

# SEES

Science, Engineering and  
Education for Sustainability

Spring 2014 Newsletter

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National Science Foundation



## FROM THE DESK OF THE SEES COORDINATOR

***Welcome!***

— Sarah Ruth

Thank you for your interest in the National Science Foundation's (NSF) Science, Engineering and Education for Sustainability (SEES) investment. In this edition, we are pleased to share some of the exciting research stemming from projects supported through the various SEES programs. We would also like to tell you what is **On the Horizon** for SEES in the coming years.

SEES was planned to be a multi-year effort across NSF to coordinate and grow research and education associated with the environment, energy and sustainability. Since its inception in 2010, with the creation of five programs focused on climate research, the SEES portfolio of activities has evolved and grown and now encompasses 17 interdisciplinary programs spanning all of NSF's Directorates and Offices.

In this newsletter, we share news from several of our SEES programs: **Dynamics of Coupled Natural and Human Systems (CNH)**, **CyberSEES**, **Sustainability Research Networks (SRN)**, **Partnerships for International Research and Education (PIRE)**, and **SEES Fellows**.

We are especially pleased to introduce you to some of the Fellows receiving support through the SEES Fellows program, which is entering its fourth year. Although all SEES programs have a workforce development component, SEES Fellows is our flagship program for the interdisciplinary training of scholars engaged in sustainability research. These bright early career researchers focus their energy, enthusiasm and skills to address the current and future complexity of challenges inherent to sustainability science. Beginning with the current newsletter and continuing in future editions we will highlight the diversity of Fellows and their research through our "Meet a SEES Fellow" article.

Although no new programs are planned for this fiscal year, several of our SEES programs are holding competitions and many of the new solicitations are already posted. **Please visit our website for updates pertaining to new program solicitations and deadline dates — [www.nsf.gov/sees](http://www.nsf.gov/sees).**



Credit: Keith Vanderlind, NSF



## SEES ON THE HORIZON

The SEES portfolio supports a growing community of research by incorporating both new programs and modified existing programs that span the entire range of scientific domains at the NSF. SEES thematic programs are aimed at building the sustainability knowledge base, while simultaneously encouraging interdisciplinary linkages, new partnerships, and education and workforce development efforts.

### SEES Beginnings

NSF developed SEES in FY 2010 in response to numerous major community reports, including the August 2009 National Science Board (NSB) report *Building a Sustainable Energy Future*, which emphasized the need for a coordinated program. Initial efforts focused on developing and coordinating a suite of research and education programs at the intersection of climate and environment, with specific attention to human behavior. NSF launched the programs Dimensions of Biodiversity, Regional and Decadal Earth System Modeling, Ocean Acidification, Water Sustainability and Climate, and the Climate Change Education Program. These programs emphasized the use of systems-based approaches to understanding, predicting and reacting to change in the linked natural, social and built environment.



NSF maintained momentum in SEES by augmenting existing interdisciplinary programs (Dynamics of Coupled Natural and Human Systems (CNH) and Research Coordination Networks (RCN)) and issuing a Dear Colleague Letter (DCL) in FY 2011. In FY 2012, NSF expanded SEES efforts through significant investments in programs related to energy and collaborative networks. These four new activities were: the SEES Fellows program; Sustainability Research Networks (SRN); Sustainable Energy Pathways (SEP), focused on integrated energy resource utilization; and a SEES-focused Partnerships for International Research and Education (PIRE) competition to advance international sustainability research networks. In FY 2013, NSF initiated five SEES Programs to complement the earlier programs — Coastal SEES; Arctic (ArcSEES); Interdisciplinary Research in Hazards and Disasters (Hazards SEES); Sustainable Chemistry, Engineering and Materials (SusChEM); and Cyber-enabled Sustainability Science and Engineering (CyberSEES). These programs focus on environmental, technological, and societal resilience, dissemination of results, responsiveness to societal needs, and workforce development.

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### **SEES On the Horizon**

SEES remains an important priority and key investment area for NSF in FY 2014. Of particular note is the Sustainability Research Networks solicitation that will build linkages to expedite progress across the complicated landscape of urban sustainability, which has emerged as a critical need for the 21<sup>st</sup> century. The FY 2014 estimated funding level for SEES is expected to be similar to FY 2013 actual spending across the portfolio of SEES programs.

Looking ahead, the SEES portfolio will continue to support the expanding SEES community of researchers through dissemination of information from the growing SEES knowledge base, as well as the workforce development critical for producing the next generation of sustainability scientists and engineers. In the years beyond FY 2014, NSF may support community planning for a new focus area on the topic of sustainable and resilient water, energy, and food systems. Other sustainability focus areas and activities will continue to yield results through ongoing projects.

NSF has supported sustainability-related research and education for decades. The SEES portfolio builds on this foundation and brings programs that address sustainability into a common framework to optimize investments and outcomes. Through SEES, NSF — in collaboration with its partners across government, academia, and industry — will have made significant investment and progress towards a sustainable human future.

— *Elizabeth Zelenski*



*Credit: Robert Carpenter, Cal State Northridge*

## MEET A SEES FELLOW: ANDREW MARKLEY, UNIVERSITY OF WISCONSIN—MADISON

**Andrew Markley** of the **University of Wisconsin-Madison** was awarded a **SEES Fellowship** in 2012. He and colleagues are working to engineer cyanobacteria to grow in nutrient-rich



Credit: Andrew Markley

wastewater. The bacteria will produce commodity chemicals and biomass. Markley has been interested in the intersection between synthetic biology and environmental applications since his days as an undergraduate in a “green chemistry” lab. We caught up with Markley and heard about the highlights of his experience as a SEES Fellow, the collegial nature of the program, and some unexpected benefits of his SEES affiliation.

*Although you are still in the early stages of your project, have you had any interesting results so far?*

**Andrew Markley (AM):** The project I’m working on addresses growing cyanobacteria—they’re “pond scum,” basically—in waste-water. So far, we’ve done that. That’s not really an earth-shattering result, however, because these bacteria do grow in wastewater. But we now know that the species our lab works with can do that. One thing that has been a challenge is that there aren’t many genetic tools for studying this particular organism. Cyanobacteria are not as well-classified and well-understood, as,

for example, common bacteria such as *E. Coli*. Much of my time for the first year has been developing these “missing” tools. We’re getting close to publishing those results.

*Why is it that there are tools developed for things like E. Coli, when they are not developed for cyanobacteria?*

**AM:** In a lot of the tools we use for what we call metabolic engineering, we’re changing how a cell metabolizes a product. We want these cells to make more of a particular by-product of metabolism. We accomplish that by turning on and turning off genes. We’d like to be able to introduce genes, or knock out genes, inside the genome. The code for doing that, however, is different between *E. coli* and cyanobacteria. We work with promoters or ribosome-binding sites, cues that tell bacteria how much of a given gene to make. The code that conveys this message differs among organisms. As part of my research, I’ve designed ways to dial in exactly how much expression we need of each gene. That will be useful for anyone working on these cyanobacteria.

*What is your favorite part of being a SEES Fellow?*

**AM:** Being a SEES Fellow has given me the freedom to know that I’m funded for three years. To know that I can pursue basic research. And it has allowed me the flexibility to become a more independent researcher.

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*Is there any advice you'd like to share with future SEES Fellows?*

**AM:** The SEES group—at least, my class of Fellows—is very social. So there have been Skype meetings to share what we're doing, and other ways of networking to help each other's research. To other Fellows, I'd say: take advantage of that and try to use your new "fraternity" as a resource.

*Do you have any other thoughts you'd like to share about your SEES Fellowship experience?*

**AM:** Another connection I've made through the SEES fellowship is with my university's Office of Sustainability. It led to a side project involving recycling: we're re-using Styrofoam boxes from shipping in biological labs. I had worked on a similar project during grad school, but having the extra university support has made all the difference. An NSF SEES fellow award opens new doors. Doors I'm walking through already – and ones I hope to in the future.

— Vanessa Lazar



Credit: Andrew Markley

**INFORMATION REGARDING NSF'S SCIENCE, ENGINEERING AND EDUCATION FOR SUSTAINABILITY FELLOWS (SEES FELLOWS) CAN BE FOUND [HERE](http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504673).**

[http://www.nsf.gov/funding/pgm\\_summ.jsp?pims\\_id=504673](http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504673)



## GROWING URBAN SUSTAINABILITY

How can we develop sustainable, resilient urban systems that provide healthy, safe, and affordable environments for the growing number of people living in cities and their surrounding metropolitan areas across the globe? The new **Sustainability Research Network (SRN) 2014** solicitation, NSF 14-534, calls for proposals that can help to answer this question.



A green roof in New York City. Credit: *Stuart Gaffin and Shaily Kedia, Center for Climate Systems Research, Columbia University*

With a focus on urban sustainability, the 2014 SRN competition seeks to fund networks that identify an ambitious and nationally important theme in urban sustainability and that present a creative and innovative research plan. These networks should bring together interdisciplinary teams of researchers, educators and stakeholders from a variety of institutions and sectors to address grand challenges in urban sustainability. Successful proposals will integrate a variety of disciplines, sectors and backgrounds in a network that will create new per-

spectives and yield new understanding and knowledge. The ultimate goal of this research is to inform societal actions for future environmental, economic, social, and cultural sustainability in urban environments.

Sustainability Research Networks (SRN) is a multi-directorate program that is part of the SEES portfolio. This is the second SRN solicitation that has been issued since the program was created. The first solicitation, issued in 2011, did not focus on a particular research topic and resulted in two \$12 million awards studying 1) the effect of natural gas development on air and water resources (<http://airwatergas.org/>), and 2) adaptation to and mitigation of the risks of climate change (<http://scrimhub.org/>). Read more about these two awards at:

[http://www.nsf.gov/news/news\\_summ.jsp?cntn\\_id=125599&org=NSF&from=news](http://www.nsf.gov/news/news_summ.jsp?cntn_id=125599&org=NSF&from=news).

### *Did you know?*

**More than half of the world's people now live in cities, including 80% of people in the U.S.!**

(Source: U.S. National Academies, "Pathways to Urban Sustainability: Research and Development on Urban Systems-Summary of a Workshop," The National Academies Press, Washington, D.C., 2010)



# UNDERSTANDING LOCUST OUTBREAKS TO BETTER MANAGE GRASSLANDS

Sustainable livestock production is of great importance to rural livelihoods in many communities across the globe, from semi-nomadic pastoralists in sub-Saharan Africa, to large-scale stocking and grazing for market production across rangelands in more developed nations. However, market forces and differing land management practices often lead to overgrazing, the economic and environmental effects of which have been well documented. Research conducted by **Arianne Cease**, of **Arizona State University (ASU)**, and her colleagues has recently shown that overgrazing of livestock in a grassland in China lowered the nitrogen content of the grasses, causing a rise in the abundance of a locust species likely to swarm. Locust outbreaks can have a devastating effect on rangeland, impacting both crop and livestock yields, and ultimately food security. These locust outbreaks can have cascading effects— creating forage shortages that affect the supply of livestock and can feed back into the market sending price signals to distant producers to alter production decisions and behaviors.

A recent grant awarded to Arizona State University by the **Dynamics of Coupled Natural and Human Systems (CNH)** Program will enable Cease, a physiological ecologist, and her colleagues to expand their research to new areas and test whether overgrazing may be a general cause of locust outbreaks in other regions. The project will include field research in grasslands on three continents — with research focused in China, Senegal, and Australia — comparing grazing practices and locust swarms to economics and social policy in the three contrasting regions. The interdisciplinary research team, comprising biologists, social scientists, and economists, will investigate the interactions among human behavior, market forces, and ecological systems in situations wherein the decision to overstock and overgraze rangeland alters plant nutrient content, potentially producing outbreaks of agriculturally-damaging locusts. The research team includes Cease and her ASU colleagues Jon Harrison, an insect physiologist, and Jim Elser, an ecosystem ecologist, as well as Eli Fenichel, a bioeconomist from Yale; Joleen Hadrich, an agricultural economist from Colorado State University; and Brian Robinson, an environmental geographer from McGill. This integrated team will also investigate how market forces and information transfer can either exacerbate or ameliorate the spatial externalities associated with overgrazing-induced locust swarms.



Australian eastern plague locust (*Oedaleus australis*).  
Credit: Arianne Cease

This project aims to develop new, sustainable strategies to understand and manage locust outbreaks, accounting for feedbacks among ecological, agricultural, and economic systems. Results will be translated directly into management and policy recommendations through collaborations with the U.S. Agency for International Development (USAID), the Plant Protection Agency in Senegal (DPV), the Australian Plague Locust Commission (APLC), the Chinese Academy of Sciences, and the Chinese Grassland Society.

— Kristin Küyük

# PIRE SPOTLIGHT: DEVELOPING LOW-CARBON CITIES IN THE U.S., CHINA AND INDIA

According to a report from the International Energy Agency (2010) almost half of the world's carbon dioxide emissions come from the United States, China and India. In 2012, the National Science Foundation's (NSF) **Partnerships for International Research and Education (PIRE)** program funded 12 sustainability-focused projects. One of these awards addresses this problem in China, the USA and India. The U.S. principal investigator, Anu Ramaswami, at the University of Minnesota is working with colleagues from five other U.S. Universities and National Laboratories – Marian Chertow, Yale University; Armistead Russell, Georgia Institute of Technology; Christopher Weible, University of Colorado Denver; Patricia Romero-Lankao, National Center for Atmospheric Research; and Rachelle Hollander, National Academy of Engineering – to examine sustainability planning for rapidly-developing cities in India and China. The US team is collaborating with four Indian Institutions and three Chinese Institutions, focusing on cities with fewer than one million people that are experiencing accelerated growth and are expected to become large urban epicenters. The overarching goal is to explore the linkages of low carbon infrastructure development with other sustainability concerns that are particularly important to many Asian cities, such as extreme water scarcity, environmental pollution, and related public health impacts.

There are several components to this fundamental interdisciplinary project. Over the remaining four years of the project, Ramaswami and her colleagues are modeling the Greenhouse Gas (GHG)

emissions in smaller, developing Asian cities and will compare the urban development of these cities with the trajectory of development in both large and small cities in Asia and the U.S. They are investigating implementable infrastructure changes - such as industrial symbiosis, electric power planning with water constraints, bus rapid transit and infrastructure innovations in slum areas - that can reduce GHG emissions while also offering significant co-benefits related to water savings, pollution reduction and public health improvements. Simultaneously, social scientists on the team are researching the social attitudes, institutional arrangements and the political structure that will provide insight into how to facilitate infrastructure change toward low carbon and sustainable development. Finally, a key component of the PIRE awards is education. As part of this project Ramaswami and her U.S. and international colleagues are designing and establishing an International Summer School focused on Sustainable Infrastructure-Sustainable Cities in the three countries. This graduate program follows the interdisciplinary nature of the whole project as it pulls together Engineering, Environmental Sciences, Industrial Ecology, Urban Planning, Public Affairs and Public Health.

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2013 Summer School Participants. Credit: Anu Ramaswami

## PIRE Spotlight — Continued from page 10

It is estimated that this project will involve almost 100 students, numerous researchers and millions of residents in and around the fieldwork cities and within the three countries. This project has powerful implications for educating a sustainably-minded, globally engaged science and engineering workforce while bringing three nations together to address key worldwide environmental challenges. The first PIRE Summer School on Sustainable Infrastructure-Sustainable Cities was offered in India in Summer, 2013, and included more than 20 graduate students from both nations, and further, engaged about 15 Indian undergraduate students in field research in different Indian cities. More information is available at <https://sites.google.com/a/umn.edu/pire-sustainable-cities/> — *Amelia Greer*

## SMART POWER GRID MANAGEMENT

Energy usage and consumption is one of the major sustainability issues in the United States and around the globe. Recent technological advances present an opportunity to coordinate energy needs to maximize societal

benefits while ultimately reducing emissions and promoting sustainable energy use. Among these advances are the fact that energy infrastructure systems (power grids) are increasingly automated with advanced sensing capabilities and have the ability to rapidly exchange information via digital communications. Through a recently-awarded **CyberSEES** project, Wei Zhang and Xiaorui Wang (Ohio State University) are capitalizing on these advancements and working in collaboration with several industrial companies to develop a new energy management framework that will balance energy consumption needs among today's growing energy consumers – including data centers, plug-in electric vehicle charging stations and residential loads.

The overarching goal of this project is to use a cyber-enabled solution to reduce the electricity costs and



environmental impacts of an integrated energy grid system and enable that system to provide clean frequency regulation services (using reference signals to keep AC frequencies within an acceptable range) across the

grid. The framework that will manage the grid consists of a real-time feedback control layer that interacts with a high-level market planning layer. Using power control strategies, the team plans to enable participating consumers to collaboratively track assigned frequency regulation signals in real time while respecting quality of service constraints. This will be one of the first projects to explore using a data center combined with other information on energy consumers to provide frequency regulation service to the grid. By grounding the management framework with realistic energy market and ancillary service market mechanisms, there may be channels to share market revenues with the participating consumer, ultimately promoting adoption of plug-in electric vehicles, reducing emissions and promoting cyber-enabled sustainability.

— *Emily McDonald*



# SEES RESEARCH DISCOVERIES AND NEWS: FISCAL YEAR 2013 IN REVIEW

*Except as noted, all articles written by*

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[NSF supports collaborative cyber-enabled research to advance sustainability](#) (Press Release 13-203: December 17, 2013/ Cyber SEES) - *Aaron Dubrow*

[Discovery: Staple of recipe favorites—the tomato — reveals processes that maintain biodiversity](#) (December 5, 2013/ Dimensions of Biodiversity)

[NSF, with interagency and international partners, makes first round of grants to understand Arctic sustainability](#) (Press Release 13-187: November 6, 2013/ ArcSEES) - *Peter West*

[‘National Chemistry Week’ celebrates sustainable resources](#) (Press Release 13-180: October 25, 2013/ SusChEM) - *Ivy Kupec*

[In Wake of Hurricane Sandy, Oklahoma tornadoes, NSF awards \\$32 million in hazards sustainability grants](#) (Press Release 13-176: October 21, 2013/ Hazards SEES)

[NSF awards first coastal sustainability grants for research on world’s most populated areas](#) (Press Release 13-171: September 27, 2013/ Coastal SEES)

[In race against time, NSF grants fund research on Earth’s threatened biodiversity](#) (Press Release 13-170: September 27, 2013/ Dimensions of Biodiversity)

[National Science Foundation awards \\$19.4 million for research on coupled natural and human systems](#) (Press Release 13-164: September 25, 2013/ CNH)

[Ocean Acidification: Making new discoveries through National Science Foundation research grants](#) (Press Release 13-148: August 26, 2013/ OA)

[NSF, USDA, DOE Award Grants to Improve Predictions of Climate Change on Regional, Decadal Scales](#) (Press Release 13-122: July 9, 2013/ EaSM)

[Discovery: Ghosts of Forests Past: Bark Beetles Kill Lodgepole Pines, Affecting Entire Watersheds](#) (June 27, 2013/ WSC)

[Discovery: Summertime: Hot Time in the City](#) (June 21, 2013/ CNH)

[Natural Underwater Springs Show How Coral Reefs Respond to Ocean Acidification](#) (Press Release 13-108: June 17, 2013/ OA)

[World Oceans Month Brings Mixed News For Oysters](#) (Press Release 13-102: June 11, 2013/ OA)

[Human Disease Leptospirosis Identified in New Species, the Banded Mongoose, in Africa](#) (Press Release 13-084: May 14, 2013/ CNH)

[Extreme Algae Blooms: The New Normal?](#) (Press Release 13-057: April 1, 2013/ WSC)

[Discovery: Blue Mussels “Hang On” Along Rocky Shores: For How Long?](#) (March 21, 2013/ OA)

[NSF Supports Global Research to Advance Science and Engineering for Sustainability](#) (Press Release 13-003: January 15, 2013/ PIRE) - *Lisa-Joy Zgorski*

[Discovery: Cooking Up Clean Air in Africa](#) (January, 3, 2013/ CNH)

[Two NSF Sustainability Research Networks Are Each Awarded \\$12 Million](#) (Press Release 12-185: October 2, 2012/ SRN)



Credit: Brian Gratwicke, Smithsonian Conservation Biology Institute