MONTANA NSF EPSCoR

Spring 2014

photo by Kathy Keatley Garvey, UC-Davis

ECOSYSTEM RESEARCHER INVESTIGATES HONEY BEE HEALTH

While the food we most associate with honey bees is the sweet gooey stuff we put on our toast, bees play a much larger role in ecosystems around the world. Bees are essential pollinators of many agricultural crops, and if a honey bee colony collapses, nearby food crops are at risk.

Recently, bee colonies have experienced increased losses, and just why these colonies decline is a research focus for IoE Faculty Fellow **Michelle Flenniken**. Her work is one component of a comprehensive Institute on Ecosystems and Montana EPSCoR research agenda to understand linkages between microbial systems and larger scale ecological processes under a variable and changing climate. The plight of honey bees is an excellent opportunity to connect research on an important ecological process—pollination—to food production, a vital human need and a significant economic driver for Montana.

An IoE investigator is combining microbiology, virology, ecology, and agriculture to figure out ***what's killing the bees?***

Flenniken, a research professor in the MSU Department of Plant Sciences & Plant Pathology, focuses on honey bee health. Specifically, she studies the molecular mechanisms underlying host-pathogen interactions in agriculturally important systems. Flenniken has received research stimulation support as part of the Montana EPSCoR RII Track-1 project. Her multidisciplinary research spans microbiology, virology, ecology, and agriculture and requires that she work closely with honey bee keepers across the country.

At an MSU summer camp, researcher Michelle Flenniken helps middle school students become "Honey Bee Investigators" and learn about bee biology and the molecular tools scientists use to detect honey bee pathogens.

Flenniken knows that honey bee colony deaths are associated with higher pathogen levels, but the specific pathogens, hosts, and environmental factors that drive these declines remain unknown. Her work is ongoing, including studies of honey bee antiviral defense, honey bee pathogen monitoring, pathogenesis of the recently discovered Lake Sinai viruses, understanding honey bee immune system response, and examining the role of agrochemicals. She hypothesizes that the impact of pathogens on honey bee colony health is governed by additional factors, including host responses and the microbial context of infection. Using cutting-edge research methods, she is examining agrochemical exposure on pathogen abundance. A detailed molecular analysis is used to identify the combinations of genes, microbes, and metabolites that augment and lessen the effects of pathogenic infections.

Increased understanding of these factors may lead to strategies that can help bee keepers mitigate honey bee colony losses. And, discoveries of honey bee immune genes and pathways may reveal evolutionarily conserved innate immune pathways in other social organisms. In other words, what she learns about honey bees can help us better understand other complex ecological processes related to agricultural systems.

What Flenninken learns will not only directly impact Montana's agricultural producers but will also help to inform how ecosystems operate across micro to landscape scales. As top-down drivers such as climate change affect ecological processes, a better understanding of these systems will help predict ecosystem vulnerabilities to change and identify best practices to mitigate and adapt.

Flenniken's Rough Cut Science talk is available at http://montanaioe.org/outreach/videos

INSIDE

MONTANA INSTITUTE ECOSYSTEMS

MONTANA STATE UNIVERSITY

UNIVERSITY OF MONTANA

UPCOMING **EVENTS**

March 2014

Rough Cut Science – Diana Six, University of Montana

Rough Cut Science – Michelle Flenniken, Montana State University

April 2014

IoE Visiting Scholar proposals due

Rough Cut Science – Ryan Jones, Montana State University

Rough Cut Science – Julia Haggerty, Montana State University

June 2014

Montana EPSCoR RII Track-1 year 3 report due to NSF

September 2014

Start year 4 – Montana EPSCoR RII Track-1 project

October 2014

IoE Annual Summit – Helena, Montana

For a full schedule of IoE events, visit http://montanaioe.org/

Montana EPSCoR's Track I focus is on understanding the effects of climate change on sustaining healthy ecosystems and economic growth. The Institute on Ecosystems (IoE) is a statewide Institute based at the flagship research universities through which current Montana EPSCoR activities are implemented.

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NEW PEOPLE IN THE IOE

JAMIE MCEVOY, EARTH SCIENCES, MSU

Jamie McEvoy is a new assistant professor of geography in the Department of Earth Sciences at MSU-Bozeman. Her research focuses on the climate-water-energy nexus in the U.S. West. Her previous research examined how the use of desalination technology affects water management, urban development, the equitable access to water services, and the emergence of new social institutions to manage water in the context of growth and climate change. McEvoy has conducted extensive fieldwork in coastal Sonora, southern Baja California Sur, and southeastern Spain focusing on the (potential) use of desalination technology in these regions. This research was supported by a National Science Foundation DDRI award, a Fulbright Fellowship and a Water Sustainability Fellowship. From 2008-2011, McEvoy worked as a research associate at the Udall Center for Studies in Public Policy (University of Arizona) on projects addressing issues of climate, water and growth in northwestern Mexico and southwestern United States. She helped coordinate several binational stakeholder workshops to assess climate change vulnerabilities, engage stakeholders in the co-production of usable climate science, and foster adaptive capacity in the water sector in the U.S.-Mexico border region. She has conducted research to assess rancher participation in a water quality improvement program and adoption of best management practices in northern Utah. She has also researched and published on the topic of the feminization of agriculture in southeast Mexico.

McEvoy earned a bachelor's of science in environmental studies and a master's degree in environmental sociology from Utah State University. Her PhD is in geography from the University of Arizona.

BEN POULTER, ECOLOGY, MSU

Ben Poulter arrived at MSU-Bozeman in January as an assistant professor in the Department of Ecology. Through his Ecosystem Dynamics Lab, Poulter is investigating the role of climate and humans on terrestrial ecosystems, which play a critical role in the earth system by mitigating climate change, providing habitat for biodiversity, and resources, such as food, fiber and water for humans. His strategies include vegetation models, remote sensing, forest inventory and physiological measurements. Poulter earned his PhD at Duke University, then carried out post-doctoral research at the Potsdam Institute for Climate Impact Research (2006-2009), the Swiss Federal Research Institute for Snow, Forest and Landscape Research WSL (2009-2011), and the Laboratoire des Sciences du Climat et l'Environnement (2011-2013).

His research addresses the role of vegetation dynamics on earth system processes, i.e., carbon and nutrient cycling and climate feedbacks. He works with an ensemble of ecosystem models known as dynamic global vegetation models, or DGVMs, to explore hypotheses related to climate, disturbance, and land-cover change impacts on vegetation. DGVM models provide a useful approach to combine information from forest inventory, flux towers, and remote sensing, with ecological theory, to test predictions at multiple timescales in the past, present, and future.

Poulter is engaged in several multi-model syntheses exercises (MsTMIP, TRENDY, WETCHIMP, LBA) and contributed to the recent Fifth Assessment Report of the Intergovernmental Panel on Climate Change Working Group I "Chapter 6: Carbon and other biogeochemical cycles".

In Spring 2014, **Nicolas Najdovski** *joined the PhD program in the Department of Ecology to work in the Ecosystem Dynamics group of Ben Poulter. Nicolas will specialize in estimating forest biomass using radar, lidar, and forest inventory data to improve carbon cycle model predictions. He joins MSU from the Université Catholique de Louvain (UCL) in Belgium, where his Masters research focused on land cover and land cover change in the tropics.*

RESEARCHERS COLLABORATE TO INCORPORATE HUMANS' ROLE IN ECOSYSTEMS

What comes to mind when you visualize an ecosystem: Trees? Birds? Rivers? Fish? Most who take part in this exercise can rapidly visualize Mother Nature but often forget one critically important component: people.

Humans play a major role in ecosystem science, affecting everything from land use changes to wildife. Often, the role of people is at least as important--and complex--as the natural components and processes.

In the Montana Institute on Ecosystems, a new "SES Team" seeks to integrate the study of human dimensions with our studies of natural ecosystems. SES stands for social and ecological systems, and SES research topics cover everything from the valuation of goods and services provided by ecosystems to how humans' perception of ecological changes compares to biophysical data collected from sensors. Integrated SES research can improve our understanding of ecosystems and the role of science information in environmental policy and resource decision-making.

In February, the IoE hosted a two-day workshop for Montana's leading social scientists with an interest in SES. Led by MSU-Billings Director of Grants and Sponsored Programs **Dave McGinnis** (see sidebar), the diverse group included economists, political scientists, anthropologists, resource geographers, landscape ecologists, earth scientists, and microbiologists. **Diana Liverman**, a University of Arizona Regent's Professor who was in Montana as a Distinguished Visiting Lecturer, provided an external context.

Social and ecological scientists don't often collaborate, and each group's terminology and approaches to scholarship can be significantly different. Liverman helped to break the ice and start building new multidisciplinary connections by acknowledging some of these differences and facilitating discussion surrounding them.

The gathered team then brainstormed SES grand challenge topics that can drive future IoE research. Building from the current Montana EPScoR RII Track-1 research objectives organized around microbiology, environmental science, and landscape vulnerability to climate change, participants identified several potential topics:

- understanding land use change in response to rapid environmental change;
- quantifying Montana's natural capital;
- measuring the adaptive capacity of resource management institutions;
- documenting how perceptions of natural resources influence management actions and land use change; and
- exploring potential positive social system outcomes from environmental change.

IoE Scholar Dave McGinnis leads SES team

Dr. Dave McGinnis, Director of the MSU-Billings Grants and Sponsored Programs office, is an active leader in the Montana Institute on Ecosystems Socio-Economic Systems Research Initiative. McGinnis. a climate scientist, focuses on global climate change and water resources, mainly from snowpack. His research encompasses physical and social sciences, including complex systems analysis in the Yellowstone ecosystem. He recently spent two years as a program officer at the National Science Foundation in the Social, Behavioral, and Economic (SBE) Sciences directorate, where he shared his time between the Geography and Spatial Sciences programs and the multitude of programs in the Sustainability portfolio representing SBE interests.

In the coming months, the IoE will engage more SES scholars and IoE Fellows to refine and prioritize the list. True SES scholarship takes time and new approaches, but the reward is a better understanding of ecosystems in a fully integrated and realistic manner.

GRAD STUDENTS TACKLE INTERDISCIPLINARY COLLABORATIONS

By Jacob Lucero, PhD student in Ray Callaway's lab (Organismal Biology & Ecology), UM

In Fall 2012, a group of newly arrived graduate students at the University of Montana sat around a table discussing their various research interests. The conversation turned to the projects of other graduate students and faculty from departments around campus. It quickly became apparent that there was a surprising degree of overlap among our interests, and that we as a campus community of researchers could greatly benefit by uniting our talents, perspectives, and expertise. We realized that we could tackle otherwise inaccessible problems by taking an interdisciplinary approach to collaboration.

Of course, our experience was not original. Interdisciplinary collaboration has long been the lifeblood of high-impact research with important and far-reaching implications. The field of biomedical engineering, for example, is the result of productive collaborations among medical doctors, mechanical engineers, computer programmers and physiologists. These collaborations have produced staples of modern medicine like the heart/lung machine, pacemakers, and increasingly life-like prosthetics of all kinds. But how might graduate students hope to form such productive interdisciplinary collaborations during their graduate careers?

We figured the first step was to connect as many researchers from as many different fields as possible. With our combined passions and expertise, surely grad students at the University of Montana and beyond had the collective talent to pursue stellar interdisciplinary research. We talked with friends and colleagues about the idea of forming a professional network that connected researchers across disciplines. The response was phenomenally positive. Nearly everyone we spoke with agreed that we could all benefit by being more familiar with one another's research interests, talents, expertise, and resources. Led by the vision and enthusiasm of UM grad student **Mandy Slate**, we drew inspiration from social media and professional organizations and formalized the idea of an Interdisciplinary

CONTINUED ON BACK PAGE

IoE GRADUATE STUDENT RESEARCHES INSECT-BACTERIA DEPENDENCY

by James VanLeuven, University of Montana

Thousands of insect species feed solely on plant sap by piercing the protective layers of a plant with their proboscis and sucking the sap out like a kid with a milkshake. Unfortunately for the insects, sap is a poor food choice because it contains insufficient amounts of certain amino acids (the basic subunits of proteins). However, sap-feeding insects succeed in life because of highly obligate mutualism they have established with bacteria. These bacteria are called nutritional endosymbionts. They exist only in insect cells, and are metabolically integrated with their hosts, and sometimes with other co-symbionts. That is to say, the insect provides the bacteria with the essential components of life—water, sugar, and a suitable habitat—and the bacteria synthesize the amino acids missing in the insect's diet. The strictly intracellular lifestyle of endosymbionts imparts selective pressures on the endosymbionts that drive their genomes to shrink in size and total number of genes.

The cicada endosymbiont *Candidatus Hodgkinia cicadicola DSEM* exemplifies the outcome of a strictly endosymbiotic life history, with only 169 genes in its entire genome. Surprisingly, we find two Hodgkinia species coexisting in basal-lineage cicada individuals of species Tettigades undata (Figure 1). These two bacteria are about 5-25 million years diverged from one another, but are genomically complementary. In each, many genes are inactivated by mutations, but together they retain the full set of genes present in their ancestor and in Hodgkinia DSEM. Using fluorescently labeled probes (Figure 2) uniquely targeting each genome, we show that the genomes of these bacteria are cytologically distinct: they are indeed separate bacteria. Therefore, we propose that genetic drift caused the ancestral Hodgkinia lineage to split into two species that remain inseparably linked by genetic complementarity. Their dependency upon one another necessarily includes processes inherent to any cell, like transcription, translation, and replication.

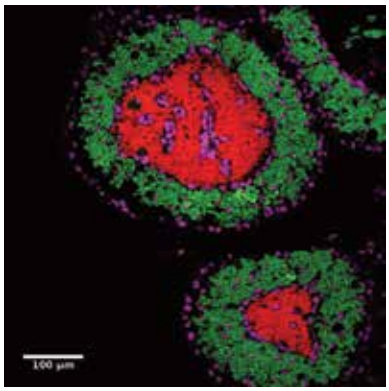

Figure 2. Fluorescently labeled bacteria are shown in green and red. Cicada host cell nuclei are shown in magenta.

How exactly this dependency arises from the simpler single-species ancestor is unknown, but we imagine that the unusual nature of Hodgkinia's cell membrane allows for the exchange of gene products between the two bacterial species. These results highlight the possible importance of genetic drift in leading to genomic complexity (not genome reduction) and suggest that even genes needed for the core processes of life can be shared, their gene products somehow made available to neighboring bacteria.

Figure 1. Cicada species Tettigades auropilosa. Photo by Sergio Bitran.

James VanLeuven is a PhD student in John McCutcheon's lab (Cellular, Molecular, and Microbial Biology), at the University of Montana

CONT. FROM P. 3

Collaborative Network (ICN) -- a forum that helps researchers from all backgrounds make connections necessary to tackle problems that span disciplines.

Our vision soon became a reality. With funding from the Montana Institute on Ecosystems, the ICN secured resources to produce a searchable database that lists experts in a number of fields by their skills and research interests. In addition, the ICN hosts a blog, social events and incorporates an active outreach component dedicated to community service. New this semester, is an ICN-initiated seminar series, designed to help graduate students better understand the logistics, benefits and challenges of interdisciplinary research. The series will target professional development skills like writing, speaking and interviewing. We are also excited to be expanding to include Montana State and Montana Tech graduate students.

We are proud of the ICN -- it is a grassroots organization started by students interested in broadening the scope and impact of their research. Please join us by creating a profile! As more partners join, our impact is enriched. Your expertise may be exactly what is needed to help tackle an otherwise inaccessible problem. Visit us at **http:\\ interdisciplinarycollaborativenetwork.org.**

OUTREACH PARTNERSHIP HONORED

An educational partnership between the Institute on Ecosystems and the Yellowstone Association received an honorable mention in the Visitors Guide category of the Media & Partnership Awards for the Association of Partners for Public Lands. *Living Colors: Microbes of Yellowstone* **is available in all Yellowstone National Park bookstores to help visitors learn about the abundance of microbial life in the Park and its role in the larger ecosystem.**