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Microbial Ecology

contents

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From the Chair...

Microbial ecology refers to the relationship of microorganisms (Archaea, Bacteria, and Eukaryotes) with one another and with the environment. These little giants play a major role in regulating various functions in ecosystems including: agriculture lands, forested lands, range lands, urban lands, and wetlands and aquatic systems. Science of microbial ecology is changing at an exceptionally rapid rate, particularly with the development of new methods and greatly increased understanding of the importance of microorganisms to fundamental processes in soils and waters. Naturally occurring microorganisms are involved in virtually all processes in soil and water, ranging from pedogenesis and elemental cycling, to the detoxification of environmental pollutants. Human activities can impact many of these processes, and a clear understanding of the fundamental controls on microbial activities is required to predict the directions and magnitudes of these activities.

The Soil and Water Science Department (SWSD) has been very active in research and education on the role of microorganisms in regulating water quality including pathogens, remediation of contaminated sites, ecosystem restoration, sequestration of carbon, production of greenhouse gases, and plant productivity. Future directions in microbial ecology in soils and water are difficult to predict given the speed at which the science is changing; however, the general trend is toward linking microbial activities across scales, and it is in this general area that a significant thrust of SWSD's future efforts should be directed. Microbial ecology is, by nature, interdisciplinary, and research across such broad scales will require collaboration between a variety of disciplines, including microbiologists, mineralogists, hydrologists, physicists, chemists, and scientists with the ability to synthesize and model these interactions across scales. The department is committed to strengthen soil and water microbiology programs to address current and future needs of our clientele, while advancing the science in this area.

In this newsletter we present a few examples of research and extension activities of SWSD faculty located both in Gainesville and the Research and Education Centers. Additional information on departmental programs can be found at: http://soils.ifas.ufl.edu.

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A Note from Andy Ogram

This is a very exciting time to be a microbial ecologist, with new discoveries seemingly made on a daily basis of the ways that microbes are important to everything from keeping biogeochemical cycles turning, to human health and agricultural productivity. This issue of Myakka highlights some of the work that scientists in the Soil and Water Science Department are involved in at the cutting edges of a wide array of basic and applied research on microbial ecology. This research ranges from the discovery of new diseases of coral reefs to greenhouse gas production in peatlands, and to the importance of microorganisms to agriculture.

The reach of the department extends far beyond the University of Florida, and our faculty collaborate with scientists around the United States and around the world. Ongoing projects include colleagues at the Smithsonian Institute, Florida State University, Mote Marine Laboratory, Louisiana State University, and various institutions in China and India.

Education and outreach are critical to training the next generation of microbial ecologists, and our faculty are very active in offering courses at the University of Florida and abroad. On-line and on-campus sections of courses on Soil Microbial Ecology, Biodegradation and Bioremediation, and the Ecology of Waterborne Pathogens are taught yearly. In addition to these courses, our faculty have been invited to present courses on biodegradation, wetland microbiology, and public health microbiology at noted universities and research institutions in India and China.

We hope you'll enjoy this special issue of the Myakka. Feel free to contact any of our microbial ecologists to learn more about their exciting work! For more information, contact Andy Ogram at aogram@ufl.edu.

Mycorrhizal Training Course

A practical, hands-on, training course on mycorrhizal associations is offered each July by the Soil Microbial Ecology Laboratory. The short course is intended for organic farmers, scientists, researchers, students, among others. Training includes technical procedures for examining and estimating mycorrhizal inoculum potential, and spore extraction and quantification. It also includes techniques to estimate percentages of mycorrhizal root colonization, mycorrhizal identification, and mycorrhizal inoculum production. The course has been increasing in attendance in recent years, and routinely attracts participants from around the United States and around the world. Our most recent course included participants from Florida, Illinois, and Georgia in the US, Nigeria, and Saudi Arabia.

Participants receive hands-on experience for each technique, such that the enrollment cap is restricted to 12 participants to ensure individual instruction. Upon completion of the course, participants will receive both hard copies and electronic copies of all procedures used in the course, and a certificate of completion. The fee is $500 per person. For more information, contact Abid Al-Agely at aaa@ufl.edu.

The 15th Annual Soil and Water Science Research Forum

The 15th Annual Soil and Water Science Research Forum was held on September 18, 2014, in Gainesville, Florida. Dr. Peter M. Groffman, Senior Scientist & Microbial Ecologist at the Cary Institute of Ecosystem Studies was the keynote speaker. Dr. Groffman's research focuses on an urban long-term ecological research (LTER) project in Baltimore that includes watershed, soil, plant, historical, socio-demographic and education and outreach components. Recent research efforts include studies of winter climate change effects on nitrogen dynamics in forests, effects of atmospheric nitrogen deposition on nitrogen gas fluxes, nitrate dynamics in riparian buffer zones, effects of a whole watershed calcium addition on soil nitrogen and carbon cycling, and the effects of exotic earthworm invasion on soil nitrogen and carbon cycling. Dr. Groffman's keynote presentation at the Forum was entitled: The Bio-Geo-Socio-Chemistry of Nitrogen in Urban Watersheds. In addition there were 11 oral presentations and 37 poster presentations at the research forum.

Mark your calendars for the 16th Annual Soil and Water Science Research Forum scheduled on September 17, 2015.

Coral's Tiny Armor

Coral reefs around the world, and especially in Florida and the Greater Caribbean, are under increasing stress. Global climate change, overfishing, and terrestrial run-off are just a few of the examples of such stressors. When stressed, corals become susceptible to infections with pathogens, leading to dramatic, ecosystem-wide outbreaks of coral diseases. There are at least two major hypotheses that attempt to explain coral disease outbreaks: 1) the majority of coral pathogens are opportunists, which are common in the seawater and attack corals only when their defenses are compromised; and 2) under some conditions, members of coral's native microbial communities activate virulence-related behaviors. In either scenario, native coral-associated bacteria play central roles in determining coral health. A broader cross-disciplinary understanding of the role of microorganisms in the health and physiology of their hosts led to the "*hologenome theory of evolution*," which postulates that in tightly co-evolved symbiotic relationships, collective genomes of the eukaryotic and prokaryotic partners within a symbiotic organism constitute one unit of natural selection, thereby conferring greater adaptive potential to the entire symbiotic assembly. Even though we are beginning to appreciate protective co-evolved functions of the beneficial microorganisms in the health of humans, animals and plants, mechanisms of this protection are not yet entirely clear.

In collaboration with scientists from the Smithsonian Institution and Mote Marine Laboratory, and with support from the National Geographic Committee on Research and Exploration and Mote Marine Laboratory's Protect Our Reefs Foundation, we identified several beneficial bacteria capable of inhibiting progression of a disease caused by *Serratia marcescens*. These beneficial bacteria prevented disease progression and supported full recovery of the polyps in the laboratory even when coral pathogens outnumbered the beneficial bacteria 10:1. It is clear that the beneficial properties of these bacteria are due to the production of novel signals that specifically block pathogenesis. However, it is not yet clear how these beneficial bacteria disrupt virulence and promote health of the polyp host. This discovery provides direct evidence in support of the Coral Probiotic Hypothesis. The ultimate goal of this research is to provide coral reef ecosystem managers with tools for pro-active solutions to deal with the coral reef crisis. For further information contact Max Teplitski at: maxtep@ufl.edu.

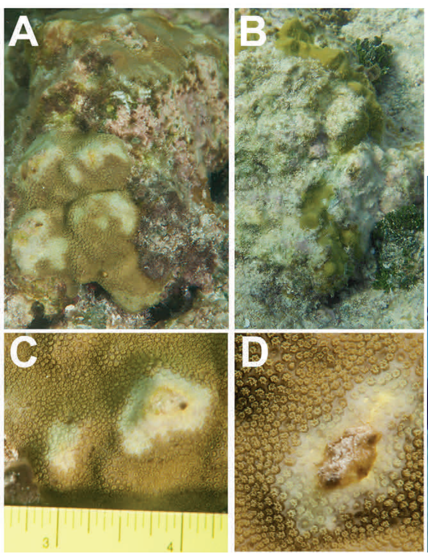


Image 1. A new disease of *Porites astreoides* discovered by the UF scientists in Belize. The disease is characterized by a progressing lesion and loss of living coral tissue. The disease occurs in summer, and is generally associated with the loss of the potentially beneficial bacterium *Endozoicomonas*. *P. astreoides* colonies were photographed in July (A, C, D) and November (B) of 2012. The same colony is shown in (A) and (B). (C) and (D) are close-up photographs of the lesion. Results of this study and this image are published in PLoS1.

Congratulations! Summer 2014 Graduates

PhD

Chumki Banik (Harris)
Pasicha Chaikaew (Grunwald)
Pamela Fletcher (Li & Kiker)
Jorge Leiva (Nkedi-Kizza & Morgan)
Rishi Prasad (Hochmuth & Martinez)
Rujira Tisarum (Ma & Rathinasabapathi)

MS

Shannon Duffy (Osborne)
Prissy Fletcher (Nkedi-Kizza & Morgan)
Alexandra Rozin (Clark)

BS

Lance Johnson – IS-EMANR (Curry & White)

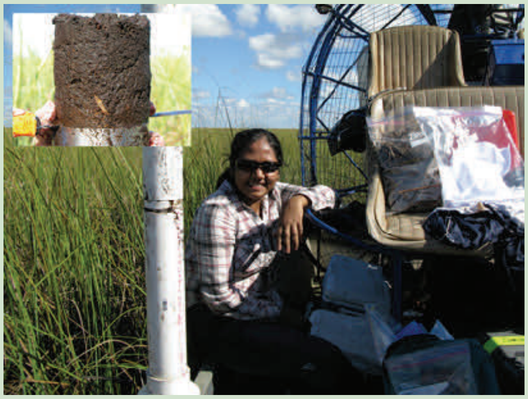
Control of Pathogenic Bacteria in Foods and Crops

Massimiliano Marvasi pursues research projects that aim to: i) identify metabolic, regulatory and structural genes in *Salmonella enterica* that are involved in successful colonization in plants; ii) characterize the relationship between the bioavailability of antibiotics and the spread of antibiotic resistance determinants through microbial populations within soil; and iii) optimize applications of nitric oxide to disperse biofilms and prevent biofouling formed by plant and human pathogens on surfaces of industrial interest.

It is well established that bacteria growing in biofilms are physiologically distinct from bacteria growing in a free- swimming planktonic state. This association, combined with bacterial plastic genomes, is in most cases the key to the success of the persistence, reproduction, and spread of microbes. Biofilms formed on food processing and produce-handling facilities can be reservoirs of human pathogens, which are difficult to control and can potentially cause costly outbreaks. Pathogens in biofilms are resistant to common disinfectants and contribute to an increase in the potential risk of cross-contamination of fresh produce and other foods.

Marvasi's studies have focused on identifying molecules that can disrupt biofilms in industrial settings typical of the fresh produce industry. Nitric oxide appears to be very promising: it can be delivered to biofilms using nitric oxide donor molecules and these molecules are currently used clinically. During last year, Marvasi has been the PI of three proposals funded by private foundations aimed at assessing the consequences of nitric-oxide mediated dispersion potential on biofilms formed by human and plant pathogens. Marvasi's research demonstrated possible applications of this new technology, advancing research, knowledge exchange and exploring commercialization opportunities. For more information, please contact Massimiliano Marvasi at mmarvasi@ufl.edu.

Some Like It Hot: the Role of Enzymes in Microbial Response to Environmental Change



Greenhouse gas production is one of the critical aspects of the global carbon cycle. In particular, the temperature sensitivity of soil organic matter decomposition leading to greenhouse gas production remains poorly understood. Research in the Environmental Microbiology Laboratory has focused on this topic by examining the temperature sensitivities of enzymes involved in carbon, nitrogen and phosphorus mineralization. Using fluorescent-labeled enzyme substrates, we found that carbon and nitrogen enzymes are more sensitive to temperature change than their phosphorus-based analogs. Such an unbalanced response of some enzyme groups affects our ability to predict greenhouse gas production under changing environmental conditions such as season or climate.

These concepts are also being applied to assess the preferential use of soil organic C versus oil derived C in contaminated marsh soils. By associating these microbial functional response to microbial structure via the use of lipid biomarker -isotope probing, research in our laboratory is also focusing on understanding the microbial adaptation to changing environment.

This work is in collaboration with SWS lab groups (Aquatic Biogeochemistry and the Biogeochemistry Modeling group) and groups from Louisiana State University. Students have also been integral to these projects including Swati Goswami (MS), Debjani Sihi (PhD), Francisca Hinz (MS) and Katelyn Foster (undergraduate, SWS).
For additional information contact Kanika Inglett Kanika@ufl.edu.

Impacts of Human Activities on the Assembly and Function of Microbial Communities in the Environment

Microbial communities in soils and sediments are considered to be the most complex ecological communities on Earth, and may be viewed as complex networks of cooperating and competing groups of microorganisms that participate in decomposition and nutrient cycling. The Soil Microbial Ecology Lab has ongoing projects in Florida, Panama, and Mexico to investigate the impacts of human activities on the structures and functions of these communities in peatlands, springs, and coastal sediments.

A long term interest of the lab has been in the ways that microbial communities in peatlands adapt to changing nutrient limitations. Wetlands harbor up to 30% of global carbon (C) stocks, such that they serve as critical sinks for C on a global scale. In addition to being important C sinks, tropical peatlands are the largest natural source of methane, a greenhouse gas that is 28 times more potent than CO_2 in storing heat. The balance between C storage and greenhouse gas emission depends in large part on the response of the resident microbial communities to changes in their environment, which may lead to changes in the relative rates of C sequestration and decomposition. The response of the communities in these ecosystems is controlled through interactive networks of microorganisms that are responsible for nitrogen and phosphorus acquisition and transformation as well as carbon transformations.

Laibin Huang is working with scientists in the Geology Department to evaluate the impacts of sea level rise on the microbial ecology controlling the geochemistry of submarine groundwater discharge in Central Florida and the Yucatan Peninsula of Mexico.

Elise Morrison is studying the molecular ecology of phosphorus cycling in peatlands, and will work with others in the lab on a large metagenomic study to characterize the assembly of microbial communities along nutrient gradients.

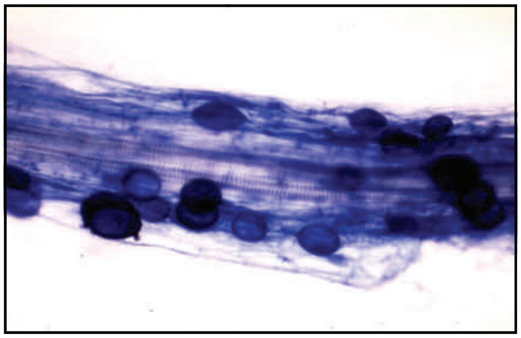
These complex networks of microorganisms form intersections with most of the biogeochemical cycles in peatlands, including some cycles that may not be immediately obvious, such as the mercury cycle. Networks that control carbon cycling are also responsible for mercury methylation and demethylation, an issue that is of great importance to management of the Everglades, and is currently being unraveled by Hee-Sung Bae. Hee-Sung recently found that syntrophic fermenters (i.e., bacteria that ferment simple organic carbon molecules with the aid of methanogens) are the dominant mercury methylators in the Water Conservation Areas of the Everglades.

For more information on the activities of the Soil Microbial Ecology Lab, please contact Andy Ogram at aogram@ufl.edu.

Soil and Water Science – Endowments

The SWSD established several endowments with the generous support from the Carlisle, Graetz, Polston, Robertson, Skulnick, and Smith families. Recently, the **Soil and Water Science Department Program Enhancement Fund** was established from funds by private donors in support of various departmental activities. In addition, K. Ramesh Reddy established a **Wetland Biogeochemistry Laboratory (WBL) Program Enhancement Fund** to support department wetlands and aquatic systems programs. We thank all our donors for their kind and generous support of soil and water science programs. To our alumni and friends please show your support for soil and water science by selecting and making your gift to a specific area of interest. Details can be found at: http://development.ifas.ufl.edu/online_giving.html.

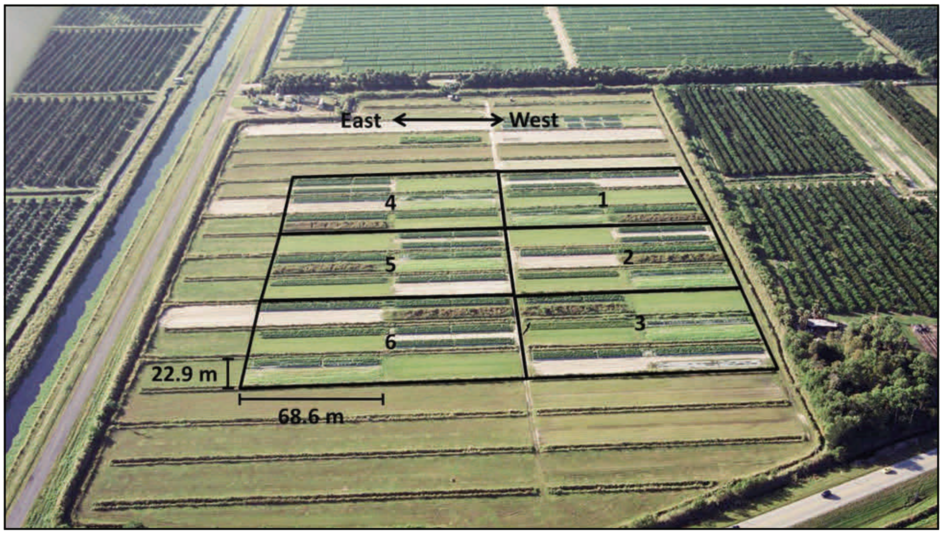
AMF Community Stability under Different Land Managements is Affected by Soil Disturbance



Glomus intraradices, an AMF commonly found in tomato roots

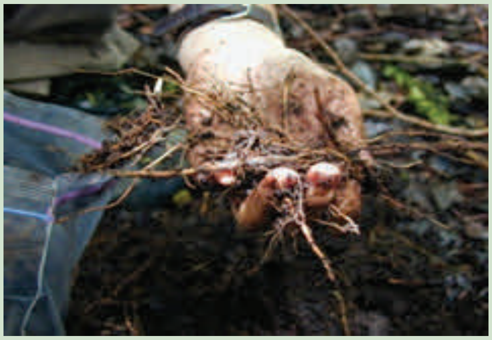
Arbuscular mycorrhizal fungi (AMF) form symbioses with most plants that are widely present in terrestrial environments and perform a variety of functions in their associations within natural ecosystems and managed agro-ecosystems. These mycorrhizal associations are believed to be capable of making a significant contribution to plant health as well as positively affecting soil quality. Based on experimental evidence, the ability of AMF to colonize roots and function under some field conditions common in intensively managed agriculture may be limited. Management practices such as phosphorus fertilization, tillage, and the application of pesticides, including the use of soil fumigants are considered potentially detrimental to AMF populations. Because of the widespread use of, and production benefits gained from, such practices that may be deleterious to AMF, it has been questioned as to whether AMF should be considered in the management of high-input agricultural systems. The value of AMF as biological indicators of soil quality and health may be significant, and their impact on agro-ecosystem functioning should be better understood. While considerable literature exists detailing the impacts of agricultural practices, little is known about the long-term repercussions that farming practices have on AMF presence, infectivity and community structure.

Dr. Dan Chellemi, USDA-ARS Ft. Pierce, set up a long-term trial to investigate diverse agricultural land and crop management practices ranging from high (conventional and disk fallow), moderate (organic) to minimal disturbance (bahiagrass and weed fallow). In collaboration with Chellemi, we used these land management treatments to investigate the impacts of agricultural systems and their disturbance on AMF community dynamics. The study design permitted the evaluation of AMF resilience after more than 10 years of conventional tomato cropping and the transition to a cropping system after the different land managements for 3 to 4 more years. As expected, soil disturbance had a large effect on the AMF community. Based on all analyses, AMF could be classified into two major communities: the disturbed; and the undisturbed. Other factors further explained the shifts in abundance of AMF within these communities. For example, the disturbed AMF community included low host availability (disk fallow management) and heat tolerant (organic cropping – soil solarization) sub-communities. The undisturbed AMF community thrived when host roots were perpetually available for colonization and the fungal networks were not frequently disrupted (bahiagrass and weed fallow land management). The disturbed community in conventional, organic, and disk fallow tomato cropping soils was composed of well described spore-forming AMF that thrive in agricultural systems. These results provide evidence for the resilience of a diversity of AMF and the existence of both active and latent communities that respond differently to disruptive cropping practices. For more information contact Jim Graham at: jhgraham@ufl.edu.



Header Canal research site showing land management plots in 6 locations (aerial photo courtesy of Dan Chellemi, USDA-ARS, Ft. Pierce)

Ecosystem Microbiology and Life Sciences Education



One of the greatest challenges we face in ecosystem ecology is the methodological challenge of how to integrate the study of microbial life (operating at spatial and temporal nanoscales) with the study of ecosystem functioning (biogeochemical cycles, operating at kilometer and decadal scales). The field of “ecosystem microbiology” pioneered by the Balser lab is focused on addressing both of these challenges. The over-arching goal of their efforts has been to increase understanding of, and ability to predict, ecosystem response to environmental and anthropogenic change. It is becoming clearer that inclusion of microbiological detail in long-term and large-scale ecosystem studies is necessary to achieve this goal. The Balser lab has taken a two-fold approach. The first is methodological. One of the most intractable challenges in linking microbial ecology and ecosystem scale research is differences in microbiological versus ecosystem, spatial and temporal scales. For example, an ecosystem scale project might encompass 1,000 samples, whereas a microbiology PhD thesis might be focused on only 50. Further, while a typical ecosystem study includes univariate canonical variables such as soil ammonium concentration, or respiration rate, microbial community data are inherently multivariate. It is critical that we find methodological ‘balance’ points and statistical procedures that allow for optimal integration of microbial and ecosystem data. The Balser lab has developed methods to increase sample throughput, and ways to process multivariate data specifically for the purpose of ecosystem-scale integration.

A second significant challenge in microbial ecology is making clear the link between microbial community structure and ecosystem functioning. The Balser lab second area of focus, microbial ecophysiology, addresses this challenge. The guiding hypothesis is that soil microbial population response to environmental stressors controls nutrient cycling in an ecosystem, and therefore directly determines ecosystem response to disturbance or environmental change. Our work has taken us all over the world as we study systems from the arctic to the old world tropics with projects aimed at understanding microbial response to changes in environmental modulators and resources (e.g. temperature, pH, pE, water, elevated CO_2, and nitrogen availability), as well as studies to examine the relationships among land use, biodiversity, climate change, species invasions and microbial community structure and activity. By making a distinction among different groups of organisms within the soil community, they have been able to demonstrate (sometimes for the first time) a relationship between microbial community structure and ecosystem processes.

These areas of research remain a passion, but more recently Balser has focused her research efforts increasingly on life sciences and environmental education. It is not enough to do the work ourselves, but it is critical that we find ways to engage and motivate students to follow us in our disciplines! Toward that end, she has published work about students and learning in environmental studies, as well as developing a successful game that teaches the nitrogen cycle. Here at UF, Teri Balser will be teaching a graduate seminar course this fall called “Professional Practice in Soil, Water, and Environmental Sciences,” focused on discovering and developing your professional “brand” and tailoring your research and teaching message for diverse audiences. For Spring 2015 she is developing a new version of the undergraduate course “Land and Life: The Challenge of Human Existence” and also teaching a graduate course “Perspectives in Global Change Ecology – Linking the Macro- and Micro-Scales”. For further information, contact Teri Balser at: tcbalser@ufl.edu.

Faculty, Staff and Students

Congratulations to the following students for their outstanding achievements

Soil Science Society of America Fellow

Every year, the Soil Science Society of America (SSSA) selects up to 0.3 percent of the Society's active and emeritus members as Fellows. This is the highest honor bestowed by our professional society. For the year 2014, **Vimala Nair** was a recipient of this Award.

<u>CALS Scholarships for 2014-2015</u>

Graduate Awards

Marcel Barbier (Li & Liu) received the William C. and Bertha M. Cornett Fellowship
Elise Morrison (Ogram & Turner) was awarded the Doris Lowe and Earl and Verna Lowe Scholarship
Biswanath Dari (Nair & Mylavarapu) received the A.S. Herlong, Sr. Scholarship
Anne Sexton (Daroub & Bhadha) received the Agricultural Women's Club Scholarship
Debjani Sihi (P. Inglett) was awarded the A.S. Herlong, Sr. Scholarship
Mohsen Tootoonchi (Daroub & Bhadha) was awarded an A.S. Herlong, Sr. Scholarship
Ashley Witkowski (Daroub) was awarded the Florida Fertilizer and Agrichemical Association Scholarship

Undergraduate Awards - Environmental Management in Agriculture and Natural Resources

Jennifer Brown (Curry & White) received the John F. Smoak Memorial Scholarship
Chelsea Hazlett (Curry) was awarded Doris Lowe and Earl and Verna Lowe Scholarship
Joshua Keen (Curry) received the Florida Rural Rehabilitation Corporation (Off-Campus) Endowed Scholarship
Andrew Land (Curry) won both the Southern States Scholarship and the Suwannee Co Conservation District & W.B Copeland Scholarship

Alumni news

Clayton Cox, currently a NIFA post-doctoral fellow (supervised by Teplitski and Brandl, USDA-ARS) was selected as an American Society for Microbiology Congressional Fellow. Cox begins his term in Washington DC in September 2014. Clayton obtained his PhD through UF SNRE, where his research focused on the interactions between a human pathogen (*Salmonella enterica*), oysters, and their native microbial associates. His NIFA post-doctoral fellowship aimed to characterize mechanisms by which human pathogens take residence in edible plants.

Welcome FAll 2014 New Students!

PhD

Setyono Hari Adi - (Kramer)
Jennifer Bearden (Mackowiak)
Andressa Freitas - (Kramer)
Stephanie Jamis - (O'Connor & Reddy)
Paul Julian - (Wright)
Kathryn McCurley (Jawitz)
Siti Jariani Mohd Jani (Toor & Thomas)
Eron Raines (Osborne)
Andres Rodriguez (Daroub & Gerber)
Lorae Simpson (Osborne)
Sheng-Yen Wu (Graham)

MS

Denise Breen (Wright)
Jordan Cuoco (Toor)
Katelyn Foster (P. Inglett)
Stephanie Heimann (P. Inglett)
Danielle Koushel (P. Inglett)
Allison Leapard (Osborne)
Daniel Lippi (Osborne)
Shanyu Meng (Li)
Michael Mertens (Toor)
Katsutoshi Mizuta (Grunwald)
Matthew Nance (Wilson)
David Pearsaul (Cisar)
Jeffrey Ragucci (Ma)
Patrick Ritchie (Clark)
Tracey Schafer (Osborne)
Cassandra Smith (Wilkie)
Tipanun Upanisakorn (O'Connor)

BS

Gianluca Heatherley - IS-EMANR-UFO (Curry)
Madison Brown - IS-EMANR (Curry)
Thomas Cawiezell - IS-EMANR (Curry)
Allison Crow - IS-EMANR (Curry)
Laura Duke - IS-EMANR-UFO (Curry)
Kristen Gaines - IS-EMANR (Curry)
Mia Gettenberg - IS-EMANR (Curry)
Yaslin Gonzalez - IS-EMANR (Curry)
Adam Greenhouse - IS-EMANR (Curry)
Samantha Kasten - IS-EMANR-UFO (Curry)
Jon Lackey - IS-EMANR-UFO (Curry)
Jonathan McMath - IS-EMANR-UFO (Curry)
Summer Perry - IS-EMANR-UFO (Curry)
Deysia Roberson - IS-EMANR-UFO (Curry)
Ericka Rodriguez - IS-EMANR (Curry)