

**WORKING  
TOGETHER  
FOR A BETTER  
TOMORROW**



**W.K. KELLOGG  
BIOLOGICAL STATION**  
ANNUAL REPORT 2016-17





## A LETTER *from our* DIRECTOR

Dear friends and neighbors,

This year we are celebrating a milestone: the 90th anniversary of the beginnings of KBS. We continue to fulfill the vision of W.K. Kellogg when he established the Kellogg Bird Sanctuary and Farm. We are proud to share how research and collaboration at KBS fulfill this vision.

In this report, we highlight new research at KBS, led by Dr. Sarah Evans. The MMRNT project focuses on how microbes in soils used for bioenergy crops respond to climate change. The project's members are faculty, staff and students in soil and microbial ecology, genomics and data science who work together to address emerging questions about sustainability through a lens of basic ecology and evolutionary biology.

The role of the Kellogg Farm in research and outreach related to sustainable agriculture continues to expand. The Farm today supports both large, long-term multi-disciplinary research projects and smaller, short-term projects, many led by main-campus-based faculty. Sharing with farmers how to incorporate innovative technology in their management and operations is an important way we implement the charge from W.K. Kellogg that the Farm be operated to showcase the "most modern system of farm management so that it may serve as an object lesson to the people of the region."

This March was the 90th birthday of Dr. George Lauff, a former director of KBS. Lauff supported both fundamental and applied research at KBS and fostered collaborations that established KBS as a nationally and internationally recognized research center. Lauff also established the first endowed student scholarship at KBS, a gift that supports the continuation of his vision.

We hope that you will join us at upcoming events to celebrate the 90th anniversary and our commitment to continuing W.K. Kellogg's legacy of conservation for a better tomorrow. We could not do it without you!

With thanks,

Dr. Katherine Gross

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### ANNUAL REPORT WRITING, DESIGN, & PHOTOGRAPHY

Bethany Bohlen  
(Courtesy photos otherwise noted)  
Lauff Story by Maddy Marquardt

### ANNUAL REPORT EDITING

Sarah Carroll, Katherine Gross,  
Jennifer Smith

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W.K. Kellogg  
Biological Station  
MICHIGAN STATE UNIVERSITY

3700 E. Gull Lake Dr.  
Hickory Corners, MI 49060  
info@kbs.msu.edu  
(269) 671-5117



### SCHEMSKE ELECTED TO NATIONAL ACADEMY OF SCIENCES

Professor emeritus Doug Schemske was elected to the National Academy of Sciences in May 2017. This election honors his outstanding lifelong contributions to research in population biology and evolutionary ecology.

## POINTS OF PRIDE July 2016- June 2017



### TENTH YEAR OF FIELD ORNITHOLOGY

This was the tenth year that the Bird Sanctuary has offered a Field Ornithology Course for the general public. The course takes place every spring, and offers adult learners of every skill level the chance to grow their birding abilities, through expert lectures and guided field trips.



### MANOR HOUSE ENDOWMENT MEETS ITS MATCH

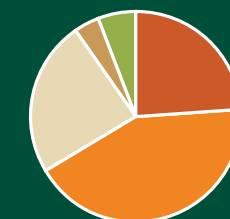
In 2012, the W.K. Kellogg Foundation established the W.K. Kellogg Manor House and Estate Endowment with a \$1 million gift. KBS pledged to raise a matching gift of \$500,000. We are proud to say that we achieved that goal thanks to your support! The Manor House Endowment ensures ongoing care and preservation of W.K. Kellogg's historic estate, and funds KBS student internships that benefit the estate and promote its history.



### SPARTAN BARLEY BECOMES BEER

Spartan barley grown at KBS for a variety trial was used by New Holland Brewery for a limited edition lager released in 2016. The beer was made with 100% Michigan ingredients. The barley was grown at the Kellogg Farm in partnership with MSU Extension.

### FY 16-17 SOURCES OF SUPPORT



42% General Fund  
24% Grants & Allocations  
24% Business Accounts  
6% Gifts & Trust  
4% AgBio & Extension



### OUTSTANDING MITTELBACH

Professor Gary Mittelbach received two awards from MSU this year honoring his exemplary commitment to teaching and research. In November 2016, he was given the College of Natural Sciences' Outstanding Faculty Award, and in January 2017, he was also honored with MSU's William J. Beal Outstanding Faculty Award.



### FITZPATRICK AWARD-WINNING NEW FACULTY

In January 2017, we added assistant professor Sarah Fitzpatrick to our faculty. Her research innovatively integrates evolution, ecology and conservation. In February 2017, she received the Jasper Loftus-Hills Young Investigator Award from the American Society of Naturalists.



### UNDERGRADUATE RESEARCH GOES GLOBAL

2016 undergraduate students Aleah Dungee (Robertson lab) and Kathryn Bloodworth (Evans lab; MMRNT project), as well as postdoctoral researcher Will West (Evans lab), were invited to share their climate change research at the World Congress for Undergraduate Research in Qatar in November 2016.



### NEW SANCTUARY OVERLOOK RENOVATIONS

The Bird Sanctuary's Overlook has beautiful views of Wintergreen Lake and is a great place to see waterfowl. It includes a museum, observation deck, stairway, and garden. This year, it received several updates, including a new railing and trim for the observation deck.

New native plantings were added around the access stairway. New waterfowl identification signage was also added, featuring a local artist's illustration of waterfowl that have been sighted on Wintergreen Lake. This project was funded through memberships and donations.



# LOOKING BENEATH THE SURFACE

Collaborative Next Generation Research for the Future of Bioenergy

## TINY MICROBES COULD MAKE A BIG DIFFERENCE IN THE SUSTAINABILITY OF BIOENERGY CROPS.

A group of MSU scientists are working together to discover teamwork between bioenergy plants and the community of microbes (microbiome) that live on or around their roots.

Plants need a number of nutrients, including nitrogen, in order to grow. Nitrogen is typically taken up by plants through the soil, and if there's not enough, nitrogen-based fertilizers are often applied to crops.

This addition is costly for farmers and can cause unintended ecosystem problems. For example, fertilizer runoff can result in eutrophication and harmful algal blooms in lakes and streams. Bioenergy crops can partially meet the demand for energy in the U.S. economy, and it's imperative that they do so at the lowest cost to farmers and the environment.

What if we could reduce fertilizer input by relying on plants and their microbiome to produce nitrogen? Could we benefit farmers and the environment?

To address this question, KBS assistant professor Sarah Evans and three other MSU faculty are working on a long-term project called Microbially Mediated Perennial Rhizosphere Nitrogen Transformations (MMPRNT). The research is funded by a \$5.7M grant from the U.S. Department of Energy (DOE) that resulted from a brainstorming session between Evans and assistant professor Lisa Tiemann.

They were interested in how microbes could enhance the sustainability of bioenergy cropping systems, especially on marginal or degraded lands that tend to have limited nutrients. A discovery that happened at KBS only months before fueled their conversation.

KBS postdoctoral researcher Sarah Roley had found that switchgrass, a

top contender for bioenergy production, formed associations with bacteria that make nitrogen available to plants through a process known as nitrogen fixation (illustrated at right). While nitrogen fixation has been known to occur in legumes like beans, discovering this process in switchgrass was new.

Switchgrass is hoped by many to be a foundation for transitioning the U.S. toward a more biofuel-based energy scenario. The plant can be grown on nutrient-poor marginal lands often unsuitable for food crops, creating potential for bioenergy expansion without sacrificing nutrient-rich land needed for food production.

"In every scenario that has been outlined that hopes to achieve lower carbon emissions, bioenergy is included," said Evans. "I think in the end, given that we're going to see more bioenergy in the future, it's responsible to understand what effect that will have on the rest of the ecosystem."

Tiemann and Evans recognized that having microbial sources of nitrogen could play a big role in making bioenergy more sustainable. They brought in Maren Friesen, a plant evolutionary ecologist who studies the interactions between plants and nitrogen fixers. Rounding out the team was a newly hired bioinformatics specialist, Jim Cole, who would help them develop new molecular tools to characterize complex microbial communities.

"I think having the complementary expertise and the strong investment of all the PIs [faculty], who are excited about these topics, has really made it a success," said Evans.

The team now includes postdoctoral researchers, graduate and undergraduate students, and research technicians. The members of the team conduct their research at six sites on marginal lands in Michigan and Wisconsin associated with the Great Lakes Bioenergy Research Center (GLBRC), including Lux Arbor Reserve near KBS.

## New Questions, New Methods

The MMPRNT team is investigating the connection between plants and free-living microbes that live in the soil next to the plant's root surface. What they discover could teach us how to adjust plant management and cropping systems to promote nitrogen-fixing interactions.

"There's this push and pull and constant communication back and forth between the plant and the microbiome, and it's been really challenging to identify how this is happening on this really tiny scale," said Evans.

The MMPRNT team is using a variety of methods, including stable isotopes, to understand these microscopic processes and track specific molecules through the plant and into microbes.

"The isotope method basically puts a tag on nitrogen molecules that the microbes then take up, and that tag ends up in the soil, and so we can measure how much of that tag is in the soil over a given time frame, and that tells us how much nitrogen has been fixed," said Darian Smercina, a graduate student in the Tiemann lab.

In the Friesen lab, postdoctoral researcher Alan Bowsher is developing methods to examine root exudates, chemicals secreted by plants' roots, and investigate



MEMBERS OF THE MMPRNT TEAM AT THEIR ALL-HANDS MEETING AT KBS IN OCTOBER 2017

what plant genes are turned on or off in response to microbes and nitrogen.

"My hope is that in better understanding the plant physiology and molecular biology side, we can be informed of how to breed switchgrass varieties that might be more tolerant of low-nitrogen conditions," said Bowsher.

Like Smercina, Tiemann lab postdoctoral researcher Yang Ouyang is using an isotope method to observe carbon and nitrogen cycling in microbes associated with switchgrass plants. He labels root exudates with carbon isotopes, feeds them to microbes, and then extracts DNA from the microbes that are using that carbon, applying tools at MSU to sequence the DNA.

The team goes beyond conventional molecular methods to understand what the microbes are doing under different scenarios. A common way to assess whether a nitrogen-fixing microbe is present is to count the number of genes that code for that function. However, most studies only

use one or two versions of that gene, and miss a lot in their count.

Cole is developing ways to measure many versions of that gene, making it possible to get a complete picture of the capacity of the root-associated community to perform that function, and see what conditions might enhance or dampen performance.

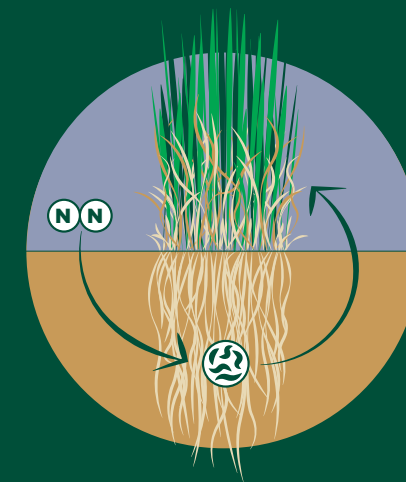
## All In This Together

Understanding the complex interactions between plants and microbes takes the skills and experiences of an interdisciplinary team and the investment of time in collaboration.

"Our PIs have a large range of expertise; this ranges from biogeochemistry to microbial ecology, and plant sciences to bioinformatics," said Steve Gougherty, MMPRNT project manager in the Evans lab. "This is a really far-reaching group of expertise that we have the luxury to study under, and this diversity in terms of interest is also reflected within people working in individual labs."

The team is committed to training the next generation of young scientists. In the summer, the team trains undergraduates who are supported on NSF grants to work on the project. The combination of laboratory and field work, and the chance to be part of a collaborative research team, is an experience many of them can't get at their home institutions.

Ideas for the MMPRNT project's future come from all of the team members, who are motivated to better understand how to implement sustainable bioenergy production into agriculture. The project will likely continue for years to come as the team conducts and shares research that illuminates interactions between plants and their microbial communities.



**NITROGEN FIXATION**  
Atmospheric nitrogen (N<sub>2</sub>) is taken up by nitrogen-fixing microbes, who transform it into a form that plants can use.





**When W.K. Kellogg deeded the Kellogg Farm to Michigan State College, now Michigan State University, 90 years ago, he intended that the College would "... operate this farm under a most modern system of farm management so that it may serve as an object lesson to the people of the region in which it is located."**

**The definition of "most modern" has changed since the 1920s, but the Kellogg Farm's commitment to its original mission hasn't. Today, the Farm puts its mission into action through modern technology, research and outreach.**

# MOST MODERN

## 90 YEARS OF SERVING THE COMMUNITY

One of Basso's drones flies over historic farming equipment at the June 2017 Pasture Dairy Center Open House. Photo credit: E. Evan Kutz, 2017 KBS Intern

### Meeting the Mission of Modernization

To keep up with changing times and opportunities, and to optimize production, farmers have to change how they operate and be willing to adopt new technology.

Ten years ago, the Farm changed its dairy operation from a confinement system to a grazing system and implemented robotic milking. Many farmers might call grazing a step backward, not modern progress; however, Kellogg Farm manager Brook Wilke sees it differently.

"I think it is modern because of the way we're doing it, in a precise way," said Wilke. "We're using a lot of data to manage the pastures and the cows, which is a lot different than historical grazing where we just send out the cows to the pasture."

Smaller dairy farmers often struggle to compete in today's market. The Farm's current grazing research and conservation-minded management demonstrate ways to reduce costs and raise product quality for those farmers.

"Farmers have to adapt," said Wilke. "If you just keep feeding cows the way we have been for the past 20 or 30 years, then it may seem modern, but in a way it's not because you're not adapting to your circumstances."

Adapting to new circumstances will increase opportunities for the next generation in farming families. Farmers who have been managing a farm for years are retiring and are passing on their farms to their children.

"Many older farmers don't necessarily want to take risks that run against their tradition," said KBS professor Bruno Basso, an MSU researcher at KBS who studies sustainable agriculture. "In ten years from now, I expect agriculture to completely change."

The new generation of farmers will be much more technology savvy, and as a result will be more likely to take risks and use new technologies that will help them make better, more informed decisions based on data.

Variability in yields between years and fields often leaves farmers with more

questions than answers. It's challenging to optimize crop production when climate, rain, fertilizer, and soil and other factors are always changing.

Basso studies changes over space and time in agricultural cropping systems by using precise data collection technologies. He can help farmers understand the variation they observe in their fields and make changes accordingly.

"The goal of my research is to make a difference and help farmers make good decisions," said Basso.

His research uses drones that fly over fields and take images that characterize plants and show spatial variation. Based on those images, Basso can run a crop simulation model, accounting for soil, water, management and genetics. Then he can make recommendations to farmers to improve their management for greater sustainability and efficiency of resources.

Understanding the management of nitrogen and water is critical for helping

farmers increase their yields and reduce their environmental impact. Using the precise data he's able to collect, Basso can help farmers reduce their nitrogen fertilizer waste and runoff, which will benefit the farmer's profits as well as the environment.

### Paying It Forward Through Research

The Farm supports two large-scale, federally funded projects on crop production involving researchers from KBS, MSU's main campus and other institutions. The Long-Term Ecological Research (LTER) project focuses on row-crop agriculture, and the Great Lakes Bioenergy Research Center (GLBRC) on bioenergy cropping systems.

Joe Simmons has been the LTER's farm manager since 2000. Simmons coordinates farming operations for the LTER and supports research on the project by developing protocols, overseeing fieldwork, and assisting with farming operations and data collection. His background and experience in farming help him see the value of the experimental approaches used in the LTER and GLBRC.

"We're doing stuff here that other farmers are not doing, and we can take those risks here, where a farmer isn't going to take those risks," said Simmons. "That's part of our mission, to do what someone else on a farm scale can't do. We're taking one for the team, and we're supposed to be able to do that."

KBS graduate student Kate Glanville studies nutrient cycling in cropping systems. She studies with KBS professor Phil Robertson, and appreciates the unique opportunities available to her at the Kellogg Farm.

"I think that having the farm available to utilize for our research on climate change will provide valuable lessons for future farmers. I feel lucky to be here and at a place that has so many resources and so much to capitalize on," said Glanville. "I'm proud to contribute to what is already here and hopefully contribute more as time goes on."

The Kellogg Farm supports researchers from KBS and beyond. MSU Extension Sustainable Agriculture Educator Dean Baas appreciates the opportunity to collaborate with Wilke and KBS researchers on the innovative work that is done here.

"I really enjoy working with the people here. It's a great group to work with," said Baas. "KBS has all the horsepower

of a large organization like MSU behind it, but in a small enough package that it's very easy to get things done. It's a great place to do research."

At the Farm, Baas conducts variety trials on several crops, including barley and organic soybeans. Baas, along with Wilke, recently partnered with the Michigan brewing industry to evaluate barley varieties, including Spartan barley, for beer production.

Spartan barley is a unique variety that was bred at MSU in 1916. In 2015, MSU researchers resurrected the variety from seeds that had been stored in the US Department of Agriculture's gene bank for more than 60 years. KBS is among several sites in Michigan for Spartan variety trials. In 2016, New Holland Brewery produced a 100% Michigan ingredient limited-edition lager featuring KBS Spartan barley.

"I'm just excited to be a part of bringing forth a variety that can be useful for Michigan agriculture and the subsequent brewing industry, particularly a variety that has so much history," Wilke said of his experience growing Spartan barley.

### Reaching Out For the Greater Good

One of the Farm's goals is to bring the research to farmers and share practical knowledge with them. Pasture Dairy Center Manager Howard Straub is enthusiastic about assisting other dairy farmers who are interested in implementing robotic milking technology and converting from confinement to grazing systems. Straub often travels to a farm to assist with the transition to robotic milking or to advise on pasture management practices.

"We have the ability to provide one-on-

one support," said Wilke. "We've spent from 2009 to present at the Pasture Dairy Center continuing to improve our system, and we've learned a lot of things so that farmers don't need to make the same mistakes. It tends to be the younger generation that is putting in robots, and they're very eager to learn, and they bring their parents along with them, so they can learn together."

The Farm is committed to sharing the results of research done here with the general public and professionals. The Pasture Dairy Center holds two open houses every year which showcase the work of the Dairy. Wilke and Straub, in collaboration with faculty and MSU Extension specialists, also host field days and tours for agribusiness professionals and farmers.

"I really love to get people out in the field looking at things," said Wilke. "I remember a couple of times on tours where I just walked or drove from field to field and showed them different things, and they just seemed so excited, and they said, 'Wow, we didn't know you guys did all this.'"

The Farm is a special place for many people, but it holds a very special place in Wilke's heart. He came to KBS as a graduate student, and feels lucky to continue working here professionally.

"I think back to when I first came here and started grad school I was kind of in awe. I came here because of how great the projects were, like the LTER and other experiments. I never dreamed I would be in the position I am now," said Wilke. "I love being involved in so many different things – I get to be a farmer, but I also get to be a scientist, and I get to be an educator."



Baas and Wilke lead a tour of barley variety trial plots at the Kellogg Farm in July 2016.



# A LASTING IMPACT

THE LAUFF SCHOLARSHIP MAKES RESEARCH POSSIBLE FOR STUDENTS



**This year, KBS celebrates 90 years since W.K. Kellogg donated the land that is now the Kellogg Bird Sanctuary and the Kellogg Farm, and 90 years since the completion of the Manor House’s construction. In addition, we celebrated former director George H. Lauff’s 90th birthday in March 2017. Lauff, pictured at left, worked throughout his life to enable and support the success of KBS students, researchers, and scientists.**

Lauff is responsible for shaping the W.K. Kellogg Biological Station as we know it. He became KBS’s first year round resident director in 1964, under the then newly founded MSU College of Natural Science. He also hired the first resident faculty at KBS. KBS’s year-round resident faculty is unique for a field station, and allows KBS to offer consistent programming and opportunities for graduate and undergraduate students.

2013 marked 50 years of aquatic ecology research at KBS, and Lauff was honored at the Aquatic Symposium here at KBS. According to Don Hall, a former KBS professor hired by Lauff in 1969, Lauff was instrumental in securing funding from the National Science Foundation (NSF) for the KBS Experimental Pond Laboratory. The NSF is generally slow to support “bricks and mortar” projects, Hall explained.

With Hall, Lauff framed the project as a request for man-made ponds to act as “giant, dirty test tubes.” It was this spin that ultimately convinced the NSF to fund the Pond Lab, which continues to put KBS at the forefront of aquatic ecology research.

Lauff knew the importance of the KBS student experience and making that experience financially accessible. Upon his

retirement in 1989, Lauff established the first endowed scholarship at KBS, the George H. Lauff Scholarship Fund. This fund would provide perpetual funding for students to work, research, and experience the culture of science and innovation at KBS. His support for KBS, both through his work and his donations, has helped empower the next generation of researchers and scientists, enabling these students to reach their full potential.

The George H. Lauff Scholarship Fund supports both undergraduate and graduate students. For many undergraduate students, the Lauff Scholarship funds their first professional position as a scientist, giving them valuable research experience. Graduate students benefit from the Lauff Scholarship through funding for research or tuition, enabling these students to push boundaries in fields ranging from community ecology and conservation to ecosystem ecology and biogeochemistry.

Since 1989, hundreds of scholars have received aid from the Lauff Fund. Scholars like Emily Grman, Darin McNeil Jr., Bonnie McGill, and Meredith Zettlemoyer all received the Lauff Scholarship while at KBS. We checked in with these scholarship recipients to see how they are doing today and hear about their time at KBS.

*“KBS was a wonderful place to learn how to be a scientist.”*

- Emily Grman, KBS alumna  
Lauff Scholarship Recipient



**Bonnie McGill**  
Graduate Research  
Awards 2015, 2016  
Graduate Student, KBS  
MSU Department of  
Integrative Biology

“The Lauff Scholarship has been a major source of funding for my graduate research at KBS. Without it, I wouldn’t have been able to do chemistry analyses of my nearly 1500 soil water samples that are the backbone of my PhD dissertation. The research, collaboration and networking opportunities I’ve experienced through the KBS LTER have had a huge impact on my career trajectory.”



**Darin McNeil Jr.**  
Undergraduate  
Research Award 2010  
Graduate student,  
Cornell University

“The KBS experience marked the first field position I held conducting real science. Since that time, I have secured two scientific degrees and am working on my PhD. These undertakings may not have been possible without my experience at KBS. I love that KBS serves as a professional nursery where young aspiring scientists can learn, make mistakes, and discover their passions in science and biology.”



**Emily Grman**  
Graduate Research  
Awards 2006, 2007  
Assistant Professor  
Eastern Michigan  
University

“The Lauff Scholarship enabled me to do research I would have had to pay for out of pocket while a graduate student. It supported much of my dissertation work, particularly while I was a new student just getting started. Writing the proposal also helped me formalize my research ideas, which was very valuable.”



**Meredith Zettlemoyer**  
Graduate Research  
Awards 2015, 2016  
Graduate Student, KBS  
MSU Department of  
Plant Biology

“I have been able to start my field research because of receiving the Lauff Scholarship. This donation helped get the supplies necessary to get the project up and running. KBS has helped provide the resources and network to do field research, get access to sites throughout Kalamazoo, network with local conservation groups, and talk to local citizens about biodiversity.”

## A Real Difference

The Lauff Scholarship has made a significant impact for undergraduate and graduate students at KBS, giving them the opportunity to conduct research and grow as scientists.

Since 1989, the Lauff Scholarship has distributed more than **\$365,500** to over **240** students

Awards Given  
**2016-17**

**17**  
GRADUATE STUDENTS

&

**14**  
UNDERGRADUATES

supported by  
**\$42,362**  
from the  
Lauff Fund

Give today to help the Lauff Scholarship grow to \$1,000,000!



# THANK YOU

*For your generosity to KBS in 2016-17*

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