I. Introductions – yourself, then others: names, institution, area of study/work

Icebreaker question (e.g., When you hear the word ‘agriculture’ what do you think of?)

Core KBS LTER question: to what extent can we manage field crops with biology rather than chemistry without sacrificing high yields? (i.e., How can we manage farm fields with fewer chemical inputs, better utilizing biological resources in cropping systems to control pests, provide nitrogen, and build soil fertility?) **Bottom line: to help make farming both profitable for farmers and good for the environment.**

II. Overview of the KBS LTER

Part of National LTER Network

- Established by NSF in 1980 to understand long-term patterns and processes of ecological systems in order to protect and manage Earth’s ecosystems, their biodiversity, and the services they provide
- 25 sites (~ 2,000 scientists and students and educators) across a broad diversity of biomes: tundra, forest, grassland, desert, wetland, urban sites, and more
- All sites have these 5 research themes/core areas:
  1. Pattern & control of primary production (what’s growing & how much, harvestable products)
  2. Spatial & temporal distribution of populations (plants, microbes, insects, vertebrates - who’s there and what are they doing)
  3. Pattern and control of organic matter accumulation (carbon cycling, CO2 capture and storage)
  4. Patterns of inorganic inputs and movements of nutrients through soils, groundwater and surface waters (nitrogen and phosphorus losses)
  5. Patterns and frequency of site disturbances (pests, disease, climate change, extreme weather)
- Lots of cross-site analyses to see how these variables change or are the same across ecosystems; All Scientists Meeting every three years to discuss the research
- (Network opportunities: data, research collaborations, grad and undergrad (REUs))

KBS joined the Network in 1988 – the only agricultural (or row-crop) ecosystem in the Network

- Focus: ecological interactions underlying the productivity of annual & perennial field crops
- Scientists investigate how crops grown in different ways interact with soil, water, air, microbes, and insects. Also conduct social and economic research; e.g., what would it take for farmers to adopt certain farming practices?
- Long-term perspective needed to really understand how the system works (e.g., carbon storage) and to capture rare events (e.g., drought)
- Importance of agriculture:
  - Everyone depends on agriculture
  - Agriculture dominates land use in the U.S. Midwest (more than 2/3 of land in farmland), which produces the majority of U.S. corn & soybean; has a huge impact on surrounding lands, waters, and air, etc.
The KBS LTER Main Cropping System Experiment (MCSE), established in 1988:

- 7 treatments on the MCSE covering 60 ha (~140 acres) and replicated 6 times
  - **Annual Crops (Corn - Soybean – Wheat rotation) grown in four ways:**
    1. **Conventional**, standard chemical inputs (to control pests and provide nutrients) and tillage to prepare the soil for planting
    2. **No-till**, same as Conventional, except no disturbance of soil
    3. **Reduced input** (cover crops (rye, red clover) to provide nutrients, reduced fertilizer and herbicide rates)
    4. **Biologically based** (certified organic, cover crops (rye, red clover), no chemical inputs, mechanical weed control)
  - **Perennial crops**
    5. **Poplar** trees – 5-6 yr rotation; harvested January of 2008; this crop planted May 2009
    6. **Alfalfa** - ~5 yr rotation, cut 3-4 times per year
  - **Successional systems (if we weren’t farming, what would be happening to the land)**
    7. **Early successional** community – abandoned after plowing in 1989, burned annually
       This treatment – and other successional treatments off this site – offer an important contrast to the managed farm treatments.

- Treatments are on 1 ha (2.4 acre) experimental units (plots), large compared to most agricultural experiments in order to:
  - Use farm-size equipment and management regimes, be relevant to working farms (e.g., no hand weeding)
  - Capture spatial variability across the landscape (e.g., soils and slopes)
  - Have enough space to sample for decades or longer & not be sampling on top of same areas

Additional treatments around the KBS landscape:

1. **Conifer Forest (CF)** 40-60 y old conifer plantations
2. **Deciduous Forest (DF)** – late successional older-growth hardwood, 2 sites never cut
3. **Successional Fields** - later successional old fields abandoned from cropping 40-60 years ago

Core sampling program:

- Project manager works with a team of research technicians to sample the plots throughout the year
- Many other samples taken for particular research questions (e.g., microbes)
- Protocols on the website; plethora of data – available on the website
III. YOUR research:

- Explain your research question(s)
- How your research fits into the overall LTER and KBS LTER programs
- Why do you study this? What got you interested in this area of science?

IV. Key Findings ([ter.kbs.msu.edu/who-we-are/research-highlights/](http://ter.kbs.msu.edu/who-we-are/research-highlights/); Robertson et al. 2014 Bioscience paper)

- **Clean water**
  - Farm management that happens aboveground affects what happens belowground; fertilizers used on crops can leach through the soils and contaminate our groundwater supplies of drinking water.
  - We sample groundwater for nitrate, a form of nitrogen, which at high levels is harmful to human health.
  - We found: perennial treatments of poplar and old fields are very good at keeping nitrate out of groundwater. No-till, low input, and organic treatments all had lower nitrate leaching than the conventional treatment.
  - **Bottom line:** we can farm the land in a way that protects our drinking water and reduces pollution in the environment.

- **Climate change**
  - Field crop agriculture both contributes to and is affected by climate change. We quantify how crop management practices affect greenhouse gas (GHG) emissions and soil carbon storage, and ultimately the global warming impact (GWI) of various cropping systems.
  - **Greenhouse gas emissions**
    - Since 1992 measured carbon dioxide, methane, and nitrous oxide
    - These GHG gases are naturally occurring (a result of microbial activity) but farm management can enhance their emissions, e.g., excess nitrogen fertilizer is converted to nitrous oxide, one of the most potent GHGs. By measuring nitrous oxide emissions and crop yield across varying levels of nitrogen fertilizer rates, our scientists have informed programs that help farmers reduce their nitrogen fertilizer levels, and therefore nitrous oxide emissions, while maintaining crop yields.
  - **Soil Carbon**
    - Changes in soil carbon levels over less than a decade are difficult to detect – need long-term experiments
    - Farmers are interested in enhancing soil carbon, or soil organic matter, for good soil quality and crop productivity.
    - We found: under no-till management, soil carbon levels are higher compared to the conventional treatment by 25%. Yields under the no-till system are about 10% higher: win-win for the soil, climate, and farmers.
    - Also found higher levels of soil carbon under our organic treatment, where the soil is frequently disturbed to control weeds. Conventional thought is that because of such intensive soil disturbance, organic fields would be losing carbon. We’re investigating this further.
  - Compared to conventional, no-till and organic systems have a much lower GWI; they mitigate, or lessen the severity of, climate change. Likewise the successional systems mitigated climate change.
- **Bottom line:** We have found ways for agriculture to help mitigate climate change while still achieving the yields farmers need. This information has informed programs in the carbon market and greenhouse gas policies worldwide.

- **Landscape diversity**
  - Our scientists have shown how plant diversity in the surrounding landscapes enhances habitat for beneficial insects that prey on pests of crops.
    - The **soybean aphid** is an invasive pest and the greatest threat to soybean production in the U.S. as it can devastate crop yields.
    - Native and non-native **ladybird beetles** eat the soybean aphid, saving farmers time and money by not having to spray pesticides (‘biological control’)
      - Our entomologists and economists found: ladybird beetles saved farmers $239 million/yr in four Midwestern states from not applying pesticides and from not having their crop yield reduced.
    - **Biocontrol in soybean fields** was greater where there surrounding landscape is diverse with many types of habitats, like our Early Successional “old field” treatment. Not only do these old fields provide habitat, they store a lot of carbon in their soils, have high diversity of plants and insects (20-30 different types of plants!), and could even be used to make cellulosic ethanol.
  - **Bottom line:** Taking a landscape approach, understanding the ecology of a system, and using an interdisciplinary approach = a monetary value on a biological control service that helps farmers and reduces pesticide use in our landscapes.

V. FAQs:

1) How much funding do you get?
   a) We receive $1 million per year to investigate these questions and run the experiment you will see today
   b) It takes the equivalent of a small business to keep this going (many committees, a director, project manager, agronomic manager, data manager, education and outreach coordinator, research technicians) along with over 120 scientists and students who are involved with the research
   c) Every six years we have to write a renewal grant to NSF, and renewed funding is not a given – we need to prove that we continue to conduct cutting edge science

2) Have local farmers adopted your practices?
   a) There certainly are local farmers using cover crops and farming organically. Out research is aimed at informing policies and programs at national levels. For example: our N2O work has created opportunities for farmers in national carbon markets.

3) What happens to the crops when you harvest them?
   a) Corn and soybean: used by the KBS dairy for feed
   b) Wheat: sold to a local mill
   c) Alfalfa: used by the KBS dairy for feed
   d) Poplar trees: chipped and used by MSU’s power plant for co-firing with coal to reduce the global warming impact of using coal