from the COBBS core; and installed pore water samplers and a gravity lysimeter at the CC weathering zone observatory.

Task A.4: Model Quaternary landscape development of the IML-CZO

Building on the conceptual model developed last year, we began building a numerical landscape evolution model to reproduce major processes. We identified two end-member cases for treating precipitation which falls on portions of the landscape unconnected to externally draining river systems: one in which this water evaporates or infiltrates into deep groundwater reservoirs and one in which closed depressions are filled to their spill points, forcing connection to external drainage. An initial model including stream-power based fluvial incision, hillslope diffusion was developed using a combination of pre-existing LandLab components and new components we developed. Initial model results indicate that drainage network integration rates are highly sensitive to the fate of water falling on the unconnected upland - when this water is not routed into external stream networks, drainage network integration proceeds more slowly than is apparent from observed pre-settlement landscapes. A preliminary approach to including groundwater in the numerical model is under development.

Task B.1: Experimental farm footprints through mobile sensor platforms

We collected surface soil samples in CCW and USRB and analyzed for bulk soil properties. Surface soil samples were collected in the USRB from hillslopes representative of the various management practices, gradients, and soil types in the watershed. These baseline samples help characterize the bulk properties and structure of the present-day critical zone in the USRB. The associated analyses of these samples provide data that identify the physical ranges for key biogeochemical and hydrological parameters that are used in the modeling exercises for constructing water, sediment, and nutrient (i.e., carbon, nitrogen, phosphorus) budgets.

The protocol for collecting and analyzing these surface soils in the USRB followed exactly the steps used for the samples collected in the CCW in April 2014. Initially, representative hillslopes were chosen throughout the watershed based on the dominant combinations of land use/ management, soil type, hillslope gradient, and location. We used the available GIS data layers to identify and group these basic characteristics and the dominant flowpaths in each field. Each site was reconnaissanced to confirm these properties while obtaining landowner permission before sampling. We identified 7 hillslopes in the USRB, which included 4 hillslopes under row crop agriculture, 1 restored grassland, 1 upland forest and 1 forested wetland. In the season prior to sampling (i.e., spring-summer, 2015), the 4 row crop fields included the following fields: 1 tilled corn; 1 no-till corn; 1 tilled soybean; 1 no-till soybean. Each hillslope was sampled in a gridded fashion. The grid nodes were at the intersections of 4 lateral transects at different catena positions (namely crest, shoulder, backslope, and toe) and three downslope flowpaths. The purpose of collecting along defined flowpaths were to ensure connectivity between the sampling locations. At each of these 12 nodes, surface soil samples from 0-5 cm and 5-10 cm depth were collected. The sampling scoops used in the collection had a defined, 5-cm x 5-cm x 5-cm geometry. On November 1, 2015, the IML-CZO team sampled 6 of the 7 hillslopes. A total of 144 samples were collected during the field campaign. Additional samples were collected along the main flowpath in each field. These samples (35 in total) were used for the ground-truthing of a concomitant aerial hyperspectral flight over a limited area. The hyperspectral flight was performed to capture bare soil spectra for surface soil texture, SOM content and surface geochemical properties. Random surface samples (47 in total) were collected throughout the remainder of the USRB for verification of the hyperspectral data.

These surface samples are being analyzed for the following bulk soil characteristics: bulk density, water content, soil texture, organic matter content, carbon & nitrogen isotopes, lignin content, aggregate stability, and organic geochemistry. Soil samples were immediately weighed, then passed through an 8-mm sieve. They were allowed to air dry and then weighed again to determine water content and bulk density. Sub-samples for aggregate stability tests were removed and sent to the University of Tennessee - Knoxville (UTK) for analysis. Another sub-sample was passed through a 2-mm sieve and partitioned for the following analyses: soil texture (UIowa); SOM and pH (UTK); and organic geochemistry/ isotopic analysis (Purdue). Currently these samples are being analyzed. For soil texture, both the pipette method and sedigraph are being used. SOM is being measured with a Visible Near Infrared Spectrometer (VNIR). We are measuring pH using 2:1 deionized water-to-soil solution. The organic geochemistry includes total C and N, as well as their stable isotopes using a flash combustion elemental analyzer interfaced to a stable isotope ratio monitoring mass spectrometer. Soil aggregate stability is measured via both wet and dry methods. The wet method involves use of a calibrated rainfall simulator, which accounts for disaggregation due to raindrop impact. The dry method involves a sieve shaker and is reflective more of mechanical breaking, as from tillage. The data will be shared openly upon analysis completion and value verification.

Further, dynamic Enrichment Ratio (ER) experiments were conducted in the USRB from April 17-20, 2016 using the UTK mobile unit of rainfall simulators. A primary goal of the ER experiments is to determine the selective entrainment of soil carbon during rainfall-runoff-erosion events. In IMLs, removal of soil carbon through erosion can be of the same magnitude as loss through respiration. However, carbon loss through erosion is poorly quantified and represented in carbon budget modeling. In several studies, the ER is assumed to be near unity but our studies have shown ER values during some events can reach up to 4. ER experiments were performed in 3 of the 4 row crop fields sampled during the baseline field campaign mentioned above. Within each field, the main downslope flowpath was selected from the preliminary information used in the baseline sampling campaign. This was to ensure connectivity between hillslope elements. Then experimental plots were developed at the crest and toe of the flowpaths. These experimental plots were 2 m wide and 7 m long, which is the effective area footprint of the 3 Norton Ladder Multiple Intensity Rainfall Simulators used in this study. The nozzles of these simulators have been calibrated to provide a similar distribution of raindrops observed in the region. At the outlet of each plot, runoff and sediment were directed through a V-notch weir. A high-resolution ruler was attached to the weir to measure the flow depths. Before each test, surface soil samples were collected just outside of the effective areas for each plot to determine the particle size distribution, baseline carbon content, and microbial activity of the soils. Then during the tests, a constant 60-mm/hr rainfall was used. This intensity is representative of a heavy thunderstorm in the region and also matches the rainfall experimental conditions used during the Universal Soil Loss Equation (USLE) experiments. Soil moisture probes were installed within the effective area of the plots to monitor changes in moisture content throughout the experiment. We ran the rainfall experiments for up to 4 hours to ensure that pseudo-equilibrated conditions were achieved for both runoff and sediment fluxes. Flow depths readings at the weir were recorded at approximately 10-min intervals once runoff was generated. A sample of the runoff was collected following each flow depth reading, labeled and time-stamped. During the experiments in the USRB, a total of 175 samples were collected. The samples include soil samples collected before and after the experiments, as well as samples of the runoff generated during the experiments. The collected soil samples and runoff-sediment samples were passed initially through an 8mm sieve to remove coarse litter fractions and were allowed to air dry. These samples are being analyzed for their size distributions. First, the bulk samples were passed through a sequence of 0.25-mm and 2-mm sieves to partition them into three distinct aggregate size classes, namely the small microaggregates (< 0.25mm), small macroaggregates (0.25-2.00mm), and large macroaggregates (>2.0mm) fractions. Sub-samples from each size class are being run on the sedigraph. The sedigraph was selected for this purpose as the sampling size was quite small (a few grams) dealing with runoff samples. In addition to particle size, the samples are being analyzed for SOM with the VNIR, as well as total organic carbon and nitrogen contents using an elemental analyzer.

Task B.2: In-situ OM measurements coupled with lab SOM characterization

We performed VNIR and other in-situ measurements for total SOM in CCW and USRB samples. In this task, the soil sub-samples collected as part of the baseline campaign and ER experiments in the USRB are being analyzed for total SOM using a Visible Near Infrared Spectrometer. The spectra provided from the VNIR scans will be used to construct a statistical model for rapid determination of SOM. These SOM values will be compared to the organic matter content determined using an elemental C/N analysis.

Task B.3: SOM modeling of short- and long-term SOM storage

We are modeling short- and long-term SOM storage for CCW. Modeling of the SOM redistribution and transport has begun for the CCW. The goal of the SOM modeling is to provide spatiotemporal predictions of SOC stocks at the hillslope scale. We have developed an improved modeling framework that accounts for the selective entrainment and deposition of SOM and the lighter size fractions. For this framework, we have developed an ER module that was interlinked with two other established models, the CENTURY soil biogeochemistry model and Watershed Erosion Prediction Project model for hillslope erosion. Using this enhanced framework, we simulated the development of the soil carbon throughout the management history (i.e., since 1930) of one of the test fields of the CCW. The simulations highlight the effects of anthropogenically-enhanced erosion and the benefits of conservation practices at replenishing carbon stocks.

Task C.1: Telescoping hydrological monitoring

Major activity included sampling precipitation, surface runoff, tile drain effluent, groundwater, vadose zone water, and stream water during storm events in the CCW headwaters. In-stream sampling during storms was also conducted at several in-stream sites in CCW and USRB. Stream water samples have been collected pre-, during- and post- storm event to evaluate how biogeochemical signatures vary in the Clear Creek and Upper Sangamon watersheds. Organic and inorganic C, sediment mineralogy and concentration, and dissolved metals (Sr, Ca) and Sr isotopes (87/86) have been monitored. Samples were collected in the field. Chemical analyses was done in the laboratory. Additionally, we have engaged in a modeling exercise using the Agro-IBIS and THMB models. These models simulate coupled water, energy, carbon, and nutrient dynamics at the landscape-scale. These are being developed for the CCW site and more broadly the Iowa River Basin and Mississippi River Basin. The key advantage of this framework is to link small-scale process dynamics to resultant landscape-scale outcomes. Additionally, these models enable our team to directly assess human land management decisions (e.g., fertilizer application rates, timing) and land use as controls on critical zone services and outcomes.

Task C.2: Biogeochemical reaction and transport -mechanisms and scales

DOC, POC, and soil moisture monitoring in CCW experiments

We performed analyses of the stable carbon isotopic composition of dissolved organic carbon. In order to measure the stable carbon isotopic composition and concentration of soil organic carbon (SOC) in stream, tile, and porewater from the CCW and USRB sites, a dissolved organic carbon (DOC) analyzer was purchased, with a grant supplement in 2014, that could be interfaced with an isotope ratio mass spectrometer (IRMS) in Purdue University's Stable Isotope Lab. The DOC instrument was constructed by Analytical Sciences Limited (Tewkesbury, UK) in partnership with the IRMS manufacturer Sercon (Crewe, UK). The instrument was received and installed in February 2015, however after extensive testing it was determined that the instrument did not meet specifications and was returned to the manufacturer for further modifications. Specifically, the high CO2 background produced by the combustion catalyst obscured the isotopic composition of SOC samples at environmentally relevant concentrations. Over the following year Analytical Sciences and Sercon, with continued input from Co-PI Timothy Filley, made substantial alterations to the DOC instrument in order to reduce background CO2. The revised TOC was returned to Purdue University and installed in August 2016. As a result of these changes, CO2 background has been lowered significantly to allow accurate isotopic characterization at SOC levels below 2 ppm carbon. Testing of the newly installed system is still underway, with analysis of archived IML-CZO samples from CCW and USRB is anticipated to begin in mid October. We are also testing its capability to analyze high salt-content solutions that would permit stable carbon isotope measurement of microbial biomass carbon and solutions generated by dithionate and pyrophosphate extractions of soil to assess iron and aluminum-bound DOC

Task D.1: Local-scale sediment budgets

We quantified erosion rates, travel times, and lag coefficients for CCW through rainfall simulator experiments. Soil surface roughness has been described along a spectrum of increasing magnitude from micro-relief variations at the grain-to-aggregate scale to random roughness at the clod scale, followed by management-derived oriented roughness and hillslope curvature. The degree of roughness at these different scales can have a profound effect on runoff, infiltration, and erosion. From the Enrichment Ratio (ER) experiments conducted in the CCW, we were able to explore more deeply the connection between rainfall and random roughness. The temporal and spatial variations of random roughness in IMLs are mainly attributed to the interaction of soil surface with rainfall and management practices. Random roughness can affect runoff and erosion at the hillslope scale in Clear Creek by altering depression storage, which can either dampen or magnify the response of runoff and erosion. The soil surface roughness was quantified in the plots of the CCW using the University of Tennessee – Knoxville (UTK) state-of-the-art instantaneous, microtopgraphical, surface-profile laser scanner with the vertical and horizontal accuracy of 0.5 mm. Scans were performed both before and after the rainfall experiments. These scans were analyzed using the semi-variogram geostatistical tool, which depicts the spatial autocorrelation of elevation data through plots of the semi-variance versus lag distance. In essence, one could distinguish surfaces developed under random Brownian motion from surfaces with some degree of spatial structure (fractional Brownian motion - fBm). From this analysis, a random roughness index is calculated to provide a measure of the mean vertical elevation differences of the surface studied, and the fractal properties of the surface are utilized as a means to estimate the characteristic scale of roughness for smooth surfaces.

Similarly, we quantify erosion rates, travel times, and lag coefficients for USRB also through the rainfall simulator experiments. In conjunction with the dynamic Enrichment Ratio (ER) experiments within the USRB, erosion rates and travel times of water and sediment were also measured. Dynamic Enrichment Ratio (ER) experiments were conducted in the USRB from April 17-20, 2016 using the UTK mobile unit of rainfall simulators. A primary goal of the ER experiments is to determine the selective entrainment of soil carbon during rainfall-runoff-erosion events; however, erosion rates and sediment travel times across the landscape can also be determined. ER experiments were performed in 3 of the 4 row crop fields sampled during the baseline field campaign mentioned above. Within each field, the main downslope flowpath was selected from the preliminary information used in the baseline sampling campaign. This was to ensure connectivity between hillslope elements. Then experimental plots were developed at the crest and toe of the flowpaths. These experimental plots were 2 m wide and 7 m long, which is the effective area footprint of the 3 Norton Ladder Multiple Intensity Rainfall Simulators used in this study.

Task D.2: Watershed-scale sediment budgets

We characterized net sediment fluxes and sediment rating curves within stream channels of CCW using storm-based evaluations. Travel times of freshly eroded sediment from the landscape through the stream channel in the CCW were determined using flow discharge, turbidity measurements, and the activities of 7Be on the suspended sediment. The 7Be is delivered to the surface soils during a rain event and is a "conservative" tracer over the time of the runoff event. The peak in 7Be activity can be tracked with the sediment moving downstream. A relationship was developed between the suspended sediment concentration and the turbidity to produce a more complete temporal record that corresponded with the discharge measurements. To determine the travel times with the flow and sediment data, we correlated the rising and falling limbs of the hydrographs of 4 storms in the CCW.

Similarly, we characterize net sediment fluxes and rating curves within stream channels of Upper Sangamon using storm-based evaluations. Samples of suspended sediment were collected by pump samplers at three locations along the Sangamon River – one in the headwaters, one in the middle portion of the river, and one toward the downstream portion of the river. Two of the samplers operated year round due to warm weather, whereas the third, in the headwaters, operated for all months expect Dec – March. Analysis of samples collected by the pump samplers is ongoing. Selected sediment samples are being analyzed in detail in the geochemistry lab of Neal Blair at Northwestern University to determine sediment concentrations and variation in the isotopic composition of nitrogen and carbon in sediment samples throughout individual hydrographs. Other samples have been analyzed for sediment concentration only to develop sediment rating curves.

We developed short-term (i.e., single event) sediment budgets for CCW using stable and radio-isotopes to partition sediment sources. In order to determine the relative contributions of terrestrial and instream sources to the total sediment load of stream, many studies have relied on unique physical and biogeochemical characteristics of natural and artificial tracers to distinguish between soil (terrestrial) and sediment (instream) sources. These fingerprinting studies use statistical tools, known as unmixing models, to tease out the relative proportions on different source materials that have been combined to make the mixture moving downstream. Papanicolaou's team has enhanced their existing Bayesian-based unmixing approach to relate the signatures of the transported material to the signatures of the source soils in CCW. Bayesian approaches allow for past data in the form of a probability distribution to be updated with new data. Using prior knowledge for model parameters eases the need for the tracers to characterize fully the source areas. This approach (see Abban et al., 2016) incorporated two new parameters, namely α and β. The α term is used to define the spatial attributes of the contributing sources, while β accounts for the time history (delivery, and residence time/integration) of source soils/ sediments delivered to and at the collection point. This recently enhanced version allows for a probabilistic treatment of α and β. In this post-analysis of data collected from the CCW baseline sites, we developed stochastic representations of α and β capable of accommodating information on the variability in source contributions, their delivery times and storage within the watershed, and, thus, better reflecting uncertainty in source contributions. Abban et al., 2016 demonstrates the application of this enhanced Bayesian approach with carbon and nitrogen stable isotope data.

Similarly, we developed short-term (i.e., single event) sediment budgets for the Upper Sangamon watershed using stable and radio-isotopes to partition sediment sources, organic matter content, trace elements and radionuclides (7Be, 137Cs, and 210Pb). 44 sediment source-area samples and 3 in-stream sediment samples collected at a monitoring station near Saybrook, IL on the upper Sangamon River were analyzed. Both source samples and suspended samples were dried, crushed, and sieved. Only fine grain size (<63μm) sediment was prepared for heavy and trace element concentrations and organic analysis. For the metal concentration analysis, 1 g of each samples were sent to Activation laboratories in Ontario, Canada for trace element geochemistry analysis with an ICP/OES after aquaregia digestion. For the organic content analysis (%C, %N), isotopic composition (δ13C and δ15N) and radionuclides (7Be, 137Cs, and 210Pb) analysis, sample were analyzed by Illinois State Geological Survey. A two-step statistical model was used to identify distinctive fingerprints of source-area sediments from the chemical properties. Each chemical property was analyzed individually using Kruskal-Wallis H test to determine the capability of differentiating between the sediment sources. Chemical properties scoring values above the critical value for the H test are considered potential tracers. Then the potential tracers were combined through discriminant function analysis – stepwise minimization of Wilks' lambda - to determine the optimal combination of tracers. The composite fingerprint is a suite of tracers that generate low Wilks' Lambda, which are capable of distinguishing between sediment sources. The contributions of the different source areas to the composition of in-stream sediment was determined using an unmixing model. Potential sources upstream of the in-stream sampling location included grazed floodplain, forested floodplain, grassland, row crop agricultural land, and stream banks. Work is also underway to develop a model to simulate hydrologic and sediment processes at Upper Sangamon River Basin.

The Upper Sangamon River Basin upstream of Monticello gage was delineated into 499 sub-watersheds (REWs or Representative Elementary Watersheds) based on DEM and LiDAR data. Climate, land use, soil order, topography data were collected for each REW as model inputs. Each REW has a hillslope component and channel component. We first used the original model to simulate hydrologic and sediment processes. Then we developed a floodplain component to capture the sediment behavior during overbank flow. It is assumed that when the water depth in the channel calculated for each reach is higher than the channel depth, overbank flow occurs. Sediment will transport and diffuse to floodplain. When the water flows back to the channel, sediment deposits onto the floodplain. Therefore, sediment storage in floodplain changes when overbank flow occurs.

Task E: Integrated Modeling and Critical Zone Services

Task E.1: Spatially distributed modeling of moisture and nutrient dynamics in IML using in situ and remote sensing data

The integrated modeling effort in IMLCZO focused on:

1. Development of a model *Dhara* for capturing the 3-D moisture, heat and nutrient dynamics across the landscape using high resolution Lidar data. This model is now in the public domain https://github.com/HydroComplexity/Dhara and formed the basis for a Modeling Summer Institute led by Kumar's group.
2. Development of the characterization of dynamics of mean nutrient age across the landscape. This novel approach to understanding nutrient dynamics has the potential to unravel spatio-temporal evolution in unique ways. This work was published in WRR (doi:10.1002/2015WR017799) and featured by NSF (http://www.nsf.gov/news/news_summ.jsp?cntn_id=139263&WT.mc_id=USNSF_51&WT.mc_ev=click)
3. Characterization of hydro-geomorphic features of alluvial river valleys. This work is under revision for submission to Earth Surface Processes and landforms.
4. Detection of shifts in eco-hydrologic process networks at various time scales using information theoretic approach. This work is being sent for publication to Water Resources Research as a two paper companion.
5. Extraction of land surface and vegetation features from lidar and hyperspectral data. This work has been accepted in IEEE Transaction in Geoscience and Remote Sensing and another publication is under preparation.

Task E.2: Identification of the physical ranges for key biogeochemical and hydrological modeling parameters

This study, was designed to investigate (1) how the ambient ground temperature fluctuates with diurnal and seasonal changes; (2) whether a well can act as a temperature conduit and potentially interfere with the natural geothermal regime; and (3) whether agriculture practices affect the thermal conditions in the subsurface hydrologic system. A fiber-optic distributed temperature sensing (FO-DTS) system was installed in two adjacent boreholes, one cased and the other uncased. The deeper, uncased borehole was advanced through all the unconsolidated glacial sediments lying above the bedrock, penetrating multiple aquifers in the glacial sediments, including the Mahomet aquifer. The cased borehole was drilled only partway through the sediments, and a groundwater monitoring well was screened in the shallower Upper Glasford aquifer. During the growing season, water was pumped for irrigation from the Mahomet aquifer (about 4,000 gallons/minute) from wells located within two miles of the site. Present monitoring of groundwater levels at the test site, in a third borehole completed in the 1990s, indicates the aquifer was drawn down several feet when the irrigation wells were being pumped.

The test site is located in the complex glacial landscape of east-central Illinois. Deposits of clayey glacial till and gravelly sand of the most recent Late Wisconsinan glaciation, and older Illinoian and pre-Illinoian glaciations bury a deeply dissected bedrock surface. A prominent feature on the bedrock surface, the Mahomet Bedrock Valley, underlies the test site. The bedrock valley, approximately 15.5 miles (25 kilometers) wide and almost 328.1 feet (100 meters) deep, is partially filled with the oldest deposits of glacial sand and gravel, which form an aquifer that is part of a regional groundwater system known as the Mahomet aquifer. A fiber-optic cable was lowered along the entire length of the borehole and sealed against the sidewall with grout. In the second, shallow borehole, only 131.2 feet (40 meters) deep, a fiber-optic cable was lowered down the borehole and attached along the outside of the casing.

Task F: Web-portal for the IMLCZO observatory

For the IMLCZO Data Portal (http://data.imlczo.org/clowder/), we released and deployed version 1.2 of the tools in September 2015, version 1.3 in February 2016, version 1.4 in July 2016. For version 1.2 we improved the sensor creation form based on user feedback. Better support for having multiple instruments per sensor was added to the form. For version 1.3 we developed new ways to map variables defined on sensors in the geodashboard (http://data.imlczo.org/geodashboard/) to standard vocabularies provided by the Semantic Annotation Service of the Earthcube Geosemantics framework (http://hcgs.ncsa.illinois.edu/). For version 1.4 we added the ability to require the user to sign an agreement when downloading data from the Geodashboard. For all three releases new versions of the underlying tools were deployed that include many improvements developed on other cyberinfrastructure projects. We attended several online meetings with the central CZO Data team to coordinate ways to make our data visible on their system.

Task F.3: Developing and maintenance of e-tools for coordination, communication and reporting

Designed a database and interface for the ARTool, a web based interface for tracking and documenting progress in the project.

Task G.1: Virtual engagement: website and social media

We improved and maintained IML-CZO web site. We produced 7 videos featuring IML-CZO investigators, students and activities. We produced 9 on-line text interviews featuring IML-CZO investigators, students and activities. We also produced one 3-D printed hydro-stratigraphic model as a demonstration.

Task G.2: Local CZO education-outreach activities

We conducted Science Teacher Training jointly between IML-CZO and State Hygienic Laboratory at Univ. of Iowa. The teacher workshop was conducted with 16 Iowa and Illinois K-12 teachers attending. Field and lab exercises was developed for science curriculum materials in chemistry, math, earth and environmental sciences, physics, and engineering. This effort advanced the integration of IMLCZO into University of Iowa STEM learning through the Department of Education. A report from this effort is attached.

Task H.1: Broadening research engagement

Alison Anders along with Nicole Gasparini and Nicole West proposed and chaired a session at the annual AGU meeting in Dec. 2015. The session was very successful with 25 posters and 16 talks presented including participation from 6 CZOs. The sessions were well attended. Alison Anders partnered with Nicole Gasparini and Nicole West to be special editors for a special issue of Earth Surface Processes and Landforms that centers on Landscape Evolution from a Critical Zone perspective.

Cross-CZO Workshop on Proxies for Provenance and Process (PPP):

On Oct 20-24, 2015 Purdue University hosted a conference and workshop entitled Critical Zone Science, Sustainability, and Services in a Changing World. It was organized by the U.S.-China EcoPartnership for Environmental Sustainability, the Intensively Managed Landscapes Critical Zone Observatory (IMLCZO), and the Working Group on Organic Matter Dynamics in the Critical Zone Observatory Network., The gathering brought together over 150 leading researchers and their students, with 54 traveling from China, to share the latest science related to terrestrial ecosystem function and vulnerability, and to discuss and debate options for sustainable use of natural resources. The program included two regional field trips, a training workshop, 35 poster presentations and 54 oral presentations. The gathering provided an important venue for the next generation of critical zone scientists as nearly one third of the attendees were graduate students, post doctoral researchers, and research associates. The conference attracted broad institutional participation with 22 U.S., 1 U.K., and 16 Chinese academic and research institutions represented. Members of the newly funded China Critical Zone Observatory Network were also in attendance and engaged in discussions to promote bi-national, cross-CZO research

Task I: Microbial Data Collections and Analysis

In the fall of 2015, a team led by Prof. Aaron Packman conducted field sampling across the Upper Sangamon River basin to obtain microbial samples from soil, stream sediment, stream water samples over a range of different land cover/use. They also joined the joint IML-CZO sampling campaign in November, 2015 to obtain baseline samples from three USRB sites, including Champaign County Forest Preserve, Goose Creek, and Blackford Slough-Apperson site. The samples were analyzed for microbial community composition, structure, distribution, and function. In August, 2016, the team collected 2x one-meter-deep soil cores from cropland and restored prairie, for the cross CZO Integrative Microbial Ecology Activity (CZIMEA).

Aaron's team organized a cross-CZO microbial ecology and biogeochemistry activity with support of the CZO SAVI grant obtained by the CZO National Office. Twenty-six participants having diverse expertise met to discuss needs and opportunities for synthesizing available microbial data from CZO, NEON, and related sites using emerging cyberinfrastructure tools to link relevant metagenomic and environmental data archives. Meeting attendees included 19 domain scientists (including eight early-career researchers) working at nine CZOs, five EarthCube developers, five national lab scientists, three NEON representatives, and three supercomputer center staff. 60% of attending domain scientists had a formal status at one or more CZOs, and the remaining 40% did not. Meeting attendees therefore represented a wide range of programs seeking to integrate microbial, biogeochemical, and broader earth-systems information over a wide range of scales in the CZ.

Attendees discussed several primary questions related to synthesis of microbial information with other critical-zone and earth-systems information:

- Challenges for uniform collection of microbial, biogeochemical, and physical data
- Needs, opportunities, and challenges for within and across-site synthesis
- Data systems and cyberinfrastructure needs for cross-CZO and CZO-NEON synthesis
- Recommendations and planning for cross-CZO and CZO-NEON intercomparison and data synthesis

Development of the standards identified as necessary by the cross-CZO group was then pursued with a joint CZO-NEON working group, and in collaboration with the Genomic Standards Consortium. Draft standards were presented in a second workshop at the ISME meeting in August, and associated EarthCube and other CyberInfrastructure tools were demonstrated for the community(CZOData, BiG CZ, MG-RAST, ODM2 Admin, iSamples, EcoGeo, NEON, and SESAR IGSNs).

In addition, based on the results of the 2015 CZO-SAVI workshop, we initiated a Cross-CZO soil sampling effort to investigate microbial communities across a variety of bedrock sources and climatic zones. Soils were sampled and processed in Summer 2016 for sequencing and environmental parameters from 8 of the 10 CZOs. This included sampling organized at the IML-CZO by Postdoc Lu, which involved training and participation by two volunteer graduate students. Further, Postdoc Lu generated IGSNs for all IML-CZO sampling sites, and trained CZO students and personnel on their use.

What are the Significant Results

Task A.1: Define and map fundamental landscape units

Our analyses have documented:

- rapid travel times (<3hrs) of infiltrating water to the water table
- rapid response of tile discharge to precipitation events
- utility of resistivity to map subsurface geology to a depth of 20 meters in a glaciated landscape

Task A.2 Post-settlement alluvium analysis using stream bank surveys, coring, fly ash screening, and radionuclide dating

PSA thickness in the USRB varies from 25-95 cm and is positively correlated with valley width and basin area. PSA deposition rates in the USRB and CC watersheds are approximately an order of magnitude faster than pre-settlement deposition rates, a ratio that is similar to observations from other parts of the Midwest (e.g., the Driftless zone). Fly ash from coal combustion provides a robust method for identifying post-settlement alluvium in the USRB where color and texture changes are extremely subtle across the pre-to post settlement horizon. Fly ash occurrence within visibly recognizable post-settlement alluvium in CC. Fly ash is likely to be useful for identifying PSA in other low-relief areas of the Midwest. Available data (which are somewhat limited) suggest that the rate of PSA accumulation during recent decades is similar to that observed on average through the post-settlement period. In other words, there is no evidence for decreases in floodplain sedimentation rates over the period of improved upland soil conservation practices. Reduced rates of PSA deposition in the USRB vs. CC and the Driftless zone suggest that landscape relief and loess thickness are key controls on post-settlement alluviation. USRB has lower relief and thinner loess than CC and areas in the Driftless zone. Geochemical data from USRB and CC indicate that post-settlement alluvium contains a record of atmospheric lead pollution related to the use of leaded gasoline in the 1950-1980 period.

Task A.3: Site weathering zone study locality in USB

- Soils formed over the last interglacial period (ca130-100ka) are about two times more weathered (in terms of weatherable minerals loss) than those formed over the Holocene.
- Weathering proceeds much more rapidly along and at shallow depth below fracture faces than in adjacent matrix materials.
- Initial physical and geochemical heterogeniety of these glacial deposits complicates the use of weathering indices to assess degree of weathering. Geochemical analyses using hand-held pXRF provide a rapid and economical strategy for assessing weathering changes in these deposits and for targeting zones and samples for laboratory-based analyses.

Task A.4: Model Quaternary landscape development of the IML-CZO

Observed landscape development appears to require some hydrologic connection between unchannelized uplands and growing channel networks. Channel network dynamics are relatively insensitive to channel incision rates within large meltwater valleys. Late-glacial landscape elements including meltwater valleys, moraines, lake plains and till plains strongly influence the trajectory and rates of post-glacial pre-settlement landscape evolution.

Task B.1: Experimental farm footprints through mobile sensor platforms

The size distributions and stability of small macroaggregates (i.e., 0.25-2.00 mm) are most influenced by both land management and landscape position. The small macroaggregates in the more intense, conventionally tilled sites are skewed towards smaller size fractions. The repeated tillage disturbances cut short the time needed for the aggregates to grow and stabilize. In contrast, the conservation tillage and restored prairie sites had larger size aggregates due to less frequent disturbances, allowing them to grow and stabilize. In general, across all sites, larger aggregate size fractions were found at the top of the hillslopes, while the bottom positions were more prevalent in the smaller fractions. This is attributed to the preferential removal of finer fractions from eroding portions of the hillslope.

Management and hillslope position both impacted Enrichment Ratio. The highest ER values were measured at the restored grassland site (1.50), with lower values found at the farmed sites (around 1.06). The perennial vegetation at the prairie site slowed flow velocities allowing coarser sediment to settle. As a result, the runoff was enriched in small particles with more organic matter attached. More specifically at the farmed sites, oriented roughness impacted both flow and sediment movement. Two experimental plots at the farmed site were both located at a mid-slope location and are under conservation management. However, one site had contour ridges which were perpendicular to the main flow direction. Here, the ridges acted like little dams that retarded flow and sediment mobilization. The other site had ridges that ran parallel with the main flow direction. As a result, the ER values were higher (1.17) at the contour ridge site because the backed-up flow behind the ridges allowed coarser sediment to settle.

Task B.3: SOM modeling of short- and long-term SOM storage

The ER experiments helped with the modeling and analysis of soil carbon redistribution. For the simulations of the main test field in the CCW, which are published in the Journal of Geophysical Research – Biogeosciences, the effects of management practice and hillslope location were seen in the net soil fluxes, ER, bulk density, and associated soil carbon stocks. During the historical management periods, which had higher tillage intensities, erosion fluxes from the upslope area were generally higher than those in the downslope area. High sediment fluxes from the upslope that entered the downslope section had a limited transport capacity to entrain more sediment. On the contrary, during the more recent conservation period, erosion fluxes from the upslope were lower, which means that they still had room to entrain the sediment in the downslope area. Net erosion fluxes exiting the upslope were consistently more enriched comparatively to net erosion fluxes from the downslope, suggesting that, under the same initial SOC stocks, SOC losses per unit eroded soil mass in the upslope would be greater than SOC losses per unit eroded soil mass in the downslope. The higher ER values in the upslope were attributed to the relatively more important role of rain splash (associated with greater selective transport of finer material) on the upper sections of the hillslope comparatively to the lower sections, where concentrated flow effects were more important. The trends in soil carbon stocks differed between hillslope locations. In the upslope, carbon stocks declined during the initial management period due to deep tillage practices and high-erosion rates. Soil carbon stocks eventually leveled off despite high erosion rates due to enhanced crop production rates from increased fertilizer usage and genetic seed advancements. During the conservation period, which had lower erosion rates, the carbon stock increased. In the downslope area, the carbon stocks remained high throughout due to net deposition and increased crop production.

Task D.1: Local-scale sediment budgets

Past studies have consistently shown that the random roughness decreases following a rainfall event. The rainfall and runoff smooth out the rough edges of the soil clods. An analogous phenomenon is observed in gravel bed streams where the bed material is comprised mostly of rounded rocks. However, nearly all of these past studies have had a “disturbed” bed as an initial condition. In the present study, our initial condition was an undisturbed system, though. The initial random roughness of the plots in this study was less than 1.2 mm. After the rainfall experiments, the random roughness values increased to values close to 2 mm. The post-rainfall random roughness reaches an equilibrium roughness scale depending on initial roughness condition and rainfall intensity. This however implies the existence of a characteristic scale of roughness independent of rainfall intensity, which can distinguish smooth from rough surfaces in terms of response to rainfall.

Task D.2: Watershed-scale sediment budgets

Travel times measured in the headwaters of Clear Creek using radionuclides and other tracers are shorter than those in the lower half of the system. The headwaters are very flashy (with a flashiness index of 0.36). Flash floods (4-m rises in stage in less than an hour) with high sediment loads are common occurrences in the headwaters. Overland travel distances are short and the sediment delivery ratios are near unity. Conversely, the reaches in the CCW are less flashy (with a flashiness index of 0.23). Sediment delivery ratios drop to below 0.3. The decreases in travel times and sediment delivery ratio both reflect the amount of places along the landscape where water, sediment, and nutrients can be temporarily retained. This is essentially the connectivity between the landscape and the channel.

Characterizing net sediment fluxes and rating curves within stream channels of Upper Sangamon using storm-based evaluations Analysis of sediment samples for rating curve development is ongoing. These curves will provide the basis for analyzing spatial variation in sediment flux from headwaters to downstream locations within the USRB.

We are developing short-term (i.e., single event) sediment budgets for CCW using stable and radio-isotopes to partition sediment sources. Use of the Bayesian unmixing model showed intra-seasonal patterns in the relative proportions of the upland and instream source components. Uplands sources were more dominant in May/June, and instream sources were dominant in July/August. We attribute this pattern to the interaction of land cover and climate. In late springtime, following planting, the landscape is still relatively bare; however, the system experiences the most intense rainfall. Thus terrestrial erosion is high. As the crops grow over the summer and the frequency of intense rainfall events decreases, the vegetation buffers the soils. Thus landscape sediment source is cutoff and instream sources become prominent.

We are developing short-term (i.e., single event) sediment budgets for the Upper Sangamon watershed using stable and radio-isotopes to partition sediment sources. Sediment fingerprinting results indicate that majority of fine suspended sediment in the upper Sangamon River upstream of the Saybrook sampling locations comes from grazed floodplain. Rill erosion intensified by cattle trampling on the floodplain appears to be the major erosional process. Field observations confirm that small rills and headcuts are common on the floodplain upstream of Saybrook. Analysis of two of three radionuclides suggests that a majority of sediment comes from the floodplain (7Be – 90%, 210Pb – 79%) while analysis of a third indicates that roughly equal amounts come from upland and floodplain.

Modeling of hydrologic processes using the original THREW model yields good results for modeling period from year 1994-2007. However, the model slightly over predicts sediment output due the simplified sediment generation and transport patterns expressed in the model. The relations between sediment delivery ratio and watershed area have been studied. Preliminary simulations indicate that the floodplain component does not significantly influence the stream flow and sediment output; however, refinement of the models is ongoing modeling results of sediment processes in sub-watersheds indicate the floodplain components do influence the sediment output, especially during extreme flood events.

Task E: Integrated Modeling and Critical Zone Services

Understanding eco-hydrologic dynamics under climate change

P. V. V. Le and P. Kumar

The rise of atmospheric carbon dioxide concentrations [CO_2], predicted to increase to 550 ppm by 2050 and probably exceed 700 ppm by the end of the 21th century, is amongst the most important global environmental changes. This rising rate of [CO_2] is the net consequence of anthropogenic carbon emissions in addition to ecosystem processes that release or remove carbon from the atmosphere. *One of the primary concerns with rising [CO_2] under climate change is its potential to alter hydrologic cycle through vegetation acclimation and modifications in evapotranspiration*. Modeling-based assessments at vertical scales incorporating acclamatory mechanisms suggest substantial changes of evapotranspiration (ET) losses as a result of the interaction between the responses associated with higher [CO_2] and temperature increases. Our work developed predictive capability for investigating micro-topographic controls on eco-hydrologic dynamics under climate change over large spatial and temporal scales.

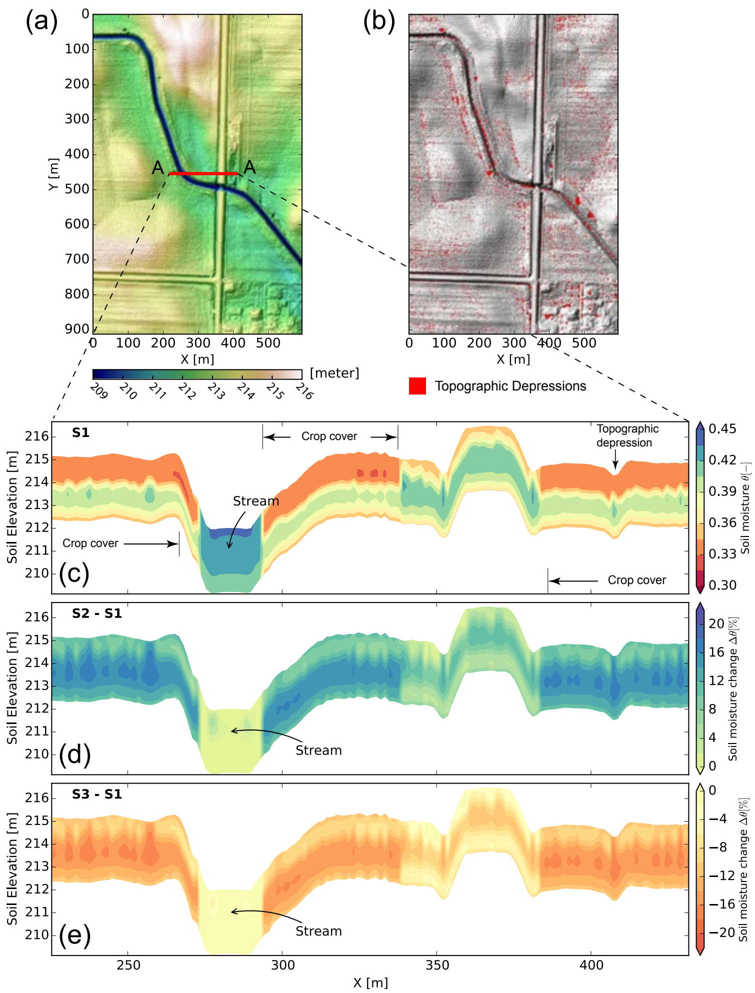


Figure 1. Comparison of soil moisture profile under present (S1 – 370 ppm) and elevated (S2, S3 – 550ppm) $[CO_2]$ conditions. Temperature in S3 is assumed 3°C higher than S1 under climate change. (a) Lidar data of a zoomed area within the simulation domain in IML-CZO. (b) Map of topographic depressions identified using lidar data. (c) Snapshot of soil moisture profile over depth in cross-section A-A at DOY 230 in 2005 growing season. (d) Difference of soil moisture profile over depth between S1 and S2 scenarios. (e) Difference of soil moisture profile over depth between S1 and S3 scenarios.

The rises of $[CO_2]$ and air temperature are expected to affect plant water-use efficiency, a key characteristic of ecosystem functioning that is central to the water, energy and carbon cycles. Characterizing alterations in eco-hydrologic dynamics associated with vegetation acclimation is critical to understand how global climate change influences ecosystem and biogeochemical processes. In this work, our simulations incorporating acclimatory mechanisms and lateral transports of surface and subsurface flow using LiDAR topographic data indicate large changes in hydrologic dynamics associated with micro-topographic variability in response to projected climate change scenarios (Figure 1). Considering the complexities and heterogeneities of hydrologic processes and their links with other environmental factors, these acclimatory responses of vegetation under global warming would have significant impacts on ecosystems, particularly those in densely vegetated and biodiverse regions where these changes are large.

The model results obtained from different scenarios show that elevated $[CO_2]$ has little to no impact on C4 plant photosynthesis. However, higher $[CO_2]$ strongly affects C4 plant evapotranspiration (ET) due to decreasing opening frequency of the leaf stomata. As a result, the reduction of transpiration rate or increase of water-use efficiency in C4 plants under elevated $[CO_2]$ condition will lead to an increase in soil moisture. This change has positive ecosystem effects under global climate change, as it could foster vegetation productivity and alleviate water stresses under drought conditions. *Given the trends in population growth and the need for doubling the food production by the middle of the century, rising $[CO_2]$*

would have significant impacts on water-use of crops and the productivity and expansion in agriculture under climate change.

Mean age distribution of inorganic soil in Intensively Managed Landscape

D. K. Woo, and P. Kumar

The distribution and transport of nitrogen in intensively managed agricultural landscapes are of significant societal concern. Due to environmental impact such as eutrophication, and human health concerns such as blue baby syndrome, our goals regarding reactive nitrogen and the nitrogen cycle are to increase nutrient use efficiency and decrease transport to water bodies. However, the problem remains a challenge due to the complexity of the soil nitrogen cycle and its interactions with eco-hydrological variability associated with plant water uptake and moisture and temperature dependent biogeochemistry. Therefore, we require a better and more nuanced prediction of nitrogen dynamics along with analysis methods to provide a better understanding of the transformation and transport properties of soil-nitrogen. We posit that one of these attributes is age, which is an estimation of the elapsed time of a constituent in a particular physical or geochemical state within a control volume. *The questions we posed are as follows: What are the temporal dynamics of nitrogen age distributions and the physical dynamics linking the age distribution to the nitrogen transformation? Do the properties of soil-nitrogen age reveal nuanced aspects of soil-nitrogen dynamics?* We develop a 1D (vertical) model for soil-nitrogen age that includes various transformations and transport associated with different processes. To facilitate the understanding of the mean nitrogen age dynamics, we also explore the age of mean non-reactive tracers such as chloride.

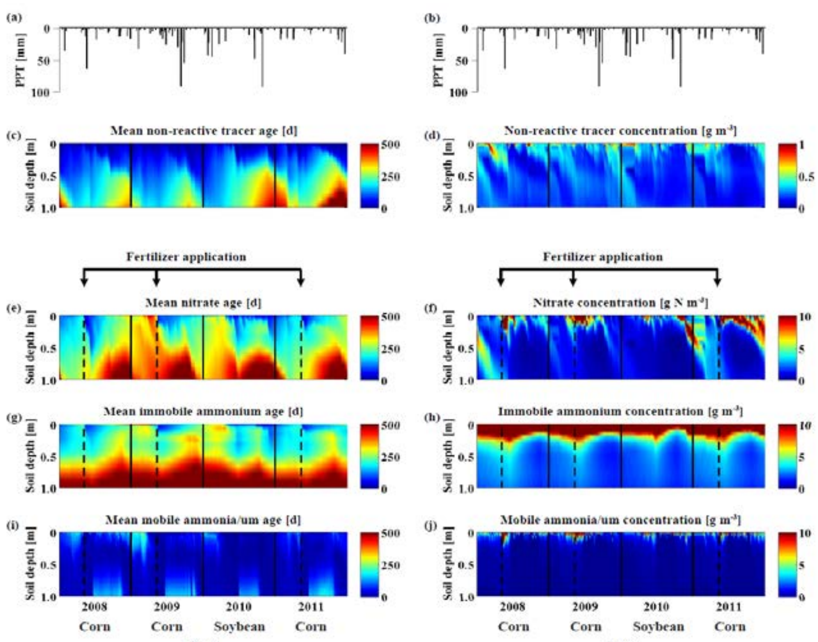


Figure 2. (a and b) Precipitation, (c) mean non-reactive tracer age, (d) non-reactive tracer concentration, (e) mean nitrate age, (f) nitrate concentration, (g) mean immobile ammonium age, (h) immobile ammonium concentration, (i) mean mobile ammonia/um age, and (j) mobile ammonia/um concentration to the depth of 1 m over a four year simulation with corn-corn-soybean rotation, which was forced by observed weather data. The solid lines and dashed lines represent the first day of each year and the day of fertilizer application, respectively.

Figure 2 shows the soil nitrate, immobile ammonium, ammonia-mobile ammonium, and non-reactive tracer concentrations and their mean age profiles to a depth of 1 m for a corn-corn-soybean rotation time period along with precipitation. *We found that the relatively high mean age of immobile ammonium compared to that of non-reactive tracer is observed at the top soil layers.* Since ammonium has positively charged ions, it adheres closely to the soil particles preventing the ammonium from leaching through the soil profile. It also shows the significantly high mean nitrate age due to nitrification in the top soil layers. These findings demonstrate that the mean ages of nitrogen transferred and transformed within the soil is dynamic, and depends on concentration as well as dynamics of nitrogen species. This study provides a proof of concept that the mean nitrogen age can serve as an additional tool to disentangle complex soil-nitrogen dynamics.

Hydrogeomorphological characterization of alluvial river valleys in glaciated landscapes: floodplain versus terrace

Q. Yan, T. Iwasaki, A. Stumpf, P.Belmont, G. Parker, and P. Kumar

It is widely known that since the last major glaciation, ending approximately 12,000 years ago, major drainage systems in the U.S. Midwest have been reorganized from the antecedent topography left by continental glaciers. However, the linkage between river valley formation and hydraulic characteristics remains incompletely understood. In this study, we examine the character and patterns of river valley geomorphic features using a high-resolution LiDAR digital evolution model (DEM) and simulate post-glacial flooding scenarios in three illustrative river valleys in the U.S. Midwest (Fig. 3). We propose a new way of quantifying geomorphic features and processes in river valleys that involves separating river valley topographic features such as floodplains and terraces. We find a direct relationship between river valley geometry and the width and height of flood water surface. This relationship suggests that an equilibrium condition of the floodplain geometry may exist. The integration of hydraulic information with geometric information enables a quantitative estimate of the maximum area at risk of flooding and identifies depositional features on floodplains. The results can be applied to both large-scale flood modeling and field characterization of the relation between floods and valley shape.

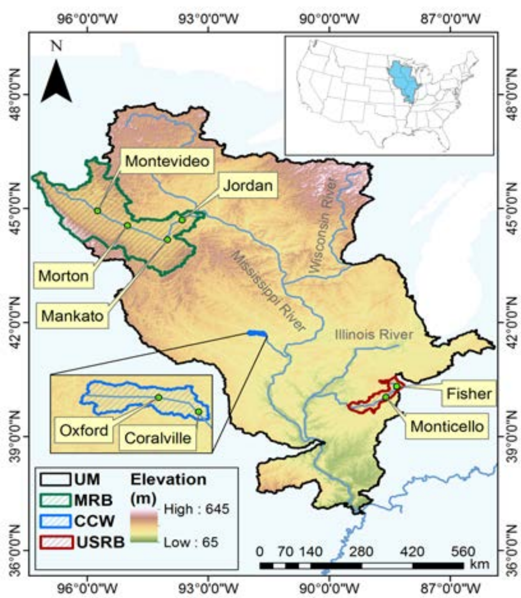


Figure 3. Spatial map of Upper Mississippi (UM) River Basin, which includes the study sites in the Minnesota River Basin (MRB), the Clear Creek Watershed (CCW), and the Upper Sangamon River Basin (USRB). CCW has longer geological time to evolve than USRM and MRB. MRB is more active then USRB in terms of sediment erosion, channel migration, and so on. Labeled locations are USGS stream gaging stations. We choose 8 river valley reaches starting from the gaging. We conduct a flood simulation using a model named iRIC. The input flow rates are bankfull discharge, 10-yr recurrence flood, and 100-yr recurrence flood. Water surface elevation and horizontal span of each discharge at steady state are measured. We also use a method, the River Valley Hypsometric (RVH) curve, to analyze the surface topography of the 8 river valley reaches.

Since there is no universal criterion to separate terraces from floodplains, it is typical to define terraces as features that are not inundated during extreme flooding events such as the 100-yr recurrence flood. The water height (labeled as Height) and water surface width (labeled as Width) corresponding to the 10-yr and 100-yr floods on every cross-section for the eight valley reaches are presented in a box-plot in Figure 4. The median values of normalized (by bankfull width (W_{bf}) and depth (D_{bf})) water surface width at the 10-yr and 100-yr floods are within the range $Width/W_{bf} = 18 \pm 4$ (the zone enclosed by the long dashed box in Figure 2a). The normalized heights of both the 10-yr or 100-yr floods progressively decrease from left to right, and asymptotically reach a roughly constant value, $Height/D_{bf} = 1.4 \pm 0.1$ (right-hand side of Figure 2b). This decrease corresponds to increasingly more mature river valleys. The values are larger in USRB because river valleys there are not yet fully developed. This relationship suggests that there may exist an equilibrium condition where the floodplain geometry is consistently proportional to bankfull width and depth. A possible explanation is that the bankfull discharge, which characterizes the hydraulic geometry and morphodynamics of the main channel, has a significant impact on floodplain formation itself.

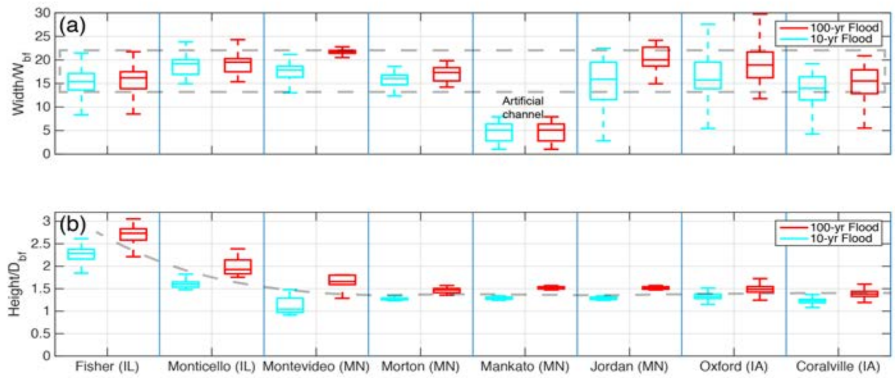


Figure 4. Box-whisker plots showing normalized water surface width (a) and water height (b) corresponding to the 10-yr and 100-yr flooding events, respectively, for the eight study sites. The long gray dashed box in (a) encloses the median values of normalized water width, and the dashed line in (b) delineates the trend of median values of normalized water height for eight study sites.

Here, we plot averaged cross-sectional lines for the eight river valley reaches (Figure 5a) and their corresponding normalized river valley hypsometric (RVH) curves (Figure 5b). We transform the cross-sectional geometry of a river valley into a relation between the height (here defined to be the vertical distance from any specified elevation to the river bottom) and the corresponding channel or valley width at that elevation. We define the height-width relationship as River Valley Hypsometric (RVH) curve. We note from Figure 3b that all of the curves more or less collapse into a single curve for the range $\left(Height/D_{bf}, Width/W_{bf}\right) < (20,2)$. The point $(20,2)$ is near the end of the lowermost low-gradient segments for all valley reaches. Combining with the flood simulation results, this overlay region on the RVH curves implies that the region within $(Height/D_{bf}, Width/W_{bf}) = (20,2)$ can be used to loosely define the floodplain. These fairly simple results may be useful in regard to related river valley research such as the morphodynamics of floodplain formation and flood risk assessment. Further analysis is needed to determine to what extent the results presented here generalize to other river valleys. However, these results are likely to be applicable to rivers in the upper Midwest of North America, as well as plains rivers in other parts of the world.

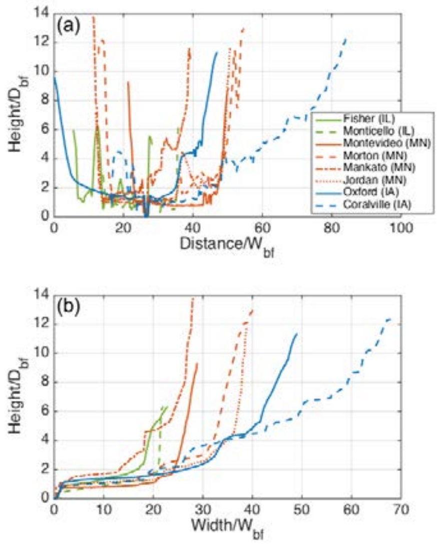


Figure 5. Averaged normalized river valley topographies for the eight study sites. a) Cross-sectional geometries. b) Normalized RVH curves. The RVH curves in USRB have only one low-gradient segment (or step), but the curves in the MRB sites have at least two obvious steps. Even though USRB and MRB have somewhat similar geologic histories, different geomorphological features can nevertheless be distinguished from the RVH curves. In MRB, the normalized scales of valley width and height are larger, and the RVH curves are more geometrically mature. The RVH curves at the two sites in CCW (Oxford and Coralville) have significantly different shapes compared with the ones in USRB and MRB. These RVH curves have more steps, larger valley width, and more gradually sloping valley walls.

A process network approach to evaluate eco-hydrologic shifts

A. Goodwell and P. Kumar

Interactions between eco-hydrologic components within the atmosphere, plant canopy, and soil both define ecosystem health and shift in response to external perturbations ranging from climate change and weather variability to land use changes. These couplings act on varying spatial and temporal scales and can involve multiple driving forces, feedback, threshold behaviors, and non-linearity. We take a process network approach to analyze couplings, in which eco-hydrologic time series variables are nodes in a network and links between nodes are information measures that shift in time scale and strength. Links that represent driving forces, feedback, or synchronization may shift as conditions change, for example from wet to dry (Figure 6). We construct these process networks for approximately 6-hour time windows of 1-minute weather station data from central Illinois between DOY 120-300, 2015. Time-series nodes are solar radiation (*Rg*), wind speed (*WS*), wind direction (*WD*), relative humidity (*RH*), air temperature (*Ta*), precipitation (*PPT*), and leaf wetness (*LWet*).

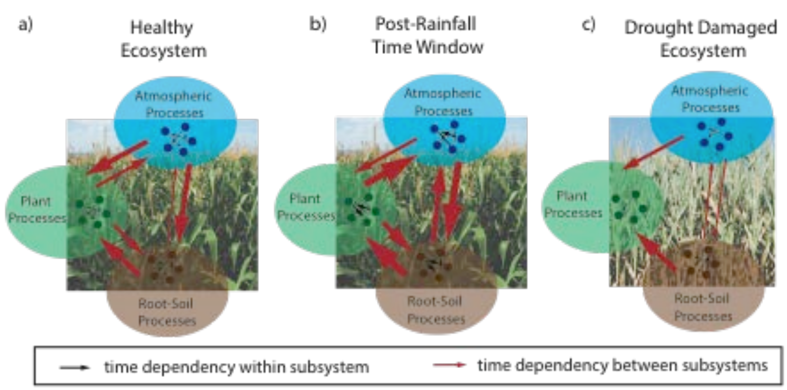


Figure 6: Conceptual illustration of eco-hydrologic process network with time-dependent interactions. (a) During an average healthy period, feedbacks exist between and within atmosphere, soil, and plant subsystems. (b) Couplings may be enhanced after a rainfall event. (c) A drought damaged ecosystem may exhibit weakened links.

We used an information decomposition framework to partition shared mutual information (*bits*) between multiple "source" and "target" nodes into redundant (overlapping), unique (individual), and synergistic (provided only when both sources known together) information quantities. In this framework, in a given time window, each node may simultaneously be a target of unique, synergistic, or redundant information from different subsets of sources. Redundant sources indicate synchronization due to feedback or forcing at fast time scales, while synergistic and unique sources generally indicate independent drivers. Results of this study show that while the source pair (*Rg, Ta)* (Figure 8b) typically provides redundant information due to their partial synchrony, a variety of source pairs provide synergistic information (Figure 7a), indicating the presence of multiple non-overlapping driving forces. We also find that network behavior shifts between day and night and with weather condition. Figure 7c-e show unique, synergistic, and redundant sources respectively to the target *LWet* for the 4 network time windows (separated by dotted lines) during DOY 124. In the early morning when a rainfall event occurred, (*Ta, RH*) are dominant synergistic and redundant sources to *LWet*. In the late morning as leaves dry, we see that (*Rg, WS*) becomes the dominant synergistic source.

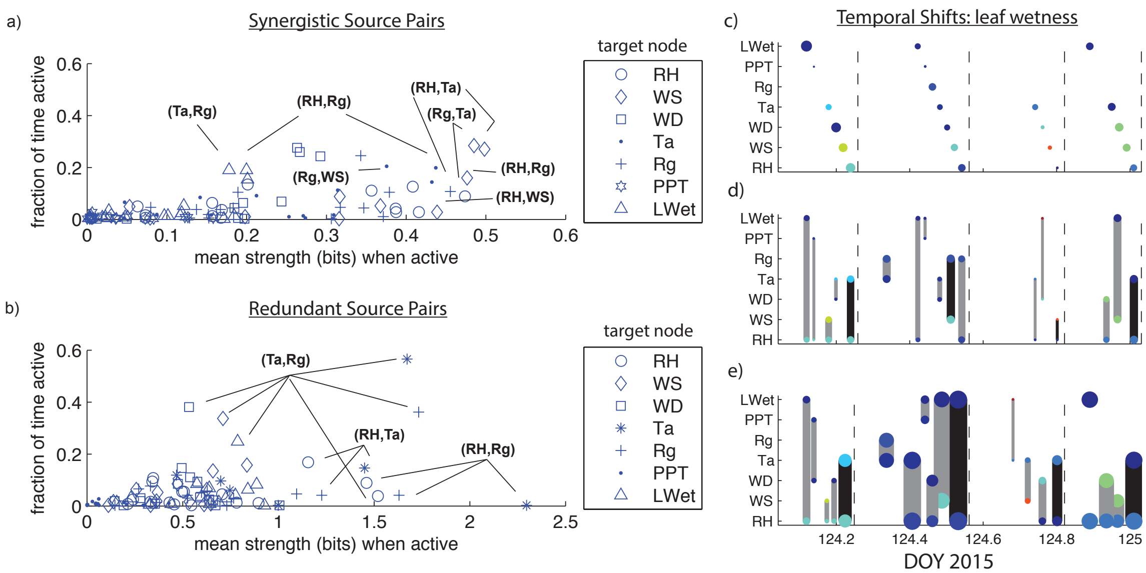


Figure 7: (a,b) Frequency (fraction out of all day-time networks) and average strength (bits) of dominant synergistic (a) and redundant (b) source pairs to each target node. (a) WS is the most common target of synergistic information, from combinations of RH, Rg, and Ta. (b) The source pair (Ta,Rg) is the most frequent source of redundant information to most targets, while (*RH,Rg*) is a less frequent but strongly redundant source. (c-e) Unique (c), synergistic (d), and redundant (e) sources to LWet for the 4 (night, morning, afternoon, night) networks constructed from DOY 124. Color and dot/line size indicate dominant time scale from 1 (blue) to 60 minutes (red) and strength (bits) of each link, respectively.

This study introduces a network and toolbox with which to identify interactions in complex networks, and reveals the nature of temporal shifts in eco-hydrologic processes as conditions vary. This improves our understanding of the sometimes weak and intricate connections between ecosystem components that lead to larger-scale properties such as ecosystem responses to drought or land use change.

Task E.2: Identification of the physical ranges for key biogeochemical and hydrological modeling parameters

Temperature measurements with 3.3-foot (1-meter) and 0.1 °C resolutions have been collected at various temporal scales, ranging from 30-minute to 2-week intervals, since June 2015. The initial data from the top 131.2 feet (40 meters) show that the temperature variations differ by amplitude and trend in each borehole. By collecting data continuously, we will be able to identify any temperature fluctuations when irrigation is occurring. We hope to understand how the geothermal regime in the shallow subsurface is correlated with climate change, artificial conduits (wells), and agricultural practices on a larger temporal scale.

Task F.3: Developing and maintenance of E-tools for coordination, communication and reporting

The ARTool has enabled efficient acquisition of the needed information for the Annual Report.

Key Outcomes or Other Achievements

Task A.2: Post-settlement alluvium analysis using stream bank surveys, coring, fly ash screening, and radionuclide dating

- Presentation of results and NC-GSA meeting
- Submission of manuscript to "Anthropocene"

Task A.4: Model Quaternary landscape development of the IML-CZO

Preliminary working model built using our own and preexisting LandLab components.

Task B: Short- and Long-Term Dynamics of Soil Organic Matter

A primary innovation of this research is the coupling of watershed erosion - organic matter cycling models with an ER module (see Papanicolaou et al., 2015). This paper offers an improved methodological framework to account for the collective effects of soil erosion on SOC redistribution in IMLs by considering monthly-aggregated changes in ER and BD. This linkage allows us to consider the effects of changing runoff coefficients, bare soil coverage, tillage depth, fertilization, soil roughness, and the effects of splash-driven interrill erosion on ER values, soil carbon redistribution, and storage. In this improved framework, WEPP supplements some missing features in CENTURY that brings the soil-column biogeochemical model to the landscape scale. WEPP can capture the downslope variability of key soil parameters (e.g., surface roughness, dry bulk density, critical erosional strength, and hydraulic conductivity) and provide dynamic updates of texture, bulk density and erosion to the active layer, all of which can strongly influence SOC fluxes, determined by CENTURY. The ER module considers separate transport capacity formulae for rill and interrill erosion to estimate selective entrainment and deposition for both rill and interrill erosion processes. The separate capacity formulae for rill and interrill areas allow for a better representation of different soil size fraction redistribution and associated SOC enrichment for the upslope and downslope areas. Additionally, this improved modeling was taken from the hillslope to the watershed scale (see the Journal of Contemporary Water Research and Education manuscript below; Wilson et al. 2016). One important aspect of this paper is the recognition that the type of carbon (labile and recalcitrant) being produced plays an important role in the soil carbon stocks. The gains in organic carbon seen with the modeling above (Papanicolaou et al., 2015) would have less of an overall impact if the carbon is comprised of readily degradable sources. The use of the Carbon Management Index, which include a lability component provided a truer assessment of sustainability for the fields of the CCW. Less intense practices lost less recalcitrant carbon, which increased their long-term sustainability. This study highlights the importance of the integrative work by the Papanicolaou team and the team of co-theme leader Tim Filley (Purdue). These two teams are looking to merge their expertise in surface carbon dynamics and carbon stabilization mechanism to foster long-term sustainability of IMLs.

Task C.2: Biogeochemical reaction and transport -mechanisms and scales

Via the use of samples from a network of ISCO samples in the Clear Creek watershed, we are studying the sources and composition of eroded materials, and especially those containing C and N, that are delivered to the waterways. Among the measurements used on the particulate phase of the stream/river suspended load are elemental (C,N), stable isotopic, and FTIR spectroscopy. Major cations (e.g. Na, K, Ba, Ca) are being measured on the dissolved phase. (1) Lime ($CaCO_3$) application is a ubiquitous treatment in agricultural systems, especially those receiving fertilizer. Dissolution of the lime via soil acid has been argued to contribute to atmospheric CO_2 as well as increased dissolved inorganic C (DIC) loads in rivers and streams as well as increased fluxes to the ocean. Particulate inorganic C (PIC) has not been considered in C-budgets. We can now document significant quantities of PIC in the suspended sediments of the two IML-CZO riverine systems. C and O-isotope indicate that this material is not unaltered (eroded) lime. Instead relatively negative $\delta^{13}C$ values show that the PIC has incorporated respired CO_2 derived from soil OM. Samples collected exiting tile drains in the Clear Creek system indicate that at least some of the carbonate is from the tile drains. We hypothesis that the dissolved lime components percolate down through soils, mix with respired DIC, and upon encountering the tile drain, precipitate as PIC. This process illustrates an unanticipated role of tile drains in the C-biogeochemical cycle. We are attempting to estimate fluxes of PIC in the IML-CZO in an effort to establish the importance to overall C-budgets. We have now documented the presence of PIC in alluvial floodplain sediments (USB, Allerton Park) and the sediments of Lake Decatur. Temporal variations in PIC concentrations have been recorded in Lake Decatur back to circa 1920's. Though we are still refining the sedimentary chronology of the lake, the PIC record appears to roughly parallel fertilizer use in Illinois. (2) We are resolving the two likely dominant sources of particulate OC (POC) and N (PN) to the streams in the watershed. Bank erosion of primarily post-settlement alluvium (PSA) appears to be a chronic source that is activated during the rising and falling limbs of a precipitation event. Surface soils with young POC are mobilized at higher threshold precipitation rates. The participation of the PSA as a source of carbon and sediment to the streams and river indicates that storage and then remobilization of eroded material can occur over the century timescale. Lowland storage of sediment and C are typically ignored in small riverine systems on active margins (such as the Eel River of N. CA) and this may have been inferred for most small systems. This is clearly not the case in low-gradient watersheds such as our Midwestern sites. This has important implications for C-budgets. Direct comparisons of surface soil C and riverine suspended load to determine C-loss from landscapes is ill-advised because not all of the fluvial material is penecontemporaneous with the current erosional sources. The mixing of POC with different ages and inferred reactivities will have an impact on the fate of the POC as it travels downstream. This in turn will impact downstream ecosystems and sedimentary records. (3) The propagation of event signals through sediment-producing systems is of interest to those of us who attempt to interpret the sedimentary record. Relating an event record to the characteristics of the actual event, such as magnitude and duration, requires a detailed understanding of how signals are generated and attenuated within a system. The Clear Creek network of samplers has allowed us to track the evolution of sediment (and C-) pulses from storm events through the watershed. Additions of POC can be seen. In at least one case, loss or dilution of C was seen in the floodplain region. This may reflect simultaneous deposition of C-rich material and remobilization of more C-poor PSA via bank erosion. Progressive peak broadening is observed as the pulse moves downstream. The variations in C- and N-isotopic compositions as a function of hydrograph will aid in the interpretation of downstream records. (4) Lake Decatur was created when the Upper Sangamon was dammed in 1922. We have analyzed a suite of 16 cores collected in the last undredged areas of the lake (the lake is currently being dredged). A sedimentary chronology (age model) is being developed using sediment texture (we believe we have cored into the original stream bed at several locations), radiochemistry (^{210}Pb, ^{137}Cs), and chemical stratigraphy. Grain size, magnetic susceptibility, and reflectivity have been used to identify what appear to be storm events. A record of C-inputs has been captured using C-isotope measurements. A clear progression to relatively more C4 plant (corn) input can be seen between the 1920's to circa 1980's and then the trend reverses towards more C3 input. We are currently trying to determine whether this is due to lake eutrophication (very likely) or a terrestrial process such as an increase in riparian buffers (also documented) or a change in crops. A record of PIC inputs has also been obtained and we are attempting to correlate it with historical lime application. The burial of POC in reservoirs is now recognized as an important source of methane to the atmosphere. Little research has been done in reservoir sediments concerning the processes responsible for methane production and their controls. Most research has focused on fluxes. Lake Decatur provides a truly unique opportunity to study methane production as it relates to watershed processes in what will be an exceedingly well-characterized system. Thus far, we have developed a proxy for methane production rate using porewater DIC $\delta^{13}C$ gradients. We see both lateral and vertical gradients within the lake bed in methane production. We are currently attempting to demonstrate that the rates correlate with burial fluxes of reactive POC.

Task D.1: Local-scale sediment budgets

Quantify erosion rates, travel times, and lag coefficients for CCW through rainfall simulator experiments. The random roughness results indicate the existence of a characteristic scale of roughness. This characteristic scale is not constant, though, since it depends on multiple factors, including soil type, residue cover, slope, initial roughness condition, magnitude and sequence of rainfall events. In the current study, the soil, residue cover and the slope of the surfaces were assumed fixed to baseline conditions.

Task D.2: Watershed-scale sediment budgets

Develop short-term (i.e., single event) sediment budgets for CCW using stable and radio-isotopes to partition sediment sources. The range of values for α and β in the PDFs are very much reflective of the degree of connectivity within the watershed and the associated variabilities in contributions, travel times, and storage of material in the watershed. Moreover, the estimated 95% credible intervals for source contributions were found to be less sensitive to changes in α and β in the enhanced framework due to the probabilistic treatments of α and β with several consequences in LULC management. From a management standpoint, a less sensitive framework is more desirable since it reduces uncertainty in decision making. Thus, by accounting for the variability in source contributions, their delivery times and storage within the watershed, we have provided a more robust framework that better quantifies uncertainty in unmixing analyses. Task D.2.4.: Develop short-term (i.e., single event) sediment budgets for the Upper Sangamon watershed using stable and radio-isotopes to partition sediment sources The results of a previous IML-CZO sediment tracing study within Wildcat Slough - a tributary of the upper Sangamon River - indicated that channel banks and floodplain forests contribute the most sediment to the fine suspended load. Two possible reasons for the different tracing results for the Saybrook and Wildcat Slough subbasins include: 1) Grazing of the floodplain upstream of Saybrook is extensive, whereas grazing of the floodplain at Wildcat Slough is limited to a small extent of this tributary near the outlet. 2) The floodplain and channel system are connected to a greater extent upstream of Saybrook than in Wildcat Slough, where channel form along much of this tributary has been altered into a drainage ditch that is disconnected from the adjacent floodplain. Thus, differences in the way in which channels and land are managed (ditches versus no ditches, grazed floodplain versus forested floodplain) in IMLs appears to be a major factor influencing the source of fine sediment in streams.

Task E.1.1: Identification of the physical ranges for key biogeochemical and hydrological modeling patameters

Data from the 328.1 feet (100 meters) deep borehole exhibit a unique thermal profile that deviates from the patterns at shallower depths and that appears to be correlated with different sediment types. Daily air temperature data for Rantoul over a 3-year period (2012-2015), obtained from the Water and Atmospheric Resources Monitoring Program (WARM) of the Illinois State Water Survey (ISWS), was used as surface temperature forcing. Subsurface temperature T at different times t and depths z in this period was simulated by using the one-dimensional heat conduction equation. Temperature time series at different depths from model results show greater amplitude attenuation and lower average temperature than those from field observations, which is caused by the difference between air temperature and ground surface temperature input data.

Task F.2: Services, workflows for data distribution and sharing

We added entries for the instruments on a new Flux tower to the Geodashboard. Created a workflow for the Flux Tower data that includes storing the raw files in Clowder and extract individual data points to the Geodashboard. The workflow also creates derived CSV files for each variable provided in the Flux Tower logs to make it easier for users to download only the subset of the data they are interested in. The metadata on the individual files includes links between files and Geodashboard datapoints. We are working with partners to help make this data easily accessible to the landowners. Developed a reusable parser for LoggerNet instruments that is being implemented at the Flux Tower and Allerton Trust Farm. Developed a reusable parser for Decagon instruments that is being implemented at the Sangamon River Forest Preserve and Allerton Trust Farm. Worked with scientists to establish a standardized data format for the DTS system for monitoring temperature along a streambed using fiber optic cables. Began to develop a parser to accommodate the 7 million datapoints that are generated daily. A node on the Nebula Cluster at NCSA (https://wiki.ncsa.illinois.edu/display/NEBULA/Nebula+Home) was purchased by the project to host the final deployment of the system. This provides much more resources for the system both in terms of disk space (30 TB) as well as CPU (120 Virtual Processors) and memory (170 GB). It also provides better short term technical support. We are in the process of setting up the system on those resources and migrate the data over. This will allow us to also make larger datasets available through the web portal.

Task G.1: Virtual engagement: website and social media

We hosted public IML-CZO bus tour in Clear Creek watershed Shuheng Zhong, Yu-Feng Lin and Andy Stumpf presented a poster "From 3-D hydrostratigraphic model to 3-D printed aquifer model" at Geological Society of America - North-Central Section Annual Meeting 2016, April 18-19, 2016, Champaign, IL.

Task H: Cross-CZO Workshop on Proxies for Provenance and Process (PPP)

The training workshop on SOM dynamics laid the ground work for the 2016 Goldschmidt Conference, Yokohama Japan, as the Organic Geochemistry theme and many of its sessions were taken right from the workshop topical discussions and led by its attendees. Three PIs from the UK-China CZO network were in attendance which fostered proposal development for a PIRE preproposal and a platform for an undergraduate study abroad program between Leeds University and Purdue in CZO science. These same groups will be meeting in China in October to discuss a Sister CZO proposal.

Task I: Microbial Data

Analysis of 2014 data revealed that habitat selection was the major mechanism shaping the distinctive microbial communities found in different habitats within the USRB watershed. Local environmental conditions influenced microbial community composition and structure. Microbial dispersal was observed within habitats, and was especially prevalent in aquatic habitats relative to terrestrial/soil habitats. Using the more-detailed CC data, we are now in the process of comparing these results along hillslopes and across major land use and geomorphic gradients (CC Zones 1-3). Further, we have begun comparing the microbial results with organic geochemistry and soil carbon data obtained by Tim Filley’s group, which will enable deduction of much more specific linkages between microbial ecology and biogeochemistry.

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

Task A.1: Define and map fundamental landscape units

Under this Task, we trained 2 undergraduates in well installation and instrumentation, water level monitoring, data collection, reduction and analysis.

Task A.2: Post-settlement alluvium analysis using stream bank surveys, coring, fly ash screening, and radionuclide dating

Under this Task, four undergrad students were trained in fly ash identification methodology.

Task A.3.1: Site weathering zone study locality in USB

Graduate student (RA) are being trained in geochemical analyses, use of pXRF, physical and chemical characterization of glacial sediments,and collaboration with scientists at other institutions (Univ of Illinois and Univ. of Nebraska-Omaha).

Task A.4: Model Quaternary landscape development of the IML-CZO

PhD student Jingtao Lai has gained skill in model development and testing as well as python programming.

Task B: Short- and Long-Term Dynamics of Soil Organic Matter

Student Training: Under the guidance of IML-CZO Co-Director Thanos Papanicolaou, there were three Ph.D. students and a Masters student who were involved in the field collection, sample processing, data analysis, and modeling components of Theme B. These include Ben Abban, Violet Freudenberg, and Christos Giannopoulos at UTK, as well as Ken Wacha, who recently graduated from UIowa. These students are mentored through frequent discussions (both organized and impromptu individual/group meetings) with their advisor and other project investigators and through regular project meetings. The students are encouraged to participate in the scientific discussions of Theme B between the Papanicolaou team and the team of co-theme leader Tim Filley (Purdue), as well as the broader IML-CZO science seminars.

CUAHSI Short Course: In late October, 2015 Co-Director Papanicolaou, along with other IML investigators, Tim Filley, Christopher Wilson, and Joshua Peschel, led a CUAHSI Instrument Training Short Course at the Purdue Agronomy Center for Research and Education (ACRE). The course was entitled “The Role of Runoff and Erosion on Soil Carbon Stocks: From Soilscapes to Landscapes” and its main emphasis was to inform students about measurements from the soil profile scale to the landscape scale that capture the effects of runoff and erosion on soil organic carbon stocks. Twenty-Five students from the US, Canada, and China, which included members of the Catalina-Jemez, Southern Sierra, Reynolds Creek, and IML CZOs, met at Purdue University to learn more about how soil organic matter moves across the landscape. The course presented to the students four key processes, namely erosion, respiration, litter incorporation into the soil profile, and microbial activity, that define the carbon budget in Intensively Managed Landscapes. Students were exposed to state-of-the-art instrumentation used to quantify key indices for these processes. These included measuring aggregate stability and enrichment ratios using a mobile unit of rainfall simulators to break apart the soil aggregates and mobilize the sediment. Additionally, the students were exposed to different methods of tracking the movement of litter and soil particles across the landscape and its incorporation into the soil matrix. These included radio frequency IDs tags, as well as stable and radioisotopes. The students were also exposed to small fixed-wing and quadrotor style unmanned aerial vehicles (UAVs) equipped with sensors currently being used in the IML-CZO and planned for use in other CZOs. The short course was run in conjunction with the Critical Zone Science, Sustainability, and Services in a Changing World workshop, which was part of the 2015

Joint Annual Symposium of the US-China EcoPartnership for Environmental Sustainability (USCEES) and the China-US Joint Research Center for Ecosystem and Environmental Change (JRCEEC).

Task C.2: Biogeochemical reaction and transport -mechanisms and scales

This project has involved one (now former) Ph.D. student and seven undergraduates at Northwestern who have received training on an array of analytical methods as well as hydrologic research in general.

Task C.2.1: DOC,POC, soil moisture monitoring in CCW experiments

Under the guidance of Co-PI Timothy Filley, there is a visiting (12 months) Ph.D. student visiting scholar (Ms. XinXin Jin) from Shenyang Agricultural University, one visiting (12 months)Associate Professor (Jufeng Zheng) from Nanjing Agricultural University, and one post-doctoral researcher (Timothy Berry) involved in the installation, testing, method development, and sample analysis with the DOC-IRMS to be used in theme C. Researchers are mentored through frequent discussions (both organized and impromptu individual/group meetings) with Co-PI Filley and other project investigators and through regular project meetings. All researchers involved in the project have also had the opportunity to interface directly industry professionals from Analytical Sciences and Sercon during the installation/testing process.

Task D.1, D.2: Local and watershed-scale sediment budgets

Student Training: Under the guidance of IML-CZO Co-Director Thanos Papanicolaou, there were three Ph.D. students and a Masters student who were involved in the field collection, sample processing, data analysis, and modeling components of Theme D. These include Ben Abban, Christos Giannopolous, and Adam Merook at the University of Tennessee – Knoxville (UTK), as well as Ken Wacha, who recently graduated from the University of Iowa (UIowa). These students are supported through frequent discussions with their advisors and other project investigators and through regular project meetings. Under the guidance of senior investigator Bruce Rhoads three PhD students Mingjing Yu, Quinn Lewis, and Muhammad Umar have participated in field data collection. Mingjing Yu has taken on primary responsibility for geochemical analysis of sediment samples, for statistical analysis of samples to determine sediment fingerprinting, for compiling and managing sediment concentration data, and for developing a model of watershed-scale sediment dynamics.

Task E.

Under Kumar's supervision, 9 graduate students are directly or indirectly contributing to the modeling and analyses studies of IMLCZO. Of these, two received PhD degrees, and four received MS degrees during this reporting period. Two undergraduate students also participated in this effort.

The IMLCZO team conducted a Modeling Summer Institute (MSI): "*High Resolution Critical Zone Modeling Framework using Hybrid GPU-CPU Architecture*", held August 16th-19th, 2016 at the National Center for Supercomputing Applications (NCSA), University of Illinois at Urbana-Champaign. The goal was to expose participants to 'Dhara' model as an open-source, interdisciplinary, and high performance CZ modeling environment for their own research. There were 20 participants (7F, 13M) including 3 faculty, 2 postdocs, 2 visiting scholars, and 13 graduate students from 5 CZOs and 1 international agency (Chinese Academy of Sciences). Prior to the MSI, 4 weekly webinars were held to cover and reinforce the theory of CZ processes involved. During the MSI, participants were provided supercomputer access and exposed to basic tutorials for MPI & GPU parallel computing. Participants learned to use the model through interactive examples specifically designed for training courses. At the end of the MSI, they are divided into 4 groups to work on different topics using Dhara model and presented findings to the audience. After the MSI, participants have been provided access to supercomputer to continue using Dhara for their research. A survey was conducted to get feedbacks from all participants. The result indicated that the MSI was helpful for most participants in their long-term research.

Professionals and students have been trained during the installation of fiber optic system, and measurement, as well as data processing. A new research project titled "High Resolution Temperature Profiling and Thermal Analysis for Geothermal Energy" is funded by the University of Illinois at Urbana-Champaign during 2016 – 2018 based on the current outcomes from the IML-CZO program.

Task G.1: Virtual engagement: website and social media

Technical writer (graduate student in Journalism and mass Communication) gained experience in communicating science activities and findings to popular media. IMLCZO team is very active on Twitter reaching a broad audience.

Task G.2: CZO education-outreach activities

From Oct 8, 2016 – Oct 18, 2016, IMLCZO Team consisting for 3 faculty (P. Kumar, T. Filley, H. Lin), one senior scientist (Y-F. Lin), 5 students (A. Goodwell, K. Wang, D. Woo, K. Goff, U. Hester), and 1 postdoc (P. Le) visited the Chinese Loess Plateau (CLP). The team was hosted by the Institute for Earth Environment – Chinese Academy of Science (IEE-CAS). This visit provided the team with an opportunity to see a loess mantled landscape developed over a period of 20 million years, understand cultural aspect of landscape change over thousands of years, and develop an appreciation for ongoing rapid changes across the landscape and societal efforts to manage environmental challenges associated with significant erosion and agricultural practices. We are working towards a joint partnership with the goal of establishing a sister CZO in CLP being led by IEE-CAS. The picture below illustrates the IMLCZO Team along with hosts from China with the CLP in the backdrop.

IMLCZO was engaged in a number of E&O activities. The Table below summarizes the number of E&O activities carried out by IMLCZO during the past year and a report from the Teacher's Training Workshop is attached.

Education & Outreach Activities	**95**
Presentations (public, academic)	38
STEM education/outreach class and field activities	23
Social Media	29
Partnerships	2
International outreach	3

Task H.1.1: Cross-CZO Workshop on Proxies for Provenance and Process (PPP)

Students and postdocs represented one third of the attendees in the conference and were an integral part of the workshop discussions and made up a majority of the poster and some presentations. The CUAHSI short course, discussed in Theme B report, run within the overall conference, directly benefitted graduate student learning related to erosion and SOM dynamics. Graduate students were also key in the organization of the conference and engagement between scientists from the U.S. and China.

Task I: Microbial Data

This project has provided training and professional development to one postdoctoral researcher, several volunteer Northwestern graduate students, and CZO students and personnel. Postdoctoral training has been provided in the form of one-on-one project discussions with PIs, group discussions and meetings, and participation in CZO, NEON, and Earthcube workshops. In addition, training has included software training, CI training (geospatial referencing, metagenomics, data archiving and analysis tools), laboratory methods training, and field methods training by the PI and Co-PIs and collaborators. We trained in total 4 postdoctoral fellows, 10 graduate students and 5 undergraduate students on sampling design, field sampling, and sample processing and analysis for microbial ecology and georeferenced CZ studies.

Professional development has been provided through a series of cross-CZO and CZO-NEON workshops. These workshops engaged a dozen postdocs and early-career researchers in community discussion, metadata standards development, and design of cross-CZO sampling programs. These workshops also provided specific overviews, demonstrations, and training in cyberinfrastructure for microbial ecology and biogeochemistry integration. Further, these workshops hosted dozens of graduate students and postdocs from other universities, providing training, high-level scientific discussion, and other professional development for many CZO-affiliated and unaffiliated early career participants.

How have the results been disseminated to communities of interest?

Task A.1: Define and map fundamental landscape units

Posters presented by 2 undergraduates at Univ.of Iowa undergraduate research symposium in July, 2016. Poster presented by one undergraduate at EPSCoR annual meeting, Cedar rapids, Iowa, August, 2016.

Task A.2: Post-settlement alluvium analysis using stream bank surveys, coring, fly ash screening, and radionuclide dating

A manuscript is currently in revision for Anthropocene. Results have been presented at North-Central Geological Society of America meeting in May 2016. Results were presented to attendees of the Watershed Improvement Research Board field trip in June, 2016.

Task A.3.1: Site weathering zone study locality in USB

Poster presented at North-Central Section meeting of the Geological Society of America meeting, April, 2016

Task A.4: Model Quaternary landscape development of the IML-CZO

Presentation to the IML-CZO research group by Jingtao Lai.

Task B: **Short- and Long-Term Dynamics of Soil Organic Matter**

Thus far, the information related to Theme B has been disseminated to outside audiences through YouTube videos, conference abstracts/ presentations, and peer-reviewed journal manuscripts. YouTube videos of the soil sampling procedure, ER experiments, and aggregate stability tests are currently online and can be found through the following weblink: http://tpapanicolaou.engr.utk.edu/videos/index.php. Additionally, aspects of the work were presented at the 2016 Goldschmidt Conference and Annual Meeting of the American Ecological Engineering Society. A specific session at the 2016 Goldschmidt Conference was organized by IML-CZO members (Neal Blair, Tim Filley, and Thanos Papanicolaou) called “Organic Matter Dynamics Controlled by Erosion and Deposition”. Finally, three manuscripts have also published in Geoderma, Journal of Geophysical Research – Biogeosciences, and the Journal of Contemporary Water Research and Education. The citations for these are listed below under “Products”.

Task C.2: Biogeochemical reaction and transport -mechanisms and scales

Some of the results have been presented in workshops and professional meetings.

Task D: Local- and watershed-scale sediment budgets

Thus far, the information related to Theme D has been disseminated to outside audiences through YouTube videos, conference abstracts/ presentations, and peer-reviewed journal manuscripts. YouTube videos of the soil sampling procedure and ER experiments. The videos are currently online and can be found through the following weblink: http://tpapanicolaou.engr.utk.edu/videos/index.php. Finally, two manuscripts have also published in Water Resources Research and the American Journal of Environmental Sciences. The citations for these are listed below under “Products”.

Task E. Integrated Modeling

- Yu-Feng Lin was invited by the Ministry of Science and Technology in Taiwan to give a lecture tour between July 25 and 29 , 2016 at Central Geological Survey, National Central University, National Science and Technology Center for Disaster Reduction, and National Chiao Tung University. One of the key topics of his lectures is "Characterizing Vertical Heat Transport and Groundwater Flow in Critical Zone."

- Yu-Feng Lin was invited to present a seminar titled “Monitoring subsurface and streambed temperature changes resulting from anthropogenic influence and climate change.” at the Construction Engineering Research Laboratory of U.S. Army Corps of Engineers on May 11, 2016.

- Yu-Feng Lin, A.J. Stumpf, Yaqi Luo, and P. Kumar, Using Distributed Temperature Sensing To Monitor Potential Subsurface Temperature Changes In An Intensively Managed Landscape, 2015 GSA Annual Meeting in Baltimore, Maryland, USA (1-4 November 2015).
- Allison Goodwell and Praveen Kumar, *A network approach to determine ecosystem vulnerability to extremes.* Poster presented at AGU Fall Meeting, Session NG31A-1833, December 2015
- Phong V. V. Le and Praveen Kumar. *Microtopographic control on ecohydrologic dynamics resulting from vegetation acclimation response to elevated atmospheric CO_2*, AGU, Fall Meet. Abstract, H41A-1273, 2015.
- Dong Kook Woo and Praveen Kumar, Impact of Hydrologic and Micro-topographic Variabilities on Spatial Distribution of Mean Soil-Nitrogen Age, AGU, Fall Meet. Abstract, B53G-0639, 2015.
- Qina Yan, Iwasaki Toshiki, Praveen Kumar, Gary Parker, *Understanding the Characteristics of River Valley Topography with Extreme Flooding Events,* GSA North-Central. Abstract, 255952, 2015
- Debsunder Dutta and Praveen Kumar, Effect of Spatial Resolution for Characterizing Soil Properties from Imaging Spectrometer Data, AGU, Fall Meet. Abstract, GC23K-1232, 2015.
- Qina Yan and Praveen Kumar, Low-relief landscape modeling with human activities, AGU, Fall Meet. Abstract, EP31B-1014, 2015
- Efi Foufoula-Georgiou, Jonathan A Czuba, Patrick Belmont, Peter R Wilcock, Karen B Gran and Praveen Kumar, Climate and Humans as Amplifiers of Hydro-Ecologic Change: Science and Policy Implications for Intensively Managed Landscapes, AGU, Fall Meet. Abstract, H33O-02, 2015
- Phong V Le and Praveen Kumar, Microtopographic hydrologic variability change resulting from vegetation acclimation response to elevated atmospheric CO2, AGU, Fall Meet. Abstract, H41A-1273, 2015
- Meredith Richardson and Praveen Kumar, Critical Zone Services as a Measure for Evaluating the Trade-offs in Intensively Managed Landscapes, AGU, Fall Meet. Abstract, H41G-1429, 2015
- Kunxuan Wang, Praveen Kumar and Debsunder Dutta, Biomass Estimation for Individual Trees using Waveform LiDAR, AGU, Fall Meet. Abstract, B43C-0558, 2015
- Praveen Kumar, Mostafa Elag, Peishi Jiang and Luigi Marini, Envisioning a Future of Computational Geoscience in a Data Rich Semantic World, AGU, Fall Meet. Abstract, IN51C-02, 2015
- Praveen Kumar, Phong V Le, Dong Kook Woo, Debsunder Dutta, Kunxuan Wang, Esther Lee, Allison Eva Goodwell, Qina Yan and Derek Wagner, Extreme Resolution Modeling of Integrated Critical Zone Processes, AGU, Fall Meet. Abstract, H52C-05, 2015
- Susana Roque and Praveen Kumar, Analysis of Long-Term Precipitation Sequencing Pattern Changes in North America, AGU, Fall Meet. Abstract, GC53B-1198, 2015
- Yu-Feng Forrest Lin, Andrew Stumpf, Yaqi Luo and Praveen Kumar, Integrating distributed temperature sensing and geological characterization to quantify spatiotemporal variability in subsurface heat transport within the Critical Zone, AGU, Fall Meet. Abstract, H53E-1702, 2015
- Derek Wagner, Phong V Le, Praveen Kumar and Dongkook Woo, High Resolution Modeling of Tile-Drained Controls on Ecohydrologic Dynamics in Intensively Managed Landscapes, AGU, Fall Meet. Abstract, H53E-1705, 2015
- Esther Lee, Praveen Kumar, Greg Barron-Gafford, Russell L Scott, Sean Hendryx and Enrique P. Sanchez-Canete, Determining the Role of Hydraulic Redistribution Regimes in the Critical Zone, AGU, Fall Meet. Abstract, H53E-1701, 2015
- Peishi Jiang, Mostafa Elag, Praveen Kumar, Scott Dale Peckham, Rui Liu, Luigi Marini and Leslie Hsu, A Smart Modeling Framework for Integrating BMI-enabled Models as Web Services, AGU, Fall Meet. Abstract, IN31C-1775, 2015

- Allison Goodwell and Praveen Kumar, *Information sharing in eco-hydrologic systems: synergy, redundancy, and uniqueness.* Oral presentation at Information Theory in Geosciences Workshop, Garmisch, Germany, April 2016
- Allison Goodwell and Praveen Kumar, *A network approach to evaluate ecosystem vulnerability.* Oral presentation at EGU, Vienna, EGU2016-1630, April 2016

- Y.F. Lin, Luo, Y, P. Kumar and A. Stumpf, 2016. *Characterizing vertical heat transport in the critical zone by using fiber-optic distributed temperature sensing*. Asia Oceania Geosciences Society 2016 Annual Conference, August 1, 2016, Beijing, China.
- Luo, Y, Y.F. Lin, P. Kumar and A. Stumpf, 2016. *Subsurface heat transport simulation with periodic surface temperature signals and groundwater flow*. Geological Society of America - North-Central Section Annual Meeting 2016, April 18-19, 2016, Champaign, IL.
- Lin, Y.F., A. Stumpf, Y. Luo and P. Kumar, 2015. *Integrating distributed temperature sensing and geological characterization to quantify spatiotemporal variability in subsurface heat transport within the Critical Zone*. American Geophysical Union Fall Meeting 2015, December 14-18, 2015, San Francisco, CA.
- Lin, Y.F., A. Stumpf, Y. Luo and P. Kumar, 2015. *Using distributed temperature sensing to monitor potential subsurface temperature changes in an intensively managed landscape*, Geological Society of America - 2015 Annual Meeting, Oral Presentation, November 1-4, 2015, Baltimore, MD.

Task F: Developing and maintenance of E-tools for coordination, communication and reporting

ARTool is a web product that is open to designated investigators as decided by the IML-CZO Executive Committee

Task G: Virtual engagement: website and social media

Field excursion, video and text on IML-CZO website and center for Global and regional Environmental Research (U of IA) website were developed.

Task H: Cross-CZO Workshop on Proxies for Provenance and Process (PPP)

The conference write up was posted on the CZO National Website, the U.S. Department of State U.S.-China Ecopartnership website, and the Purdue Ecopartnership for Environmental Sustainability website.

Task I: Microbial Data

In the past year, we held two workshops and one planning meeting on CZO and cross-CZO microbial ecology and biogeochemistry, as well as given presentations at one national meeting and one international meeting. The first workshop was the Cross-CZO Microbial Ecology-Biogeochemistry workshop at Argonne National Lab. The second workshop was held at the International Society for Microbial Ecology conference in Summer 2016. Each workshop consisted of about 30-35 participants, with almost 100 Critical Zone and NEON biogeochemists and microbial ecologists from all career stages participating, learning and contributing. In addition, one planning meeting was held at NEON, Inc. Headquarters in Boulder, CO in March 2016 to further refine metadata standards and determine how these could be applied both for multi-institution cross-CZO work and for NEON's centralized data-collection efforts.

The Table below provides a summary of outcomes:

Products	86
Journals	32
Book Chapters	1
Books	0
Thesis / Dissertation	4
Other Conference Presentations/Papers	35
Other Publications	5
Technologies and Techniques	1
Patents	0
Inventions	0
Licenses	0
Websites	5
Other Products	3

Website details:

"Dhara", an integrated modeling platform using hybrid computing (CPU+GPU) has been developed and made available as open source modeling platform. See https://hydrocomplexity.github.io/Dhara/ .

Geosemantic Framework for Model-Data Integration- EarthCube supported project for developing GeoSemantic Framework for model-data integration leverages and builds on IMLCZO data system: http://hcgs.ncsa.illinois.edu/

IMLCZO Data- A GUI based interface to IMLCZO data: http://data.imlczo.org/geodashboard/

IMLCZO Data System - A collaborative environment for IMLCZO data: http://data.imlczo.org/clowder/

IMLCZO Activities Report Tool - Website for internal tracking of activities and outcomes across different teams based on work breakdown structure : http://s-iihr32.iihr.uiowa.edu/pro/artool/

Other Audio or Video Products:

Investigator and student interviews: http://criticalzone.org/iml/news/

video production highlighting Teacher workshop http://criticalzone.org/iml/news/story/critical-zone-observatory-environmental-science-workshop/

A video that portrays an artistic rendition of Critical Zone Observatory for Intensively Managed Landscapes has been developed as an E&O tool. See https://www.youtube.com/watch?v=FkR495FJNGo&feature=youtu.be

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

During the fourth year of the project we will complete the laboratory analyses of field and experimental samples collected so far and continue with the collection of field observational data. We will aim to address how connectivity across scales impacts fluxes and emergent behavior. But most importantly we will focus on integration of field data with models across the different themes. In particular, in the broad context of the dynamics of water, carbon, nitrogen, soils and ecological processes, we will address the following questions:

- To what extent are the models informed by the data and what we can measure?
- To what extent are the measurements informed by model based open questions/hypotheses?
- How do we determine the appropriate complexity of a model?
    - High resolution
    - Coarse resolution
    - Reduced complexity
        - How does the spatial and temporal scale determine the choice(s)
- What type of questions can we address across these for IMLCZO?
- How do we/(to what extent do we) incorporate the human dimension in the models?
- We use a range of models for different process. Is it time to bring these together or reconcile advantages/differences?
- When do we need predictive models versus phenomenological models (predict past/future trajectory or predict tendencies and interactions) for IML processes?
- What type of model(s) & capabilities are required to represent the complexities we are finding in the empirical data and our evolving conceptual models?

Further, for E&O we will be continuing our web-interview video series focusing more on investigators, students and activities across IMLCZO, and in addition developing an online platform of resources, including a field component, with the purpose of delivering it to NGRREC (National Great Rivers Research and Education Center) and other Educational outreach groups, that provides a wide range of accessible activities for teachers based on CZO science. We will pilot this through 4 students currently enrolled in the Masters of Science Education Program Univ. of Iowa (the effort will be headed up by Ted Neal, Clinical Instructor of Science Education in the Department of Teaching and Learning her at Iowa, cc'd above). The platform will be developed to enable easy addition of more exercises and topics as the course is taught moving forward. We will be offering a teacher stipend during the fall, 2018 semester to field test curriculum developed by the four masters students.

E&O Report from Teacher's Training Workshop 2016

Outreach and Engagement

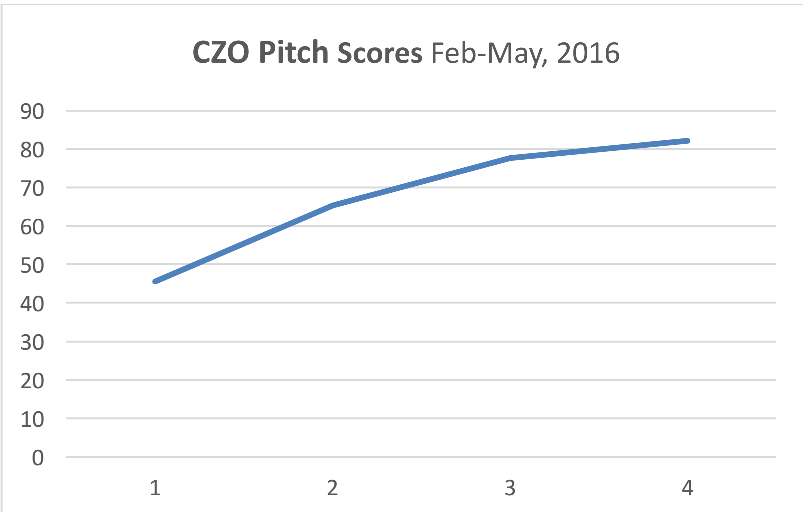
Engagement and Outreach (E & O) planning between Dr. Art Bettis (Earth and Environmental Science) and Dr. Leslie Flynn (Science Education) began in the fall, 2015. The strategic plan involved engagement of multiple stakeholders who can most effectively impact and integrate CZO topics into K-12 school practice; namely, pre-service student teachers, K-12 in-service teachers, and K-12 students. During the spring 2016, pre-service teachers designed curriculum, instruction, and assessments to be utilized in a summer workshop with in-service teachers. In-service teachers attended a 1-day field-based workshop and spent 1 month with Flynn developing curriculum integration plans in the summer, 2016. High school students in the fall, 2016 are engaging with scientists, K-12 educators, pre-service teachers, and entrepreneurs on developing solutions to the problem of integrating CZO concepts and scientific practices into K-12 schools and how to inform the public of the importance of CZO in maintaining a healthy planet and high quality of life for citizens. Moving forward in the spring, 2017 high school students will continue to advance solutions to CZO problems and pre-service teachers will revise curriculum, instruction, and assessment items after pilot testing prototypes with K-12 students and teachers.

Curriculum, Instruction and Assessment Development

In the spring, 2016 a team of 5 pre-service science teachers under the direction of Professor Flynn accepted the project pitched by Bettis and Flynn to advance a solution to the problem of how to incorporate CZO into K-12 school curriculum. Students used the STEM Innovator problem-based learning framework and assessment tools (www.steminnovator.org). Students were required to develop a prototype and receive feedback on it from peers, science teachers, professors, and community members. The prototype included an agenda, content, activities, assessments, standards implementation strategies, and a follow-up engagement model. Creating a prototype and receiving feedback from the end-users ahead of time is a crucial step in the development of E & O activities for teachers. Sharing the prototype and receiving feedback reduces the chance that large amounts of time and energy will be spent developing a product no one wants, or one that teachers do not have time to implement because it doesn't fit into their already crowed curriculum.

Students received feedback on their prototype 4 times across the course of the semester (Feb-May, 2016) by pitching during community forums (face-to-face and virtual). In total 27 individual reviewers provided 104 pitch review ratings on the project. Pitch feedback forms assess the 1) understanding of the problem, 2) viability of the solution, 3) value of solving problem and solution, 4) resources available, 5) team qualifications, 6) validation people want solved and will commit resources 7) sustainability of maintaining impact, 8) next steps strategies, 9) delivery, 10) need. Figure 1 demonstrates the statistically significant ($p<.001$) growth curve in pitch scores across the course of the semester. After each pitch students reflect on the score and written feedback and make adjustments to the strategy moving forward. Here students seek out assistance from community partners on items such as content knowledge, activities, assessments, and districts standards. The revision process is a continual feedback loop and this may have led to increased scores over time, meaning the proposed plans for the workshop were seen as improving.

Figure 1: Pitch Scores on Rapid Prototype Curricular Materials for Teacher CZO Workshop



The end result is the development of an effective summer 2016 teacher workshop that meets the needs of the teachers and solves the problem of integrating CZO topics into K-12 curriculum.

The value-add for pre-service teachers is three-fold: 1) engagement in developing authentic materials utilized in the teacher workshop, 2) experiencing the iterative process of curriculum writing and redesign based on evidence, and 3) working with community experts to produce an exceptional product.

Additionally, 15 pre-service science teachers (including 3 on the spring 2016 project) in Flynn's fall 2016 Nature of Science class reviewed summer workshop evaluation data and made recommendations moving forward.

Intensively Managed Landscape Environmental Science Workshop

<u>Participants:</u> In June 2016, sixteen in-service and pre-service K-12 teachers were invited to participate in a one-day field-based experience. Teachers were recruited from schools near the Clear-Creek watershed. Recruitment involved distributing fliers to principals, department heads and to teachers who previously participated in University of Iowa professional development programs. All teachers who applied were accepted. Table 1 highlights demographic data of the participants.

Table 1. Demographic Data for Teacher Participants in CZO Teacher Workshop

Characteristic	Number
Participants Role	
Student Teacher	3
Elementary Teacher	8
Secondary Teacher	5
Total Teachers	**16**
Participants Gender	
Female	10
Male	6
Participants Ethnicity	
White, Non-Hispanic	14 (87.5%)
Black	1 (6.25%)
Asian	1 (6.25%)
Schools	
Elementary	4
Secondary	4
Total Schools	**8**

Staff: In addition to the sixteen teacher participants, 8 staff members participated (2 UI professors, 2 staff from State Hygienic Laboratory, 3 research assistants (1 graduate, 2 undergraduate), and 1 media specialist. The interdisciplinary staff team was drawn from departments of Earth and Environmental Science, Science Education, Journalism, Civil and Environmental Engineering and the State Public Health Laboratory. Staff expertise ranged from scientific content, field-based sampling and data analysis, to K-12 curriculum implementation and assessment. Collectively the staff diversity added to the richness of the day and increased likelihood teachers would draw connections within and between disciplines.

Agenda: Participants spent half a day in the Clear Creek watershed collecting samples, analyzing data, exploring equipment used for research, completing a field activity and dialoguing with staff about implications of multiple variables on the health of the watershed. The afternoon session focused on engaging in classroom-based activities and how to implement the concepts acquired in the morning into classroom practice and the new Next Generation Science and Engineering Standards. Table 3 highlights the main agenda items for the workshop day.

Table 2. Agenda for Teacher Workshop

Critical Zone Observatory (CZO) Intensively Managed Landscapes (IML)
Environmental Science Workshop

Hosted by The University of Iowa, Department of Earth and Environmental Science, College of Education, and the State Hygienic Laboratory

June 28, 2016

Agenda

7:30 a.m.	Meet & Greet at the State Hygienic Laboratory
8:00-11:30 a.m.	Clear Creek Watershed for Field Work o Testing of water quality, including nitrate, pH, turbidity, dissolved oxygen (DO) levels in still vs. moving water o Analyzing characteristics of water, including velocity and water movement associated with ground vs. stream water o Observing biotic components of stream ecosystems, including plant and animal species living in and around the aquatic o Discovering equipment used to analyze watersheds, including tools used in testing shallow and deep wells at the field site and equipment used to collect water during rainfall events
12:00-12:45 p.m.	Lab, Lunch & Learn, State Hygienic Laboratory, Lower Level
12:45- 2:15 p.m.	Water Quality Lessons
2:15-3:30 p.m.	NGSS Curriculum Implementation, Next Steps
3:30 p.m.	Close of Workshop

What to Bring

Clothes and Special Equipment

- Items that can get wet: long pants, shoes or boots, writing utensil;
- Hat, sunglasses, sunscreen, bug repellent, and water bottle;
- Dry shoes, shorts/pants for afternoon session.

Workshop funded by the generous support of the National Science Foundation, Critical Zone Observatory for Intensively Managed Landscapes Project (NSF-EAR-1331906), and the Telligen Community Initiative (TCI) grant.

Field Activity: Participants engaged in a morning field activity to provide an overview of the IML-CZO and understand variables that impact the Clear Creek Watershed. The field study for this workshop takes place in the upper reaches of the Clear Creek Watershed study area of the Intensively Managed Landscapes - Critical Zone Observatory (IML-CZO). The main focus of the IML-CZO is to understand how intensive agricultural use of the landscape is affecting processes that shape the landscape, influence soil processes, and control the movement of sediment, carbon and nutrients from uplands to the stream network. As all participants are drawn from rural Iowa schools serving students directly impacted by agricultural practices in our community the activity addresses a real world application of interest to students and teachers. The Field Activity is found in Appendix A and focuses on water and biotic environments.

Classroom-based Activity: The afternoon classroom-based activities were developed and facilitated by the State Hygienic Laboratory (SHL). The SHL is Iowa's Public Health Laboratory conducting water quality testing across the state of Iowa. The afternoon session included a tour of the limnology facility including the collection of aquatic life found in Iowa waterways. Teachers engaged in case studies of water samples to identify aquatic life, gather information on the species generalized tolerances and overall optimal levels for aquatic life. After synthesizing all the data teacher teams decided on the quality of the water sample. Appendix B illustrates one example of a concept map developed for an aquatic species, in this example a caddisfly.

Whole-group Discussion

1. How teachers will incorporate the day's topics into classroom practice;
2. How the workshop incorporated and assisted in the understanding of the NGSS Practices of Science;
3. How the workshop incorporated and assisted in the understanding of the NGSS Disciplinary Core Ideas; and
4. How the workshop incorporated and assisted in the understanding of the NGSS Crosscutting Concepts.

The discussion served as a catalyst to introduce the curriculum work across the next month where teachers worked alone or in a team with Flynn to create a curriculum implementation plan aligned to the NGSS standards. NGSS was just adopted in Iowa and teachers are struggling with understanding how to implement, especially CZO concepts which have not been previously emphasized in K-12 curriculum. The workshop serves to increase understanding of both CZO concepts and how these fit into the new NGSS standards. Teachers also provided feedback on a) what went well in the workshop, b) what they learned, c) how they will incorporate into instructional practice, and d) how the workshop can be improved.

Curriculum Implementation

Following the teacher workshop in the summer of 2016 teachers engaged in forming curriculum integration plans focusing on how CZO concepts and practices integrate into the Next Generation Science Standards(NGSS). Teachers designed lessons for implementation focusing on the three core NGSS area: Practices, Disciplinary Core Ideas, and Crosscutting Concepts. Fifteen of the 16 teachers (94%) completed an implementation plan. Table 3 categorizes teacher plans to integrate the NGSS practices through engagement with CZO concepts.

Table 3. Integration Plan of NGSS Standards Utilizing CZO Concepts

NGSS Standard	**Teachers Citing Standard N=15 total**	**Example Teacher Response on how to Implement Standard**
1. Analyzing and interpreting data	12 (80%)	Students supplied with data from Limnologist from State Hygienic Lab and practice analyzing the meaning of that data with others in their group. This type of a lesson would work perfectly during our Diversity of Life unit. Students look for patterns in the data. Students consider the reliability and accuracy of data when they compare their own to others.
2. Engaging in argument from evidence	9 (60%)	Students use data to debate solutions to the environmental problem.
3. Constructing explanations (for science) and designing solutions (for engineering)	8 (53%)	Provide time for research on negative impact some agricultural practices have on water quality. Steer [students] to resources on till farming, water testing and share what they've learned. [Students] share best ideas for solving a problem they've read about. Students use variety of data to make an argument for whether or not a stream is high or low-quality based, then design solution. I will use activity we did in the workshop.
4. Asking questions (for science) and defining problems (for engineering)	7 (47%)	During our Weather Unit, Water Cycle, show the video that was taken the day of our workshop. Communicate [to students] testing for water quality, introducing them to the terms, units, and vocabulary we were introduced to. Since Iowa is an agricultural state, I'd like to have students brainstorm (ask questions) about how agriculture impacts water quality and changes the environment. I could give them some time

		to research and later relay some issues that are currently being raised about agriculture and our water quality While working in the field during our workshop, it was evident that scientists had seen a reoccurring problem in water quality in the field and sought to obtain quantitative data in order to determine a solution. After gathering data over time, analyzing the data, and determining the problem, scientists then worked to find a solution to improve the water quality. Secondary Modeling the asking of questions is an essential part of good science teaching and all investigations are driven by questions. Essential questions spiral throughout their academic experience, e.g. “How can we tell if we are doing a good job protecting our water resources?” or “Why are some aquatic ecosystems more diverse than others?”
5. Obtaining, evaluating, and communicating information	7 (47%)	Students using chemical assessments, measurement tools & probeware to collect data streamside. Uploading and downloading data from Iowater database.
6. Using mathematics and computational thinking	5 (33%)	Measurement with tools, practice with estimation, extrapolation.
7. Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard	3 (15%)	Both standards address the impact of weather-related hazards. The erosion of farmland and the effects of this on what ends up in our streams and rivers will be something that I now have a better understanding of and can make connections for my students. As my students collect data in the classroom as we look at stream table models and study the water cycle, I will be able to share with them how “real” scientists at the University of Iowa and around the world are collecting data and using it to provide evidence to the world about the effects of human activity on our water cycle.
8. Make observations and/or measurement	5 (33%)	Both standards (#8 and 9 listed) address the impact of weather-related hazards. The erosion of farmland and the effects of this on what ends up in our streams and rivers will be something that I now have a better

s to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.		understanding of and can make connections for my students. As my students collect data in the classroom as we look at stream table models and study the water cycle, I will be able to share with them how "real" scientists at the University of Iowa and around the world are collecting data and using it to provide evidence to the world about the effects of human activity on our water cycle.
9. Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard	3 (15%)	Students perform a cost-befit analysis to highlight solution value versus perceived negatives of pursuing the solution.

All 15 teacher respondents identified at least one NGSS standard they could address in their classroom practice based on resources and activities acquired during the summer CZO workshop and follow-up implementation meetings. A strong connection was made between opportunities to have students 1. Analyze and interpret data (80%) and subsequently make scientific claims through arguing from the evidence collected (60%). This is important as elementary students are usually not afforded the opportunity to engage in this type of investigation in class. In total teachers reported the ability to implement 9 of the NGSS practice of science standards into practice.

Following the workshop the State Hygienic Laboratory revised the workshop materials based on teacher feedback and observations by staff during activities and discussions. The final materials are found in Appendix C.

Of the 15 teachers who completed evaluations at the end of the summer, 15 (100%) said they would recommend this professional development to a colleague. Regarding the materials provided to participants, 11 of 15 (73%) could immediately implement concepts into practice and the remaining 4 of 15 would do so by differentiating the activities to their classroom environment.

Appendix A

Field Activity

The field study for this workshop takes place in the upper reaches of the Clear Creek Watershed study area of the Intensively Managed Landscapes - Critical Zone Observatory (IML-CZO). The main focus of the IML-CZO is to understand how intensive agricultural use of the landscape is affecting processes that shape the landscape, influence soil processes, and control the movement of sediment, carbon and nutrients from uplands to the stream network. This morning's workshop activities focus around water and biotic environments.

Water

Water in the Clear Creek headwaters area originates as rainfall. Depending on several factors some of that rainfall infiltrates into the soil surface and what doesn't runs off into rills, gullies, road ditches and eventually the stream. Water that infiltrates into the soil is either used by plants (ET), stored in the soil and underlying geologic deposits, or passes below the root zone through fractures or other pores to become shallow groundwater. Some of that shallow groundwater eventually discharges to the stream.
Our exercise surrounding water will compare and contrast physical and chemical properties of rainwater, shallow groundwater, and stream water.

Water parameters worksheet

Source	Temperature	pH	Turbidity	Nitrate	Dissolved O
rainwater					
stream above riffle					
stream below riffle					
shallow well					
deep well					
surface inlet tile					
subsurface only tile					

Water moves from higher to lower areas on the landscape (it flows downhill!!) and from zones with higher pressure to zones with lower pressure (sometimes uphill!!). Today we will investigate the rate and amount of water flowing down the creek and compare that with the rate and amount of shallow groundwater flowing to the stream.

The amount of water passing a point on the stream channel during a given time is a function of velocity and cross-sectional area of the flowing water.

$$Q = AV \qquad \textbf{(1)}$$

where Q is stream discharge (volume/time), A is cross-sectional area, and V is flow velocity. **Equation 1** is a form of a mass-balance equation typically referred to by hydrologists as the **Continuity Equation**.

If you change the cross-sectional area, but have to pass the same discharge, Equation 1 shows that flow velocity must increase to maintain continuity. An increase in velocity results in an increase in the energy in the flow. This means that the flow can do more work, such as erosion and transport of sediments.

There are two relatively easy methods for determining stream discharge in small streams; the float method and the velocity meter method. You will use the float method and the velocity meter method will be demonstrated.

1. **Float method** –This method measures surface velocity. Average velocity is obtained using a correction factor. The basic idea is to measure the time that it takes the object to float a specified distance downstream.

   $V_{surface}$ = travel distance/ travel time = L/t

   Because surface velocities are typically higher than mean or average velocities

   $V_{mean} = k\ V_{surface}$ where k is a coefficient that generally ranges from 0.8 for rough beds to 0.9 for smooth beds (0.8-0.85 are commonly used values) but values can be much lower in shallow rough streams.

   Procedure:

   Step 1. Choose a suitable straight reach with minimum turbulence (ideally at least 3 channel widths long)

Step 2. Mark the start and end point of your reach (upstream to downstream)

Step 3. ***If possible***, travel time should be at least 10-20 seconds

Step 4. Drop the tennis ball into the stream upstream of your upstream marker.

Step 5. Start your stopwatch when the object crosses the upstream marker and stop the stopwatch when it crosses the downstream marker.

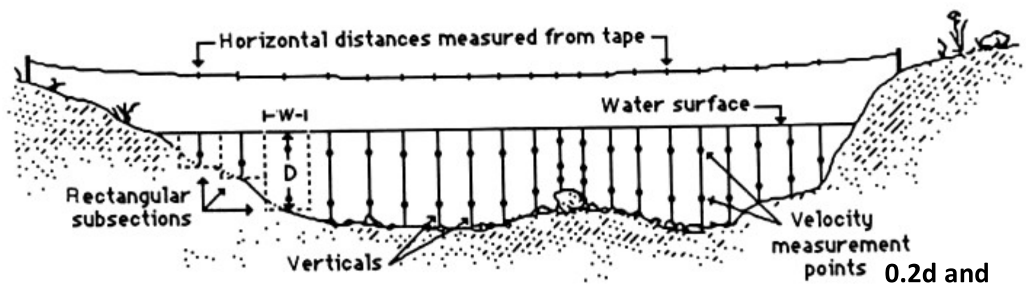
Step 6. You should repeat the measurement at least 3 times and use the average in further calculations.

Step 7. Measure the width of the stream cross-section and take 3 or 4 depth measurements to get an average depth. With an average depth and a width, you can compute an area. Correction factors to convert surface velocity to average velocity typically range from 0.8-0.9. Many times 0.85 is used.

With an estimate of cross-sectional area, discharge can be computed as Q = AV.

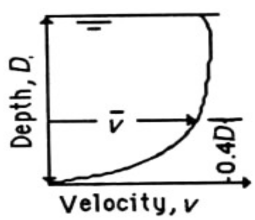
2. **Velocity meter-** When using a current meter, the stream is divided into small sections perpendicular to the stream flow and velocity and depth are measured in each section. The subsection area extends laterally from half the distance from the proceeding observation vertical to half the distance to the next (see diagram below). The width of the subsections can be variable across the cross-section. The width of each subsection is calculated by subtracting the distance to the previous vertical from the distance to the next vertical, then dividing by 2. Ideally, the stream is divided into sections so that no more than 5-10% of the discharge flows through any subsection. In practice, depth and velocity measurements are taken at *up to* 20 points along a cross section in the field while the sub-sectional widths, areas and discharges are calculated later by hand or with a spreadsheet (See example calculation below). The number of points will vary with stream width, desired accuracy, and **available time.**

   String a tape across the stream perpendicular to stream flow. Note that the zero end of the tape does NOT need to be at the water's edge. It's much easier to tie it off to a twig or branch. No one needs to hold either end.



Definition of terms used in computing discharge from current meter measurements (see text). Note variable spacing of verticals

The mean velocity is assumed to be 0.4 d from the bottom (or 0.6d from the water surface). In deeper streams (> 2.5 feet) you should take a velocity reading at 0.2d and 0.8d and then average those to get mean velocity in a section.



Example calculations for the flow meter discharge method: Data is entered in columns 2 (initial distance), 3 (depth) and 5 (velocity). Formulas in a spreadsheet are set up to fill in Interval width, area, Q interval and % total flow.

	Site:	Goblin Creek		Gage Height/Time		11/26/00 13:00	
	Date:	11/26/00		Stage:	0.243 feet or (74 mm)		
	Method:	Six-tenths					
	Tape	Width of Interval	Depth	Area	Velocity @ 0.6D	Q interval	% total flow
Left Edge of Water	9.000	1.500	0.000	0.000	0.000	0.000	0%
	12.000	2.000	0.900	1.800	0.200	0.360	2%
	13.000	1.000	1.200	[illegible]	[illegible]	0.492	3%
	14.000	1.000	1.400	[illegible]	[illegible]	1.064	7%
	15.000	1.000	1.400	1.400	[illegible]	1.134	7%
	16.000	1.000	0.500	0.500	0.810	0.405	3%
	17.000	1.000	0.600	0.600	0.770	0.462	3%
	18.000	1.000	1.600	1.600	0.810	1.296	8%
	19.000	1.000	1.700	1.700	0.620	1.054	7%
	20.000	1.000	1.450	1.450	1.120	1.624	10%
	21.000	1.000	1.500	1.500	1.350	2.025	13%
	22.000	1.000	1.200	1.200	1.470	1.764	11%
	23.000	1.000	0.700	0.700	1.290	0.903	6%
	24.000	1.000	0.600	0.600	1.350	0.810	5%
	25.000	0.750	1.000	0.750	0.880	0.660	4%
	25.500	0.750	1.100	0.825	1.270	1.048	7%
	26.500	1.000	0.000	0.000	0.000	0.000	0%
	27.500	1.250	0.700	0.875	0.820	0.718	5%
Right Edge of Water	29.000	0.750	0.000	0.000	0.000	0.000	0%
					Q total =	15.818	

W=(12-

Multiply

W=(20-18)/2

Sum

W=(29-27.5)/2

Enter data for tape reading, depth, and velocity@0.6D – excel does the rest

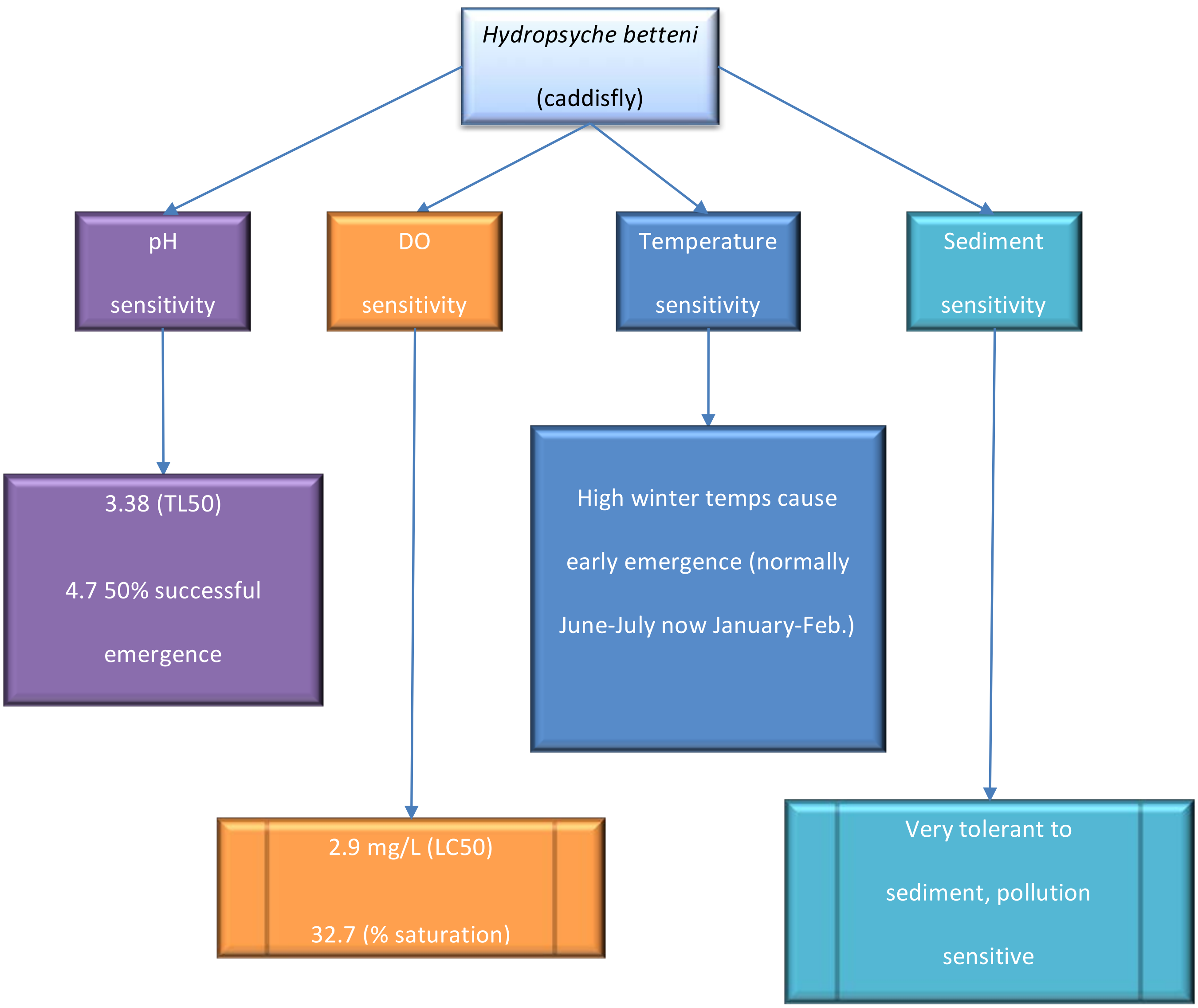
Biotic Environments

Midwestern agricultural landscapes are generally considered to have relatively low biotic diversity compared to unaltered landscapes in similar climatic settings. Nevertheless, if examine biotic diversity at a relatively small spatial scale we see significant changes in species composition and abundance even in an agricultural landscape. In this exercise we will investigate the various environments present in and adjacent to the stream, within the riparian (treed) zone around the stream, in the grassed buffer between the field and stream and in the bean field.

Some things to consider when identifying environments – add others you think of and add additional environments:

- Stream
    - Substrate
    - Water velocity
    - Water depth
    - Shade or sun?
    - Vegetation? (type?)
    - Physical and chemical properties of the water (see water activity)
- Stream bank
    - Steepness
    - Aspect (direction it faces)
    - Vegetation
- Riparian strip
    - Tree and other species
    - Height above flood level

Appendix B   Case Study



Dissolved oxygen (DO):

- 0-2 mg/L: not enough oxygen to support life.
- 2-4 mg/L: only a few fish and aquatic insects can survive.
- 4-7 mg/L: good for many aquatic animals, low for cold water fish.
- 7-11 mg/L: very good for most stream fish/insects.

---

pH (acidity):

Temperature:

- Maximum temperature for warmwater fish is 27 C° (80.6 F˚)
- Maximum temperature for coldwater fish is 20 C° (68 F˚)

Turbidity (sediment concentration):

- 0 JTU ➲ Excellent
- >0 to 40 JTU ➲ Good
- >40 to 100 JTU ➲ Fair
- >100 JTU ➲ Poor

JTU: Jackson Turbidity Unit: Amount of cloudiness/haziness of a fluid caused by particles (like smoke or fog in the air)

Dissolved Oxygen (DO): Amount of oxygen present in water (measured in milligrams per liter)

http://extension.usu.edu/waterquality/whats-in-your-water/aquatic_macroinvertebrates (water quality standards)
https://programs.iowadnr.gov/bionet/ (aquatic macroinvertebrate specifics)
http://www.iowadnr.gov/Environmental-Protection/Water-Quality/Water-Monitoring/IOWATER/Library (water quality in Iowa)

Appendix C : Post Workshop Revisions

Table 1. Participants: Critical Zone Observatory (CZO) 2016 Summer Workshop

Participant	Role	Organization	Discipline*
1. Alex Hardcastle	Student Teacher, Undergraduate	Earth & Environmental Science, College of Education, U of Iowa	EES, SCI EDU
2. Amanda Solomon	Student Teacher, Undergraduate	Earth & Environmental Science, College of Education, U of Iowa	EES, SCI EDU
3. Carolyn Walling	High School Teacher	Iowa City West HS	Chemistry
4. Chad Hippen	Elementary Teacher	Lincoln Elementary	All Science K-5
5. Dan Hill	Middle School Teacher	Northwest Junior High	All Science K-5
6. Danielle Lopez	Elementary Teacher	Lucas Elementary	All Science K-5
7. Heather Davidson	Middle/High School Teacher	North Cedar Jr/Sr HS	Computer, ENG
8. Kirk Ryan	Elementary Teacher	Robert Lucas Elementary	All Science K-5
9. Lisa Murray	Elementary Teacher	Weber Elementary	All Science K-5
10. Marianne McGrane	High School Teacher	Iowa City West HS	Physical Science
11. Mary Jo Williams	Elementary Teacher	Weber Elementary	All Science K-5
12. Matt Cain	High School Teacher	West Branch HS	Physics, ENG
13. Monique Cottman	Elementary Teacher	Longfellow Elementary	All Science K-5
14. Rebekah Doymayer	Student Teacher and Research Assistant	College of Education, State Hygienic Laboratory, U of Iowa	SCI EDU
15. Tracy Elmer	Elementary Teacher	Weber Elementary	All Science K-5
16. Yukiko Hill	Elementary Teacher	Lincoln Elementary	All Science K-5
17. Sarah Parcher	Undergraduate Research Assistant	University of Nebraska	EES
18. Art Bettis	Professor, Earth & Environmental Science	Earth & Environmental Science, U of Iowa	EES
19. Erica Larson	Laboratory Education Manager	State Hygienic Laboratory, U of Iowa	SCI EDU, STEM
20. Jazmin Lopez	Undergraduate Research Assistant	U of Iowa	CEE
21. Katie Goff	Graduate Research Assistant	U of Iowa	EES
22. Nick Fetty	Media Specialist	U of Iowa	Communications
23. Leslie Flynn	Professor, Science Education	College of Education, U of Iowa	SCI EDU, STEM
24. Rick Bonar	STEM Coordinator	State Hygienic Laboratory, U of Iowa	STEM
***NOTE:** ESS= Earth & Environmental Science, SCI EDU= Science Education, CEE=Civil and Environmental Engineering, ENG= K-12 Engineering, STEM=K-12 Science, Technology, Engineering and Mathematics			

Budget

	y1	y2	y3	y4	y5		Year 1	Year 2	Year 3	Year 3 (Actual Expenses)	Yr 1 + Yr 2 + Yr 3	Yr 1 + Yr 2 + Yr 3 (Actual + Encumb-rances)	Year 4
A. Senior Personnel													
Kumar	-	-	-	0.25	0.25	mos.	$ -	$ -	$ -	$ -	$ -	$ -	$ 5,390
Anders	0.25	0.25	0.25	0.25	0.25	mos.	2,134	2,220	2,308	-	$ 6,662	6,447	2,401
Rhoads	0.25	0.25	0.25	0.25	0.25	mos.	3,540	3,681	3,829	3,849	$ 11,050	10,980	3,982
Keefer	1.50	1.50	1.50	1.50	1.50	mos.	9,491	9,870	10,265	-	$ 29,626	9,347	10,676
Peschel	1.50	1.50	1.50	1.50	1.50	mos.	11,613	12,078	12,561	-	$ 36,252	14,964	13,063
Luigi Marini	1.45	1.45	1.45	1.45	1.45	mos.	8,257	8,587	8,931	5,090	$ 25,775	20,862	9,288
Parker	-	-	0.25	-	-		-	-	6,136	-	$ 6,136	-	-
Garcia	-	-	-	0.25	-		-	-	-	-	$ -	-	6,423
	-	-	-	-	-		-	-	-		$ -		-
B. Other Personnel	-	-	-	-	-		-	-	-		$ -		-
Post Doct	-	-	-	6.00	6.00	mos.	-	-	-	-	$ -	-	42,511
Field Tech	2.50	3.00	3.00	3.00	3.00	mos.	11,458	14,300	14,872	15,118	$ 40,630	28,556	15,467
IT	4.00	4.00	4.00	4.00	4.00	mos.	21,667	22,533	23,435	18,346	$ 67,635	66,546	24,372
Research Assistant - Post BS	-	-	-	-	-	mos.	-	-	-		$ -		-
Research Assistant - Post MS	22	22	22	24	24	mos.	44,000	45,760	47,590	49,032	$ 137,350	114,140	53,993
Research Assistant - Post Pre	-	-	-	-	-	mos.	-	-	-		$ -		-
	-	-	-	-	-		-	-	-		$ -		-
Hourly	200	350	350	500	500	hours	1,947	3,500	3,500	46,216	$ 8,947	65,666	5,760
Total Salary and Wages							114,107	122,530	133,428	137,651	$ 370,065	337,507	193,326
C. Fringe											$ -		
Academic 44.67%, RA 5.99%, Hourly 7.79%							33,234	35,743	39,903	30,071	$ 108,881	81,181	63,350
											$ -		
Total Personnel							147,342	158,273	173,331	167,723	$ 478,945	418,688	256,676
											$ -		
											$ -		
D. Equipment											$ -		
							72,666	83,312	27,534	30,357	$ 183,512	115,902	7,038
E. Travel							-	-	-		$ -		-
Domestic							10,892	12,500	12,012	11,796	$ 35,404	32,200	12,500
Foreign							1,500	3,000	3,000	3,303	$ 7,500	3,303	3,000
							-	-	-		$ -		-
F. Paticipant Suppot							-	-	-		$ -		-
							7,500	24,900	28,500	14,570	$ 60,900	42,645	
							-	-	-		$ -		-
G. Other Direct Costs							-	-	-		$ -		-
Materials and Supplies							14,014	24,900	24,312	11,566	$ 63,225	40,745	15,872
Publications							3,000	6,000	6,000	144	$ 15,000	1,967	6,000
Services							4,000	4,000	4,000	25,511	$ 12,000	57,392	4,000
Budget Pool (Discretionary+E&O)											$ 47,702		19,473
IA (Univ. of Iowa)							160,956	187,006	89,423	92,474	$ 437,385	365,510	111,479
UTK (Univ. of Tennessee)							72,143	95,923	93,337	69,766	$ 261,403	202,573	105,882
IU (Indiana Univ.)								26,607	66,274	45,696	$ 92,881	92,302	67,449
NU (Northwestern Univ.)							101,939	83,665	85,340	53,520	$ 270,944	198,328	87,081
PS (PennState Univ.)							17,298	20,484	20,805	10,686	$ 58,587	34,430	21,138
MN (Univ. of Minnesota)							50,542	-	42,555	(46,039)	$ 4,503	4,503	-
PU (Purdue Univ.)							106,820	97,604	103,706	164,972	$ 308,130	295,228	74,281
Tuition -- 62% of RA Salary							27,280	28,371	29,506	29,010	$ 85,157	64,660	33,476
Total Other Direct Costs							557,992	574,561	565,257	503,346	$ 1,697,810	1,357,636	546,130
											$ -		
Total Direct Costs							797,892	856,546	809,633	731,094	$ 2,464,071	1,970,374	825,344
I. Indirect Costs													
											$ -		
Facilities and Admin. 58.6% of UIUC TDC less tuition and equipment							105,918	122,282	130,475	127,545	$ 358,675	395,799	174,656
Facilities and Admin. 58.6% of first $25000 of Sub							73,250				$ 73,250		
Total Project Cost							**$ 977,060**	**$ 978,828**	**$ 940,109**	**$ 858,638**	$ 2,895,997	**$ 2,366,173**	$ 1,000,000
+Supplementary grant from NSF (to Purdue Univ.)								$ 30,367			$ 30,367	$ 30,367	
Carry forward											$ -	**$ 529,824**	

Year 4 Budget Justification

The year-4 budget is in-line with that proposed initially, except for the following adjustments:

1. Indiana University was established as a new sub-contract in year 2 as Prof. Adam Ward, who was previously with Univ. of Iowa, has moved to Indiana University. A budget transfer of $66,449 in year 3 from Univ. of Iowa to Indiana University is included to accommodate this new sub-contract.
2. Since Year 2, some re-scoping of Education and Outreach activity has been done to take advantage of the activities available at Univ. of Iowa. Funds have been reallocated from Univ. of Minnesota to Univ. of Iowa. A budget transfer of $62,160 from Univ. of Minnesota to Univ. of Iowa was included to accommodate this re-scoping. However, since Dr. Doug Schnoebelen, Director of E&O activities at Univ. of Iowa, has taken a new position in January 2016, prof. Art Bettis has taken the lead on E&O activities. As a result the Sub-contract for Univ. of Iowa has been revised upward from $82,986 to 4111,479.

The budget consists of the following categories of expenditures, listed with specific justification for each category.

Section A. Senior Personnel

The highly interdisciplinary nature of the proposal requires expertise and people from a variety of backgrounds. Nominal salary support is included for our inter-disciplinary team whose names and responsibilities are listed below.

- **Praveen Kumar** will serve as the ***Director*** and, in consultation with the Executive Committee, will set goals to accomplish the vision of the CZO, allocate resources, and work with academic and other partners to achieve objectives pertaining research, diversity, partnerships, and education and outreach. He will also be the primary liaison with NSF and other institutions and agencies and will be responsible budget reallocation decision as needed to meet the project goals.
- **Alison Anders** will serve as a Co-PI and a Co-Leader for Theme A.
- **Bruce Rhoads** will serve as a Co-Leader for Theme D.
- **Laura Keefer** will serve as a Site and Facilities Coordinator.
- **Josh Peschel** will serve as a Site and Facilities Coordinator.
- **Luigi Marini** will serve as Coordinator for Data Support System and IT Technologies.
- **Gary Parker** will provide expertise on river morphodynamics.
- **Marcelo Garcia** will provide expertise in sediment transport.

Section B. Other Personnel

- **Post doctoral research associate** (Mentoring guidelines for postdocs was attached in supplementary documents with the original submission].
- **Graduate Students***:* A number of graduate students are expected to be supported throughout the duration of the CZO.
- **Undergraduate hourly:** We have budgeted for a number of undergraduate students to be engaged in the CZO research and education activities.
- **Field Technician:** A 2.5-month FTE is included to support field technician. We expect that this could be paid to more than one person to allow us to tap specialized expertize as needed.
- **IT Personal:** A 4-month FTE is included to support data and computer support services.

For all personnel appointments, preference will be given to women and under represented minority.

Section C. Fringe Benefits

These costs are associated with Section A and B, and amount to 44.67% of wages paid to senior personnel and Postdoctoral Research Associates; 5.99% of the graduate research assistant's wages; and 7.79% of the undergraduate student wages.

Section D. Equipment

The breakdown of the equipment budget is given below. Given the nature of the project and the requirement to be agile and opportunistic in measurements in response to weather and other events, we expect that different quantities of equipment listed below or even equipment not on this list may be required and the funds will be re-budgeted as needed.

Component	Model	Quantity	Cost/Unit	Year 1	Year 2	Year 3	Year 4	Year 5
30-ft Universal Tower w/ Adjustable Mast	UT30	2	$5,000	$5,000	$5,000			
Open Path Eddy Covariance System	-	2	$23,910	$23,910	$23,910			
Time Domain Reflectometer (TDR) System	TDR100	3	$6,920	$6,920	$6,920		$6,920	
Turbidity and Temperature Monitoring System	OBS-3A	3	$6,800	$6,800	$6,800	$6,800		
Weather/Eto Station	ET107	3	$5,260	$5,260	$5,260	$5,260		
Hydroinnova Cosmic-Ray Soil Moisture Probe		4	$12,500	$12,500	$12,500	$12,500		
Data Server		1	$8,500	$7,276	$1,224			
Raid Data Storage						$2,974		
Compute Server 1		1	$26,698	$5,000	$21,698			
Compute Server 2		1	$17,212				$2,212	$15,000

Section E. Travel

Travel budget is based on estimates for Co-PIs to attend CZO Coordination meetings organized by NSF and IMLCZO strategic planning meeting organized by our team. We expect about two CZO strategic planning meetings each year. The travel budget also includes field site travel expenses by the CZO team members. The sites are in Illinois, Iowa and Minnesota. When full day or longer travel is required, meals and lodging costs will also be covered. It also incorporates estimates for attendance at conferences by Co-PIs and students/postdocs and included are the cost of travel, per diem, and conference registration. It also includes the cost of travel for the Advisory Committee members (three people) for one meeting per year. Travel budget also includes cost of travel for visitors or potential CZO users as CZOs are expected to engage a broad scientific community; and the cost of national and international travel by the Co-PIs to foster such engagement.

Section F. Participant Support Cost

Participant support cost is included to support a Summer Institute and hosting of external scientists during years 2 through 5. It also includes cost associated with CZO strategic planning meetings (about two a year) and other collaboration meetings. Both Summer Institute and strategic planning meetings include breakfast, lunch, coffee/snack breaks, and dinner. Catering will be needed. Travel for outside visitor is budgeted for airfares and hotel accommodations. Conference facilities may be used and rental for equipment may be required. Each planning meeting will be attended by about 25 people. The meetings will be at UIUC and other partner institutions.

We have carry forward budget of $18,255 in our Participant Support Cost at Univ. of Illinois. This is sufficient to meet the needs for the 4th year of the project. We would therefore like to request that the funds ($28,500) originally budgeted as Participant Support Cost for Year 4 be reallocated to support a post-doctoral research associate. Similarly, we request that $20,000 allocated to Purdue Univ. and $8000 allocated to Penn State Univ. as Participant Support Cost be rebudgeted to equivalent support for students and/or postdoctoral research associate at the respective institutions. We expect to meet the original goals of Cross CZO synthesis and attracting external scientists to the site through our carry forward funds in this category. The need for synthesizing across experimental and modeling effort is significant and this allocation will help us support this crucial activity at this stage of the project.

Section G. Other direct costs

Funds are budgeted for consumable materials and supplies, cost of maintenance and repairs of field facilities and computer equipment, and software purchase and licenses at a level expected for the operation of a CZO. We also include costs of laboratory analyses of samples and production of educational materials to meet the CZO E&O goals. We also expect to pay for services for drilling, construction of platforms for deployment of instruments in the field and their management, services for data transmission from the field through wireless or cellular phone network, and repair of existing equipment for deployment as part of the CZO effort to allow leverage and integration with other projects related to the CZO science theme. Budget for Laptop computers need for data collection in fieldwork is included. Publication costs and NCSA computer support costs are also included. Tuition Remission is charged at 62% of graduate research assistant wages as a direct cost.

Section I. Indirect costs
The usual indirect costs are applicable. They amount to 58.6% of Direct Cost excluding equipment, and tuition.

Subcontracts
Subcontract charges are included for all Institutions that are partners in this effort: University of Iowa, Purdue University, PennState University, University of Minnesota, Northwestern University, Univ. of Tennessee, and Indiana University.