Applied Earth Observations Innovation Partnership Webinar Series
February 28, 2023, 11:00 am – 12:00 pm EST

AGENDA (US Eastern Time)

- 11:00 am: AEOIP Welcome and Updates
  Andy Hudak, USDA Forest Service | Sabrina Delgado Arias, Science Systems and Applications, Inc.
- 11:05 am: Development of successful pathways for Earth Observation data uptake into land management decision-making – USFS and NASA Perspectives.
  Everett Hinkley, USDA Forest Service & Keith Gaddis, NASA Headquarters
- 11:25 pm: Transcriptomics from Space: Linking Remote Sensing to Tree Gene Expression to Monitor Forest Responses to Water Availability
  Nathan Swenson, University of Notre Dame Environmental Research Center
- 11:45 am: Discussion and Q&A

This seminar will highlight a new project that cross-leverages genomics and satellite remote sensing to better understand threats to forest health following drought and water stress. The project is led by **Dr. Nathan Swenson from the University of Notre Dame Environmental Research Center** in support of a public-private partnership between NASA's Ecological Conservation Program and the biotechnology company, Illumina. How can this new research help lead to improved management strategies to ensure the health and resiliency of forests in a changing climate? We invite you to join us to learn more about this new methodology and to share with us how information derived from this project may contribute to your management priorities.

Everett Hinkley, National Remote Sensing Program Manager for the USDA Forest Service, and **Keith Gaddis, Program Manager for the NASA Ecological Conservation program**, will kick-off this seminar with an overview of current efforts at their respective agencies to help identify and facilitate the development of successful pathways for Earth Observation data uptake into land management decision-making.

Transcriptomics from Space: Linking Remote Sensing to Tree Gene Expression to Monitor Forest Responses to Water Availability
A great deal of progress has been made over the past two decades to the determine the distribution of species and biodiversity by describing how key plant traits relate to environmental gradients. This progress has been made possible through a focus on a handful of traits depicting important tradeoffs that can be measured relatively quickly across large numbers of species using standardized protocols. A downside of this approach, however, is that a great deal of the functional diversity within and across individuals and species cannot be assayed and the dynamic responses of individuals to changing environmental conditions is often not measured. Transcriptomics, the sequencing and analysis of all the functional genes expressed in a tissue, has the potential to transform the field of functional ecology and to overcome some of these previous barriers. While transcriptomic studies have been previously limited to a few model species and highly controlled conditions, recent work has demonstrated the ability to

carry out transcriptomic studies in the wild on non-model tree species. This includes work demonstrating that the degree to which species express similar genes under drought conditions provides far better predictions of tree species distributions in a natural stand when compared to commonly measured plant functional traits. Given evidence that remote sensing can detect differential gene expression in crop systems and tree responses to environmental stress and traits related to photosynthesis, it stands to reason that it is possible to estimate pixel-level gene expression via remote sensing to estimate how tree species are distributed on a landscape and how they function through a growing season and in response to water deficit.

In this talk, I will introduce new research that leverages our previous work quantifying gene expression in response to drought for the dominant tree species found in northern Wisconsin and supplement this with additional physiological and transcriptomic information and remote sensing products from ECOSTRESS, GEDI, and DESIS. This research addresses the following questions:

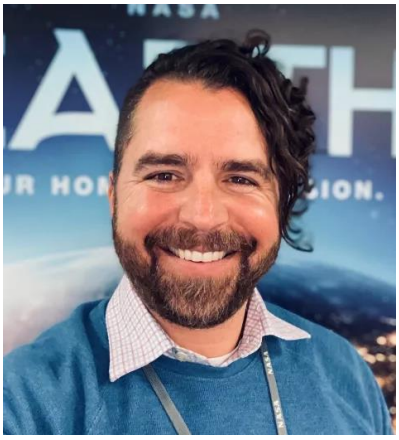
- how well does inter-specific diversity in hyperspectral and thermal infrared signatures map onto leaf gene expression in individual canopy tree species during the growing season and under non-drought and drought conditions?
- given that species with similar gene expression responses to drought cluster topographically, can remotely sensed information regarding topography, seasonal water stress and leaf traits be used to map pixel-level gene expression on the landscape?
- and, finally, how well can we predict the distribution of species and their gene expression through space and time on the landscape using remotely sensed information?

The approach includes greenhouse and field studies to confirm a linkage between gene expression and hyperspectral and thermal infrared signatures, measurements of leaf gene expression coinciding with the timing of satellite-based measurements and out-of-sample prediction of tree species distributions and gene expression based upon remotely sensed information. The work will be conducted using two long-term research sites in northern Wisconsin and the upper peninsula of Michigan – one is a Smithsonian ForestGeo long-term forest dynamics plot and the other is a NSF NEON site.

Nathan Swenson is the Gillen Director of the University of Notre Dame Environmental Research Center and a Professor of the Biological Sciences. He is a plant biologist by training with a research focus on using phylogenetic and functional information to understand the distribution and dynamics of biodiversity through space and time. He received his Ph.D. in ecology and evolutionary biology in 2008 from the University of Arizona and was a National Science Foundation postdoctoral fellow in bioinformatics with the Center for Tropical Forest Science at the Arnold Arboretum, Harvard University. Since he began his Ph.D. in 2004, Swenson has published over 170 peer-reviewed journal articles and book chapters and two books, and he has received research

grants to support his work on topics ranging from ecosystem carbon flux to gene expression. His primary research contributions of note have been the integration of phylogenetic information and plant trait data into community ecology with a special focus on diverse tree assemblages. In recognition of his work integrating phylogenetic and functional trait information across scales, Swenson has been named a Fellow of the John Simon Guggenheim Memorial Foundation in the "plant sciences" category. He also received a 2011 Jasper Loftus-Hills Young Investigator's Award from the American Society of Naturalists and the 2012 Ebbe Nielsen Prize from the Global Biodiversity Information Facility.

Everett Hinkley is the National Remote Sensing Program Manager for the USDA Forest Service located in Washington DC. In this position, Hinkley is responsible for providing national remote sensing program guidance and coordination to Forest Service field units throughout the United States and serves as the Forest Service remote sensing liaison to other federal and state agencies. In June 2013, he was appointed to the position of USDA Senior Advisor to the National Coordination Office for Space-Based Positioning, Navigation, and Timing, and is the USDA representative to the Civil Applications Committee. Areas of focus include land cover mapping, forest change detection, wildfire mapping and the evaluation of unmanned aerial vehicles and new sensors for land management applications. He holds a Master of Science degree in Mapping and Geographic information systems from Ohio State University and a Master of Science degree in Geology from Miami University of Ohio.



Keith Gaddis is the program manager for the Ecological Conservation program and the program scientist for the Biological Diversity program at NASA Headquarters. He is a former AAAS Science and Technology Policy Fellow, visiting assistant professor at Texas A&M University and Peace Corps volunteer in the Islamic Republic of Mauritania. Keith is an ecologist and biogeographer by training with expertise using remote sensing and genetics to address questions in ecology, evolution and conservation biology. He has worked in ecosystems across Africa, South America, Europe and North America—examining how environmental disturbances have shaped natural history and determine future population viability. Keith is a vocal advocate for science communication and the use of science for public decision-making. Keith represents NASA in several interagency relationships with other executive branches and private organizations and is involved in several NASA Earth Science Division and NASA Science Mission Directorate efforts to open transparency and opportunity across NASA funded activities. In 2020, he received NASA's Early Career Public Achievement Medal. Keith received his bachelor's degree from the University of Iowa, with a double major in Biology and Environmental Science. He completed his Ph.D. in Biology at UCLA in the Department of Ecology and Evolutionary Biology.