W.K. Kellogg Biological Station

Long-term Ecological Research Walking Tour

Welcome to the KBS LTER Walking Tour! This short 3/4-mile loop will only take about an hour. Look for the numbered stops along the way. They match the numbered stops in this trail guide. For your safety and to protect the research, please stay on the grass.

The research landscape that surrounds you was shaped by both the hands of humans and the processes of nature. This is a place where scientists seek answers to questions about how humans, plants, soil and insects live together to produce the food and fuel we need.

The story of how we learn about our natural world begins just up ahead — each stop reveals something about the research we do. Enjoy your walk!

Visit Us On:

facebook.com/KBS.LTER

lter.kbs.msu.edu

KBS LTER Website

@KBSLTER

Artwork by Sara S. Cole. Guide written by Sara S. Cole, Kori Taylor, Samantha Shaughnessy and Julie E. Doll.

Why do we need long-term research to understand agriculture?

The KBS Long-term Ecological Research (LTER) experiment was started in 1988 to provide science-based information on how to make farming both good for the environment and profitable for farmers. Using this experiment, KBS scientists are addressing questions such as:

- How does tillage affect soil quality?
- How do beneficial insects like ladybugs help farmers grow healthy crops?
- How does agriculture affect climate change?
- How can we manage the land to produce food AND improve the environment?

While the lifespan of most agricultural research projects is only a few years, KBS LTER research has been going on for over twenty years! **Long-term research** is important to really understand changes that can't be seen in just a few years. It's necessary to understand how crops respond to rare events, for example droughts and insect pest outbreaks. It also allows scientists to study processes that take a long time to play out, such as changes in soil quality and tree growth. We're excited to share with you how we do our research and some of what we've learned in the last 20 years!

What are the effects of different agricultural treatments?

As you walk through the experiment, you'll see the following seven treatments in the various plots of our experiments. For the first four treatments, each year we plant either corn, soybeans or wheat. Up ahead you'll be able to tell which of these crops we planted this year.

1. Conventional: rotation between corn, soybean and wheat. Tillage and herbicide are used to control weeds. Synthetic fertilizer is applied.

2. No-till: rotation between corn, soybean and wheat. The soil is never tilled and herbicide is used to control weeds. Synthetic fertilizer is applied.

3. Reduced input: rotation between corn, soybean and wheat. Fewer chemicals and fertilizer than used in the conventional system. Cover crops are used to supply nutrients to the soil.

4. Organic: rotation between corn, soybean and wheat. No synthetic fertilizers or peticides are used. Tillage is used to control weeds. Cover crops are used to add nutrients to the soil.

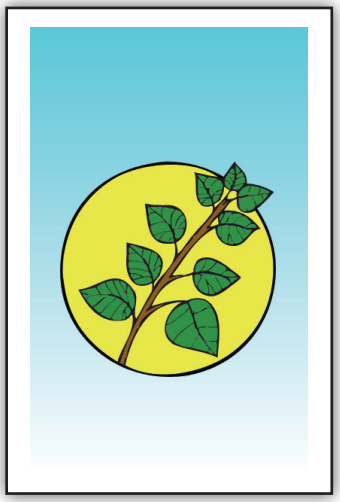
5. Alfalfa: this crop is cut and harvested three times per year. A new stand is established every five or six years.

6. Poplar trees: harvested every 10 years.

7. Native vegetation: the only management is a spring burn to control woody shurbs.

Station 1

Growing Our Fuel



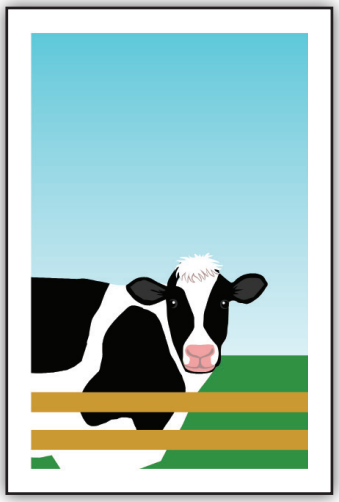
Welcome to the first station of the tour — the poplar plot! Poplars have great potential as a *cellulosic biofuel* crop since they grow so quickly. Cellulose — the leaves, stems and other fibrous parts of a plant — is the most abundant biological material on Earth! In the laboratory, cellulose can be converted into liquid fuel (ethanol) that can be used in our gas tanks. Since many potential cellulosic biofuel cropping systems are perennial and include a diversity of species, they can result in: healthy soils, reduced pesticide use and a beautiful, diversified landscape.

A Very Poplar Tree

The poplar trees standing before you are one of the fastest growing trees in North America, growing about 10 feet in 2 years. These poplar trees were just small 6–inch saplings when they were planted in May of 2009. Can you estimate how tall the poplars are now?

Station 2

Perennial Crops: Good for the Climate



The crop you are looking at, alfalfa, is a perennial crop. That means it grows back every year, and farmers do not need to disturb the soil to replant it. This helps to build soil carbon. Soil carbon is commonly referred to as soil organic matter. You'll hear a lot about ways to build soil carbon on this tour — that's because it keeps the soil healthy and it's good for the climate! One of the gaseous forms of carbon is carbon dioxide. Carbon dioxide is a greenhouse gas that occurs naturally and allows us to survive on Earth by warming air near Earth's surface.

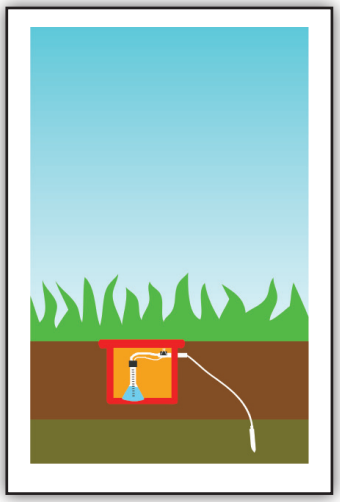
Human activities are now increasing the amount of greenhouse gases, including carbon dioxide, which leads to changes in the climate. Through photosynthesis, plants take carbon dioxide out of the air and use it to build their roots, stems and leaves. When plants decompose in the soil, some of that carbon is sequestered (stored) underground, keeping it out of the atmosphere and helping it improve soil quality.

Hay You!

Alfalfa is grown as a large crop to feed animals. It is more commonly recognized in its dried, rolled–up form — HAY! After alfalfa from the LTER is harvested, it is given to the KBS Dairy Farm across the street. Can you guess what farmers might use in exchange from the cows to grow healthy plants? You're right, it's manure! Many farmers use manure as a natural fertilizer on their fields.

Station 3

Keeping Our Drinking Water Clean



What we do above ground affects what happens below ground. For example, fertilizers used on crops can contaminate the groundwater supply of drinking water. Contamination occurs when there is more nitrogen fertilizer applied than the plants need. When this happens, the nitrogen moves down through the soil (leaches) onto the groundwater in a form called *nitrate*. Too much nitrate in groundwater is harmful to human health. Scientists have found that some perennial crops, such as the poplar trees you've seen, and native fields (up ahead!) are very good at keeping nitrate out of the groundwater. They also found that farming corn and wheat organically, using *no-till* management, or using *cover crops* can reduce nitrate levels in our groundwater. You'll learn more about no-till and cover crops up ahead!

How Do They Do It?

How do scientists test the groundwater for nitrate? In each of the plots you'll see today, KBS LTER scientists use a tool called a soil water suction sampler (seen in the picture) to collect water from the ground. It is buried 3 feet under the plot, and it is connected to a tube and jar that sit in a box buried underground to protect them. Twice a month, field technicians pump water from the soil sampler. This water is taken to the lab and analyzed using laboratory instruments to determine the amount of nitrate in it.

Learn More:

Station 4

"Old Fields" for Fuel?

What does a farm field look like after it has been left abandoned for twenty years? You are looking at it! Historically this "old field" was used to grow corn and soybeans, but has been left alone since 1989. This is because scientists wanted to observe how the plant community would change over time. Even though nothing has been planted here since 1989, plants have grown from seeds that were present in the soil, blown in or dropped by birds. By sampling which plants are here every year, KBS discovered that 50 percent of the plants are native species. Because these plots and other "old fields" can produce a lot of plant material every year with basically no inputs, they could be good sources of cellulose for ethanol!

A Fiery Tradition

As shrubs started to invade the "old field" research plots, our scientists tried to figure out the best way to control them. Cut them? Apply herbicide? A historian working on the project came up with the solution we use today: burn the plots! She revealed that since the year 700, the Potawatomi Native Americans in this part of Michigan used fire to manage the landscape vegetation. This is one reason why the Potawatomi were known as keepers of the fire or the fire–keepers. Locals will recognize this as the name of the casino near Battle Creek.

Common Plant Species

- Canada Goldenrod (pictured right)
- Black Locust
- Tall Oatgrass
- Red Clover
- Timothy
- Dogbane

Station 5

Can You "Go Green" by Growing Organic?

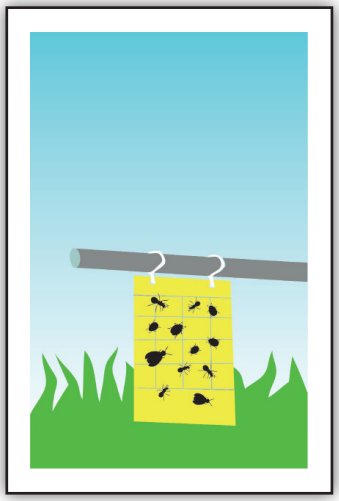
Corn, soybean and wheat are important crops for humans and animals. The plot in front of you uses organic methods to grow these crops. No human-made insecticides, herbicides or fertilizers are used. To help provide nutrients to the soil, *cover crops* are planted (see Station 7!). KBS scientists have found that yields of organic soybeans are the same as yields in the conventional system. However, corn and wheat yields are less, probably because the cover crop is not adding enough nitrogen to the soil. Unlike most organic fields, we don't apply any manure here, which would help to boost yields by providing organic nitrogen. We don't add manure because KBS scientists want to see whether a cropping system could get ALL of its nitrogen from internal sources like cover crops!

Test Your Knowledge!

The picture on the sign shows seeds of three of the crops we grow in our experiment. Can you identify and name each of the seeds pictured? (Answer on back of booklet.)

Station 6

The Fields are Alive



Listen for a moment. What do you hear? Agricultural ecosystems are full of life, including plants, birds, insects and humans. Some of the sounds are from insects in the landscape. Some insects are pests and damage crops. Other insects, such as ladybugs, help boost crop yields by eating insect pests like soybean aphids. If the ladybugs do the work to eat the soybean aphids (a pest that damages soybeans), that means that farmers don't have to spend time or money spraying pesticides. This is an example of "biological control." In fact, KBS scientists found that in four Midwestern states, ladybugs saved farmers $239 million per year! KBS researchers also found that biological control is greater where the surrounding landscape is diverse with many different types of crop and non-crop habitats, like the "old field" plot you see before you. This is an example of importance of biodiversity in the landscape.

Learn More:

Counting Bugs

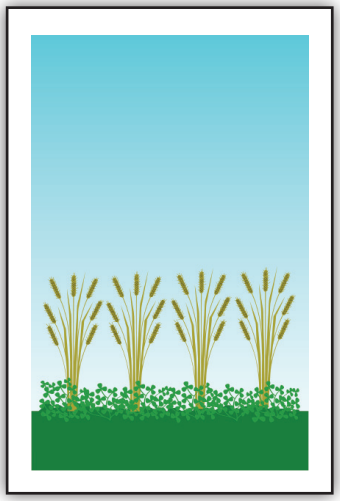
The yellow sticky traps you see in the picture — and may see in the plots around you — help monitor which insects are here. Twice a month scientists take these yellow sticky traps into the laboratory to identify and count everything that is stuck to them. By monitoring these plots for over 20 years, entomologists (scientists who study insects) have made important discoveries about how insects move and behave in agricultural landscapes.

Top 10 Most Common Bugs in This Plot

1. Thrips (small)
2. Aphids (small)
3. Diptera (flies)
4. Parasitoid wasps
5. Cicadoidea (hoppers)
6. Dolichopodidae (long–legged flies)
7. Coleoptera
8. Ants
9. Anthocorids
10. Mirids

Station 7

A Carpet Made of Plants



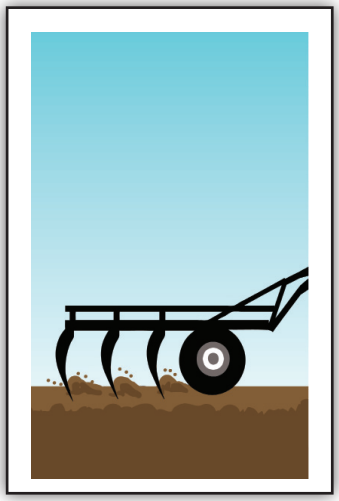
Do farmers put carpets on their fields? Well no, but cover crops serve as a beneficial cover, just like carpets do. There are many benefits to using cover crops! Cover crops act as "green manure." They are plowed under the soil surface, where they decompose and add nutrients to the soil, helping future crops grow. They also prevent soil erosion, provide plant diversity and sustain more kinds of life (particularly insects). Organic farmers use cover crops to keep weeds out. KBS scientists study how well leguminous (nitrogen-fixing) cover crops reduce the need for nitrogen fertilizer. This can save farmers money and help protect the environment.

Where Are They?

You may not see any cover crops now, but depending on the year various cover crops were in this plot! In the years that we grow winter wheat, red clover is planted in the spring and grows under the wheat crop (pictured above). After the wheat is harvested in July, the clover keeps the ground covered. Early in the spring it is plowed under the soil before corn is planted. As the dead clover decomposes, it adds nitrogen to the soil which helps the corn grow. After that corn is harvested in the fall, another cover crop, rye, is planted. It is tilled into the ground the next spring before the soybeans are planted. After the soybeans are harvested in the fall, the winter wheat crop is planted, starting the three year crop rotation all over again!

Station 8

Soil Tilling: The Good, the Bad and the Microbial



Plowing the land and planting seeds go hand in hand. If you lived thousands of years ago, you'd have to plow by hand, and if you were lucky, you had an animal to help. Today, most farmers use a *chisel plow* (pictured at the left) pulled by a tractor. The chisel plow is the best way to get tilling done quickly and is commonly used in farming. Although it is helpful to get rid of weeds and prepare the soil for planting, there are some downsides. Tilling the soil causes mixing of soil and air. This stimulates microbes in the soil to feast on soil organic matter, converting it into carbon dioxide that escapes into the atmosphere. Carbon dioxide is one of the *greenhouse gases* responsible for global warming. Lower soil organic matter levels in the soil can also reduce crop yields.

Alternatives?

If tillage reduces soil quality, is there another way to farm? Yes, many farmers use a system called "no–till" where the soil is not turned over to control weeds or plants. You'll see a no–till plot up ahead! No–till works better in some soil types over others. Scientists are busy studying this and other barriers to adopting no–till farming.

Learn More:

Station 9

Harvest Time

Harvest time at KBS means more than just good things to eat. We measure how much plant material is produced from each and every plot, including the abandoned "old fields"! By tracking the productivity of each plot year after year, we learn how to manage the land to produce all the things we need. This includes food and fuel AND healthy soil, air and water. This information helps not only the farmers, but policymakers and others who work with agriculture and the environment.

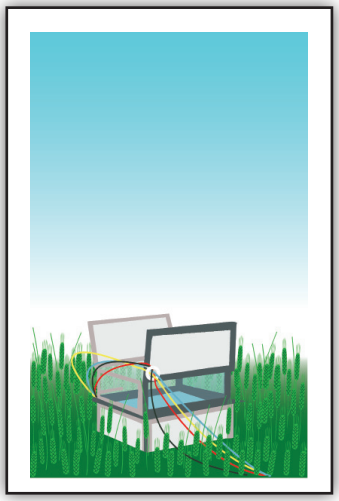
What Do We Do With Our Crops?

The KBS dairy uses our corn, soybean and alfalfa to feed the animals. The wheat we harvest is sold to a local mill. We harvest our poplar trees approximately every 6 years. For the upcoming harvest, the trees will be chipped and then sent to MSU's power plant to be used as a biofuel.

Learn More:

Station 10

Boxes in the Field



See that white trailer near the crops? It's part of a system that measures greenhouse gases. When the crops are short you can see white boxes in the field (like the one shown in the picture). These contraptions, called automated gas flux chambers, are very specialized pieces of equipment that help measure changes in three important greenhouse gases: carbon dioxide, nitrous oxide and methane. These gases are produced by the microbes in the soil. Each box is over soil that receives a different level of nitrogen fertilizer. From this experiment, our scientists discovered the levels of nitrogen fertilizer farmers can apply that keep crop yields high AND reduce levels of greenhouse gases: a win–win situation!

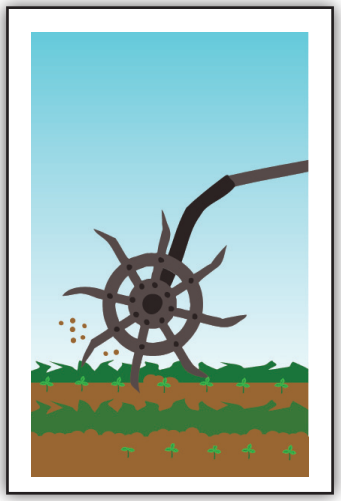
No Humans Needed?

Everything about the gas sampling chamber is automated; they capture gas samples many times a day no matter what the weather. Every four hours, each box snaps shut for 15 minutes. The gases that are released from the soil during that time are captured in the boxes. Samples of the gases travel through tubing to the white trailer at the end of the field. Instruments in the trailer analyze the gas samples and document the amounts of greenhouse gases that were released. These chambers never slack off! However, to manage the system and keep it running — even in the winter! — requires a full–time trained technician.

Learn More:

Station 11

Tools of the Organic Trade



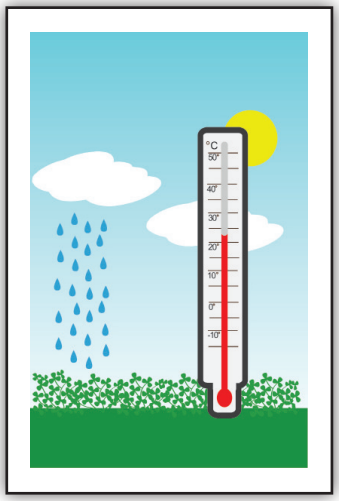
Have you bought organic vegetables before? Why has organic produce become so popular? The main reason is because organic management can be better for the environment since it does not use chemical fertilizers and pesticides. Because they can't use these things, organic farmers need to find other ways to provide the nutrients the plants need and kill insect and weed pests. As you learned earlier, cover crops can be used as a "green manure" to provide nutrients and limit weeds. The rotary hoe is another way organic farmers kill weeds in organic systems. It is pulled behind a tractor and only disturbs the soil a little bit.

More Carbon

Remember how tillage can reduce soil organic matter (soil carbon)? Well, KBS scientists were surprised to learn that organic management can offset that loss! They discovered that even though the organic plots are tilled, they are gaining soil organic matter. They think the increased plant diversity — by including cover crops — is helping to do that.

Station 12

Weather and Climate



The tower in the distance to the right is our weather station. It measures daily temperature, cloud cover, wind speed and precipitation levels — in other words, it measures the weather. *Climate* is different than weather. Climate refers to 30-year averages in weather data: it's what happens on average over the long haul. What has scientists concerned is that the *long-term* climate trends are changing. One documented change is that on average, the Earth's temperature has been rising. This is causing the changes in climate we have been experiencing more cloudliness, warmer winters and less ice cover for the last 30 years on average. The good news is that scientists at KBS and all over the world are learning ways to mitigate climate change by reducing greenhouse gas emissions and removing carbon dioxide from the atmosphere and storing it in plants and soils.

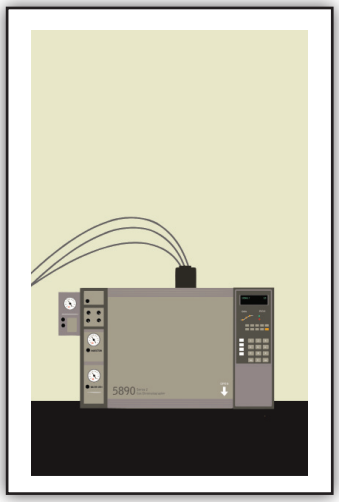
Strength Of A Network

Temperature and precipitation are measured at all of the LTER sites across the United States, not just here at KBS! When LTER scientists pooled their data, they found that air temperatures have increased in 27 out of 50 sites they studied over the last 20 years. Since they have been monitoring temperature and precipitation for such a long time, the LTER sites are helping us to understand how our climate is changing across the nation.

Learn More:

Station 13

In the Lab and Field



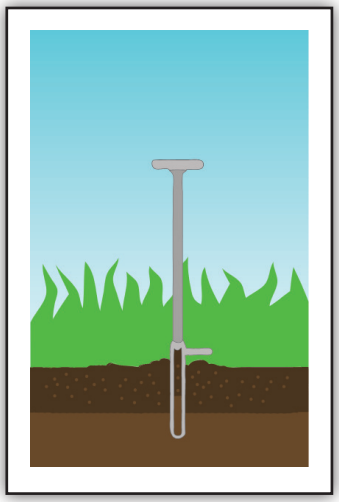
Have you ever visited a laboratory or taken a chemistry class? Well, our agricultural research does not stop in the field. Much of it is conducted in the comfort of a laboratory equipped with instruments like the one pictured at the left. This machine, called a gas chromatograph, analyzes gas samples taken from the air and soil. Gas chromatography can provide valuable information about greenhouse gas emissions from different cropping systems.

Who Does it All?

Managing this experiment takes a lot of people! Here's a list of all the folks needed to keep this experiment going: a project manager with a large staff of trained technicians, a farm manager and a crew who farm the plots, a science coordinator to run things, a director and executive committee to guide the science, a data manager to keep our data safe and an outreach specialist to share our results. In effect, our LTER site is like a small business! In addition to that, undergraduate and graduate students, professors and visiting scientists from Michigan State University and universities around the world use these plots for their research.

Station 14

Carbon in the Air, or Carbon in the Soil?



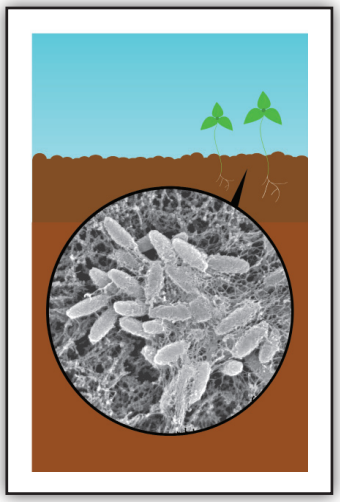
Can you see the decaying leaves and stems from last year's crop on the soil surface? You are looking at a plot that hasn't been plowed (tilled) in over 20 years! As you learned earlier, tilling the fields stimulates microbes, speeding up the rate at which they convert soil carbon to carbon dioxide which is then released into the atmosphere. No-till farming, like in this plot, avoids plowing and thus allows more carbon to stay in the soil. This limits the release of gases that cause climate change. This highlights how farm management affects the whole world! Our scientists use *soil corers* (like the one pictured at the left) to collect soil from the field. Soil samples are then taken to the lab to be analyzed for carbon and other nutrients.

Let's Store Carbon!

The tool shown above takes shallow soil core samples out of different plots. Scientists can then analyze the soil for carbon content (organic matter) and track how it is changing over time. In addition to these shallow samples, every ten years our scientists take ~1,000 deep soil cores. These deep cores are over 3 feet deep and allow us to monitor what's happening in the lower levels of the soil. Now that's deep!

Station 15

Microbes: The Unseen Players



As you walk across the soil, you are walking on millions of undiscovered micro-organisms (microbes) invisible to the naked eye. In one teaspoon of soil, there are approximately 100,000,000,000 microbes, most of which have yet to be identified or named! These microbes are hard at work: they regulate how carbon, nitrogen and other nutrients move through the environment. Microbes affect every aspect of our lives, from plant growth to human health. Our scientists found that soil microbial diversity is not much affected by agricultural management. However, there is one important exception! The LTER farming treatments affected those groups of microbes involved in the production and consumption of the important greenhouse gases methane and nitrous oxide.

Microbes At KBS

Pictured above is a group of new microbes discovered here — we named them KBS 89. Creative, huh?! If you discovered a new microbe in the soil, what would you call it?

Learn More:

Station 16

Why Research at KBS LTER?

Why do we do research? To learn, to answer questions and to solve problems! The results of experiments at the KBS LTER are shared with other scientists, teachers, land and resource managers, policymakers and citizens. As you've seen, plants, organisms and chemicals from small to large have an impact on our lives. The more we know, the better we can sustain our complex system of food, energy and climate.

Thanks for taking the walking tour today! **For more information visit our website: www.lter.kbs.msu.edu**

If you don't want to keep it, please return this brochure to the tractor mailbox. We hope you visit us again soon!

Please let us know what you thought of the tour. Write any comments or questions on the clipboard in the mailbox — thanks!

Visit Us On:

facebook

lter.kbs.msu.edu
KBS LTER Website

twitter

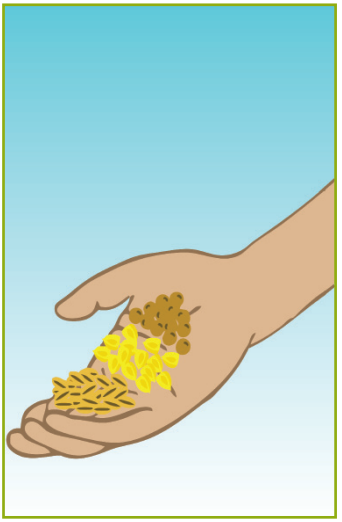
Thank you for taking the

Long-term Ecological Research Walking Tour

KBS LTER
Kellogg Biological Station
Long-term Ecological Research

LTER

MICHIGAN STATE UNIVERSITY | W.K. Kellogg Biological Station



Answer to Question at Station 5

(From left to right on the hand): wheat, corn, and soybeans

Revised 10/18/12