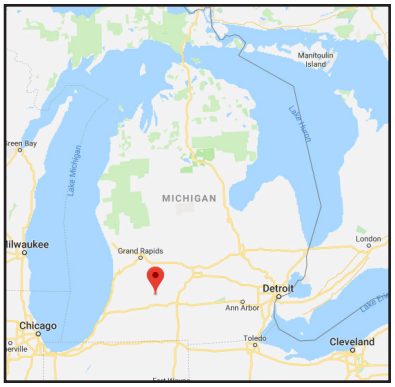
KBS LTER
Kellogg Biological Station
Long-term Ecological Research

Kellogg Biological Station LTER

Photo credit: Kevin Kahmark / KBS LTER

Since 1988, Kellogg Biological Station (KBS) LTER has been the only LTER site focusing on agricultural cropping systems, which occupy 1.5 million ha in the United States. Research from KBS LTER has advanced understanding of how agronomic management based on ecological knowledge can better deliver ecosystem services, including yield, greenhouse gas mitigation, nutrient conservation, and pest suppression. Socio-ecological research at KBS LTER reveals how farmers perceive and provide ecosystem services. By simultaneously considering both natural and human factors across a mosaic of agricultural and non-agricultural land covers, KBS LTER research reveals mechanisms that contribute to the resilience of important populations and processes in agricultural landscapes in the face of increasing pressures from long term land use and climate change.



Between 2008-2018:

235 investigators

37 institutions represented

204 graduate students

Mixed Landscape

Principal Investigator:

Nick Haddad

Michigan State University

Est. 1988

Funding Cycle:

LTER VI

NSF Program:

Biological Sciences / Division of Environmental Biology

Key Findings

Environmental management can mitigate greenhouse gas emissions. Agriculture emits quantities of greenhouse gases equivalent to those from the transportation sector, and long term LTER research has revealed how farmers can better manage intensive row crop systems to mitigate climate change. Plant-microbe-soil interactions can enhance soil carbon sequestration, reduce nitrous oxide emissions, and promote methane oxidation. Implemented widely, improved management could make cropping systems a major mitigator of climate change. [Products 1-4, 7, 8, 10]

Landscape diversity enhances pest suppression. Simplification of agricultural landscapes reduces abundance of predatory insects, at substantial cost to farmers and society. Diverse landscapes harbor generalist predators such as ladybird beetles, which control crop pests such as soybean aphids, limiting the need for insecticide use. Given global declines in insect abundance, increasing the diversity of habitats and their spatial arrangement across landscapes could enhance biodiversity and provide biocontrol services worth hundreds of millions of dollars per year, while reducing the need for insecticides. [3, 10]

Evolutionary responses of microbes that underpin functions and services. Twenty-plus years of nitrogen fertilization have caused rhizobia in soybeans to evolve toward reduced nitrogen fixation. These evolutionary changes have ecological consequences, as the evolution of reduced cooperation alters soil nitrogen availability. Directed changes to the microbial community, through plant-soil management or added bioinoculants, represents an important frontier for improving cropping system resilience. [3, 9]

Consumers express willingness to pay for ecosystem services from agriculture. Research from KBS LTER reveals not only how changes in cropping practices improve ecosystem service flows, but also the economic value of those flows. Paired studies of farmers and consumers track farmer willingness to provide changed practices along with consumer willingness to pay for ecosystem services that come from those changed practices, such as climate mitigation, water quality regulation, and natural pest control. [3, 5]

Photo credits: KBS LTER (left); Kurt Stepnitz Photography (above)

Synthesis

The Lotic Intersite Nitrogen Experiment (LINX) was a 17-year cross-site collaboration among scores of stream ecologists to better understand how streams process watershed nitrogen inputs. Researchers at KBS LTER played a pivotal role in methods development and lab analyses. In partnership with Andrews Experimental Forest LTER, KBS LTER built an accessible online database of all LINX data.

Partnerships

Department of Energy Great Lakes Bioenergy Research Center | U.S. Department of Agriculture Long-Term Agroecosystem Research (LTAR) | AmeriFlux | National Phenology Network | Nutrient Network (NutNet) | Aerosol Robotic Network

The "Productivity-Diversity" project began in 1996 when 16 LTER sites convened with the goal of examining the relationship between Annual Net Primary Productivity (ANPP) and species diversity. Eleven sites with herb-dominated plant communities (including KBS LTER) joined in a now 20+ year synthesis as the Productivity-Diversity-Traits Network (PDTNet) to better understand ANPP and its environmental drivers.

Data Accessibility

Kellogg Biological Station LTER maintains an online catalog of data collected at the site. Snapshots are periodically submitted to the Environmental Data Initiative (EDI) repository. The catalog also includes a spatial data and aerial image repository dating back to the 1960s.

Photo credits: Kurt Stepnitz Photography

Broader Impacts

Getting data into classrooms. The KBS LTER K-12 partnership between LTER researchers and rural school districts has been supported by Schoolyard LTER funds and two NSF Graduate STEM Fellows in K-12 Education (GK-12) awards at KBS LTER. The partnership developed Data Nuggets to bring ecological science into Kindergarten through college classrooms. These curricula use LTER data contributed by KBS LTER and other sites, and are used by teachers in all 50 states and in 140 countries.

Mentoring the next generation. Undergraduate research interns, many from underrepresented groups, are a highlight of the KBS LTER program. Through their blog posts, they describe the transformative and educational values of time at KBS. CarIneshia Johnson, an REU student in 2017, wrote:

"I have never worked so hard for anything in my life until I came to KBS. I was forced to gain confidence because it would've been a hard summer without it. I didn't come into my newly found confidence alone though; it was because of my mentor, my lab family, peers, and other people at KBS."

Photo credit: Kurt Stepnitz Photography

Connecting with the real world. Research at KBS LTER bears directly on agricultural management and policies at local (e.g., soil and water conservation) to global scales (climate change mitigation). LTER researchers conduct surveys and discussion forums for scientists, farmers, extension educators, government and state agency staff, industry, and private sector farm advisors to build the foundation for making their research more translational to — and informed by — diverse stakeholders. Strengthening public-private networks and collaborations is imperative to effecting change in agricultural management.

Informing greenhouse gas policies. Partnering with agricultural professionals and industry, KBS LTER developed a carbon credit protocol for agricultural nitrogen management to allow farmers to participate in voluntary carbon credit markets. This protocol, the first for nitrogen, compensates farmers for precise application of nitrogen fertilizer in order to reduce nitrous oxide emissions.

Top Products

1. Culman, SW et al. 2012. Permanganate oxidizable carbon reflects a processed soil fraction that is sensitive to management. **Soil Science Society America Journal.** doi: 10.2136/sssaj2011.0286
2. Gelfand, I et al. 2013. Sustainable bioenergy production from marginal lands in the US Midwest. **Nature.** doi: 10.1038/nature11811
3. Hamilton, S et al. 2015. The Ecology of Agricultural Landscapes: Long-Term Research on the Path to Sustainability. **Oxford University Press**.
4. Kravchenko, AN et al. 2017. Field-scale experiments reveal persistent yield gaps in low-input and organic cropping systems. **PNAS.** doi: 10.1073/pnas.1612311114
5. Ma, S et al. 2012. Farmers' willingness to participate in payment-for-environmental-services programs. **Journal of Agricultural Economics.** doi: 10.1111/j.1477-9552.2012.00358.x
6. Mulholland, PJ et al. 2008. Stream denitrification across biomes and its response to anthropogenic nitrate loading. **Nature.** doi: 10.1038/nature06686
7. Robertson, GP et al. 2014. Farming for ecosystem services: an ecological approach to production agriculture. **BioScience.** doi: 10.1093/biosci/biu037
8. Tiemann, LK et al. 2015. Crop rotational diversity enhances belowground communities and functions in an agroecosystem. **Ecology Letters.** doi: 10.1111/ele.12453
9. Weese, DJ et al. 2015. Long-term nitrogen addition causes the evolution of less-cooperative mutualists. **Evolution.** doi: 10.1111/evo.12594
10. Werling, BP et al. 2014. Perennial grasslands enhance biodiversity and multiple ecosystem services in bioenergy landscapes. **PNAS.** doi: 10.1073/pnas.1309492111