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MICHIGAN UNIVERSITY-WIDE SUSTAINABILITY & ENVIRONMENT CONFERENCE 2018

Program & Schedule

February 14, 2018
12.30pm - 5.30pm

February 15, 2018
9.00am - 5.00pm

Michigan League

Sponsored by
School for Environment and Sustainability,
College of Engineering, Rackham Graduate School,
School of Public Health, College of Literature Science and Arts,
Climate and Space Sciences and Engineering, Political Science,
Industrial and Operations Engineering,
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UNIVERSITY OF MICHIGAN

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About the Michigan University-Wide Sustainability and Environment Initiative

The pace and scale of global environmental changes to Earth systems and the pivotal role humans are playing in driving those changes have introduced challenges which confront science and society. Although many scholars are working in this area, these challenges are far from solved. Tackling these challenges requires communication and collaboration both within academia and between researchers and the public. The Michigan University-Wide Sustainability and Environment (MUSE) Initiative was founded to bring together emerging scholars to foster this crucial dialogue and encourage collaborations. MUSE consists of a bi-weekly workshop, an online network of scholars, and this annual conference.

MICHIGAN UNIVERSITY-WIDE SUSTAINABILITY & ENVIRONMENT

So, we warmly welcome you to the 2nd annual MUSE Conference! The conference's goals are to bring together the immense array of sustainability and environment related research that we are doing here at the University of Michigan, Ann Arbor and foster on-going connections and collaborations. The conference is a constructive environment where we will share ideas and be open to the differences between disciplinary approaches – recognizing, embracing, and exploring this diversity is what will make our research richer and perhaps provide it that extra impact, so that together we can make real change in this world.

We offer our sincere thanks to our sponsors without whom this conference would not be possible.

Sponsors: School for Environment and Sustainability, College of Engineering, Rackham Graduate School, School of Public Health, College of Literature Science and Arts, Climate and Space Sciences and Engineering, Political Science, Industrial and Operations Engineering, Erb Institute | Business for Sustainability

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Learn more about MUSE: https://muse-initiative.umich.edu

MICHIGAN UNIVERSITY-WIDE SUSTAINABILITY & ENVIRONMENT CONFERENCE 2018

Schedule: Wednesday, February 14

12:00 – 12:30pm **Registration**

12:30 – 12:35pm **Welcoming Remarks (Ballroom)**

12:35 – 2:00pm **Plenary Session (Ballroom)**

- *Susan Scott Parrish (Keynote)*
- *Katherine E. Hummel*
- *Alec Foster*

2:00 – 3:30pm **Workshop Part 1 - parallel sessions**

I. *Climate Systems (Room 4, 1st Floor)*
II. *Urban Systems (Hussey)*
III. *Energy Systems (Kalamazoo)*
IV. *Agricultural and Food Systems (Room D, 3rd Floor)*

3:30 – 4:00pm **Poster Lightning Talks (Ballroom)**

4:00 – 5:30pm **Poster Reception - food and beverage provided (Ballroom)**

MICHIGAN UNIVERSITY-WIDE SUSTAINABILITY & ENVIRONMENT CONFERENCE 2018

Schedule: Thursday, February 15

8:00 – 9:00am **Breakfast (Concourse)**

9:00 – 9:30am **Open Plenary - coffee provided (Vandenberg)**

- *Seth Guikema*

9:30 – 11:00am **Presentations - parallel sessions**

1. *Environmental Risk and Behavior (Hussey)*
2. *Environmental Decision-making and Policy (Kalamazoo)*
3. *Urban Environments and Infrastructure (Michigan)*
4. *Land Use and Land Cover Change* (Vandenberg)

11:00 – 11:30am **Coffee break (Concourse)**

11:30 – 1:00pm **Presentations - parallel sessions**

5. *Energy Norms and Futures (Hussey)*
6. *Sustainable Food and Agriculture (Michigan)*
7. *Perceptions of Science and the Environment (Vandenberg)*

1:00 – 2:00pm **Lunch (Concourse)**

2:00 – 3:30pm **Workshop Part 2 - parallel sessions**

I. *Climate Systems (Room 4, 1st Floor)*
II. *Urban Systems (Hussey)*
III. *Energy Systems (Kalamazoo)*
IV. *Agricultural and Food Systems (Michigan)*

3:30 – 5:00pm **Concluding Panel (Vandenberg)**

6:00 – 8:00pm **Public Reception – RSVP required (Zingerman's Greyline)**

Keynote Speaker: Susan Scott Parrish

Susan Scott Parrish is a Professor in the Department of English and the Program in the Environment at the University of Michigan. Her research addresses the interrelated issues of race, the environment, and knowledge-making in the Atlantic world from the seventeenth up through the mid-twentieth century, with a particular emphasis on southern and Caribbean plantation zones.

Her new book, ***The Flood Year 1927: A Cultural History*** (Princeton UP, 2017), examines how the most devastating, and publicly absorbing, US flood of the 20th century took on meaning as it moved across media platforms, across sectional divides and across the color line. Her first book, *American Curiosity: Cultures of Natural History in the Colonial British Atlantic World* (UNCP, 2006), is a study of how people in England and in British-controlled America conceived of—and made knowledge about—American nature within Atlantic scientific networks. This book won both Phi Beta Kappa's Emerson Award and the Jamestown Prize. She has also written on such Anglo-Atlantic plantation figures as William Byrd II, Robert Beverley, John Gabriel Stedman, and Richard Ligon.

She has served on the editorial boards of *American Literature*, *Early American Literature*, and the *Winterthur Portfolio*, has been a council member at the Omohundro Institute of Early American History and Culture, and has served on the Executive Committee of the MLA's "American Literature to 1800" Division.

Title: *The Flood Year 1927: A Case for Interdisciplinary Environmental History*

Using material from Flood Year 1927, I will address the issue of why interdisciplinarity is important in reckoning with environmental problems, and disasters, of the past and of the future. In particular, I think Flood Year can help us see that how an environmental event takes on public significance is as important to consider as the causation and shape of the bare event itself.

Plenary Speaker: Katherine E. Hummel

Katherine E. Hummel is a second-year Ph.D. student in English Language and Literature. She holds a BA in English from La Salle University and an MA in Literary Studies from Purdue University. Her research interests focus on contemporary postcolonial literature, environmental ethics, critical animal studies, and visual culture.

Title: *Aerial Photography and the Multi-Scalar Challenges of Sustainability in Post-Hurricane Haiti and Puerto Rico.*

Sustainability has emerged as the common focus for Caribbean recovery efforts as the 2017 hurricane season ends. As Vann Newkirk II writes in The Atlantic, "sustainability is literally survival" for post-Hurricane-Maria Puerto Rico. Rather than frame sustainability as short-term infrastructural repairs, this environmental humanities project considers the temporal limits of sustainability in a future marked by climate change. With Caribbean spaces facing unprecedented environmental change, what are the conceptual and representational challenges for imagining sustainability in wide-ranging temporal and geographical scales? To engage this question, I turn to aerial photographs taken after Hurricane Matthew in Haiti and Hurricane Maria in Puerto Rico. I argue that photographs, as temporally dynamic forms, can teach viewers to attend to multiple human and non-human temporalities that intersect in the moment of photographic capture. Analyzing the images' composition and circulation, I claim these aerial photographs prioritize human survivors' voices, traces, and histories by repurposing the spectacle of environmental disaster to draw attention to otherwise invisible experiences. Engaging with the politics of photographic exposure can thus develop stronger ethical modes of spectatorship and more critical perspectives on what sustainable futures in vulnerable environments look like.

Plenary Speaker: Alec Foster

Alec Foster is a Postdoctoral Research Fellow in the School of Natural Resources and Environment at the University of Michigan. He is a broadly trained Urban Geographer, with both quantitative and qualitative research skills and experience. His dissertation research examines the role of participation in urban environmental stewardship on Philadelphian's sense of self, place, and nature.

Title: *Detroit, How Does Your Garden Grow? The Potential and Challenges of Scaling-Up Urban Agriculture in the Motor City*

Long a presence in the global South, an urban agricultural (UA) renaissance is now well-underway in cities throughout the global North. Perhaps no Northern city has received more attention regarding UA than Detroit. However, there has been little research that actually documents the composition, spatial extent, and motivations for UA in Detroit. This paper fills these lacunae through a mixed methods analysis. Focusing on Detroit's Lower East Side, a time-series analysis of Google Earth imagery from 2010 and 2016, ground truthed through physical site audits, reveals rapid growth in the number of UA sites, although they remain a small portion of the available open land in the neighborhood. Qualitative interviews revealed the motivations that led lower eastside residents to participate in UA. Most frequently mentioned were community building and aesthetic benefits, with other common motivations being a connection with nature, economic and food access benefits, and a history of gardening or farming. Finally, we synthesize the challenges associated with scaling up UA. Challenges are both technological and social, highlighting the importance of understanding urban areas as complex social-ecological systems.

Thursday Keynote Speaker: Seth Guikema

Seth Guikema is an Associate Professor in the Department of Industrial and Operations Engineering and the Department of Civil and Environmental Engineering at the University of Michigan. Much of his group's recent work is focused on the problems of urban and infrastructure resilience and sustainability in a changing climate, though areas of application are broad. It is grounded in risk analysis, particularly data-drive risk analysis and complex systems simulation.

Title: *Resilience and Sustainability in Disaster-Prone Communities*

Many communities throughout the world are prone to natural hazards such as hurricane, earthquakes, floods, and wildfires. These communities evolve over time in response to many different drivers, including the impacts of disasters and behavioral and policy responses to these impacts. This evolution over time can substantially alter the vulnerability of the community to future natural hazards. This talk will provide an overview of several recent projects aiming at better understanding how the dynamics of individual and policy responses to disasters can change the trajectory of a community and how this affects community resilience and sustainability.

Workshops

The conference will contain two workshop sessions on the theme, *"Big questions and the importance of interdisciplinarity."* The workshops aim to encourage discussions between conference participants and foster interdisciplinary collaborations. Each session will contain four parallel tracks:

- Climate systems
- Energy systems
- Agriculture and food systems
- Urban systems

The overall output of the workshops is a group challenge that involves coming up with an interdisciplinary research proposal focused on a topic developed during the workshop sessions. The workshop sessions will proceed as follows.

Workshop 1 (Wednesday 14th, 2-3:30pm): this session will begin with a panel of faculty and/or postdocs working in the field of the workshop track. The panelists will be discussing and fielding questions about "big issues" in the field and the importance of interdisciplinary research. This will be followed by breakout discussions, where workshop participants will work together to propose broad research ideas/directions that span disciplinary boundaries. The goal here isn't to solve the problem, but to identify interesting questions amongst your group.

Schedule:

Time	**Activity**
2:00 – 2:10	Arrival and introductions
2:10 – 2:40	Panel discussion
2:40 – 3:15	Breakout discussions
3:15 – 3:30	Reporting back

The confirmed panelists are:

Theme	**Panelists**
Climate	Frank Marsik (CLASP) Jonathan Overpeck (SEAS) Carina Gronlund (SPH)
Energy	Margaret Wooldridge (Mech. Eng.) Daniel Raimi (Ford School) Joe Arvai (Ross/SEAS)
Agriculture and food	Arun Agrawal (SEAS) Lesli Hoey (Taubman) Julia Wolfson (SPH)
Urban	Josh Newell (SEAS) Larissa Larsen (Taubman)

Workshop 2 (Thursday 14th, 2-3:30pm): the goal of the second workshop is to build the research ideas that were tabled the day before into a more comprehensive research plan. The research ideas will be displayed in the conference venue leading up to the second workshop. Conference attendees are not obliged to attend the same track both days, and can browse the list of ideas and find the idea/track that is of most interest to them. Attendees will write their name next to the idea that they are interested in working on and attend that track.

The session will begin with a presentation from a faculty or postdoc focusing on their experience and advice for coming up with an interdisciplinary research plan, and/or the importance of considering a particular underlying issue relating to the track's theme. Following this, teams will break out into the self-identified teams and work on their research plans. The workshop will conclude with a group discussion focusing on the experience of the past two days: what went well, what was difficult, and lessons learned for interdisciplinary research going forward.

Schedule:

Time	**Activity**
2:00 – 2:10	Arrival and introductions
2:10 – 2:20	Presentation
2:20 – 3:10	Breakout
3:10 – 3:25	Group discussion
3:25 – 3:30	Farewell / contact details exchange

The presenters are:

Theme	**Panelists**
Climate	Maria Carmen Lemos (SEAS)
Energy	Sarah Mills (Ford School)
Agriculture and food	Terry Nelidov (Erb) Melissa Zaksek (Erb / Graham Institute)
Urban	Joe Grengs (Taubman)

Parallel One: Environmental Risk and Behavior

The Fracking Debate
Daniel Raimi, Ford School of Public Policy

Over roughly the past decade, oil and gas production in the United States has surged dramatically—thanks largely to technological advances such as precise horizontal drilling and high-volume hydraulic fracturing, more commonly known as "fracking." This rapid expansion has generated widespread debate, with proponents touting economic and energy security benefits, and opponents highlighting the environmental and social risks of increased oil and gas production. Despite (or perhaps because of) the heated nature of the debate, many of the facts remain under dispute. In The Fracking Debate (Columbia University Press, 2017), Daniel Raimi gives a balanced and accessible view of the risks, benefits, and uncertainties of oil and gas development, clearly and thoroughly explaining the key issues surrounding the shale revolution.

Coupling a deep understanding of the scholarly research with travels to every major US oil and gas producing region, Raimi highlights stories of the people and communities affected by the shale revolution, for better and worse. The Fracking Debate provides the evidence and context that has so frequently been missing from the national discussion of the future of oil and gas production, offering readers the tools to make sense of this critical issue.

The role of behavior in undermining the effectiveness of adaptive measures in reducing long-term vulnerability to natural hazards
Tom Logan, PhD Candidate, Industrial and Operations Engineering
Co-Authors: S. Guikema, J. Bricker

There remains considerable debate about the efficacy of hard protective measures such as seawalls at reducing the vulnerability of coastal communities to natural hazards. While hard measures protect against smaller events, they may induce a behavioral response among the population that leaves the community more vulnerable to larger events. We develop a coupled tsunami-land use change model and study community vulnerability to repeated tsunamis. We compare alternative seawall heights with increasing community awareness of the hazard and their effects on how the risk of building stock damage evolves over time when subjected to repeated tsunami events. Our results show that while hard adaptive measures protect against expected events, they increase a community's vulnerability to future, larger events, as occurred leading up to the 2011 Great East Japan Tsunami. These results quantitatively challenge existing practice for hazard adaptation and demonstrate maladaptation due to hard-adaptive measures.

Livelihood and Climate Adaptation of Indian Farmers
Sam Russel and Hanna Droessler, UROP Students, School for the Environment and Sustainability

Livelihood diversification is often lauded as means to improve a household's resilience to shocks and potentially improve the food security and wealth of a household. Women's access to income opportunities is particularly emphasized given their willingness to invest more in household nutrition and health as compared to male counterparts. However, it is not clear that more

diversified households are better off and the process through which people diversify has not been rigorously explored.

Though the common adage of "not putting all one's eggs in the same basket" may hold true for some households, it is not the case that adding more income sources will necessarily improve a household's condition. Instead, a preferred livelihood portfolio is one that has multiple means of achieving the simultaneous financial goals of securing enough food, buying household goods, and accessing cash in an emergency. The ability to achieve these goals or to invest in new productive activities is shaped in surprising ways by a person's gender and caste; the resources and institutions they have access to; and the jobs that they already have. This presentation will feature research findings from 120 interviews and initial results from household surveys, which are being collected from 1,200 households across 4 states in rainfed regions of India each month for a year.

Individual Differences in (Dis)comfort with Altering the Natural World: The Tampering with Nature (TWN) Scale

Kaitlin Raimi, Ford School of Public Policy
Co-authors: Kim S. Wolske, P. Sol Hart, Victoria Campbell-Arvai

People differ in their comfort with tampering with the natural world. While some see alterations to nature as a sign of human progress, others see them as dangerous or hubristic. This can lead people who are concerned about environmental risks (e.g., climate change) to resist approaches that might ameliorate those risks (e.g., geoengineering). We developed the Tampering with Nature (TWN) Scale to explore discomfort about tampering with nature. We demonstrate that TWN is a distinct construct related to moral and religious values, environmental concern, and trust in technology. Unlike environmental concern, TWN is not tied to political ideology. Furthermore, TWN predicts opposition to a wide range of activities—from GMOs to gene therapy—including donation behaviors. By illuminating who fears tampering with nature and what predicts these beliefs, TWN provides opportunities for better understanding of public opposition to technological innovations, consumer preferences for "natural" products, and strategies for science communication.

Using Earth Concepts to Effectively Tailor Pro-Environmental Messages

Julia D. Liao, Department of Psychology
Co-authors: Brian D. Vickers, Colleen Seifert, Stephanie D. Preston

Pro-environmental appeals can backfire if inappropriately framed for their target audience. Can people's concepts of the Earth be used to design effective targeted appeals? In previous studies, we found that political liberalism correlates with seeing the Earth as vulnerable, whereas conservatism correlates with feeling relatively less bad about destruction of the Earth. Regardless of political orientation, however, many people conceive of the Earth as being awe-inspiring. In the present study, we found that liberals favored a pro-environmental ad describing the Earth's vulnerability (an image of a polar bear and text describing "our beautiful, fragile earth"), whereas conservatives favored an ad describing the Earth's awe-inspiring qualities using religious themes (an image of a mountain lake and text describing "the wild beauty of God's earth"). This political polarization disappeared for an ad that also invoked the Earth's awe-inspiring qualities but without religious wording—conservatives and liberals liked this ad equally. Interestingly, both liberals and

conservatives donated more after viewing the secular awe ad or the vulnerable ad, indicating some disparity between stated preferences and actual giving. We conclude that pro-environmental appeals could benefit from tailoring their messages or switching to less polarizing appeals that emphasize a shared sense of awe.

The influence of generational difference on loss aversion and risk taking

Sara Goto, School for Environment and Sustainability
Co-authors: Joseph Arvai

Prospect theory describes decision-making behavior where individuals place higher relative value on losses than they do on equivalent gains. However, because prospect theory relies upon reference points for judging the value of losses, it stands to reason that intergenerational variability will influence the magnitude of loss aversion felt by decision makers. For example, over the course of a lifetime, individuals will experience multiple losses. To this point, older adults have had more opportunities to experience loss, and may make decisions and take risks that look quite different from those made by younger people who have experienced many fewer losses. As such, people could be expected to fall into patterns of loss aversion based on generational cohort as this classification sorts individuals by age, experience, and values. It is this generational difference, and its impact on present day environmental decisions, that were the focus of this research. More specifically, the effect of generational cohort and prior environmental losses on conceptions of environmental risk and support for future policy.

Parallel Two: Environmental Decision-making and Policy

The making of effective decision-maker scientist partnerships
James Arnott, School for Environment and Sustainability
Co-authors: Maria Carmen Lemos

Numerous gaps exist between the supply and demand for science to inform decisions. Funding agencies have been identified as one possible driver of change to support improved connections between scientists and decision-makers, but few studies have been conducted to learn more. In this study, we examine a body of applied science projects (n=120) funded through NOAA's National Estuarine Research Reserve System from 1998-2014. Regular innovation in the design of this funding program offers a natural experiment to test hypotheses about the how program design influences research practice, utilization, and broader impacts. Using content analysis of project reports and interviews of project participants (n=40), we find that funder mandates significantly influence the intensity of interaction between researchers and practitioners as well as affect long-term change in research cultures. When interaction intensifies, corresponding gains occur in the readiness of research to support decision-making. Collaborative methods transform research practice. It remains unclear whether these practices actually lead to more direct use of science to inform decisions. We find that improved and more flexible evaluation approaches at the project level and more nuanced, supported and guided by program sponsors, are needed.

From biofuel chemistry to biofuel policy: On how scientific findings can—and should—inform policy-making
Margaret Wooldridge, Mechanical Engineering
Co-authors: Cesar Barraza Botet

This work presents key research findings on the combustion chemistry and physics of ethanol-containing fuel blends from the perspectives of fuel performance and pollutant formation for internal combustion engine applications. The impact of the current U.S. biofuel policy—the Renewable Fuel Standard (RFS) Program—on the deployment of biofuels with the lowest GHG emissions is analyzed, as well as the technical and political challenges during its controversial implementation. Complementary policies aimed to increase vehicle fuel economy and reduce emissions of GHG and air pollutants are also discussed regarding their interactions with the RFS program and their potential to achieve a harmonic set of regulations for fuels, vehicles and emissions. The role of stakeholders in the RFS rulemaking process is also analyzed, particularly on the intersection of vested interests and the technical components of the program. Lastly, this work discusses how more rigorous basic research can be used to inform sound biofuel policy.

Too Many Cooks in the Kitchen? The Consequences of Fragmented Jurisdictions for Environmental Policymaking
Michael Lerner, Political Science

This paper investigates the implications of fragmented ministerial responsibilities for the creation of environmental policy. The number of ministries responsible for making environmental policy varies considerably among countries and over time. In this paper, I introduce the concept of

ministerial fragmentation and argue that increased fragmentation should lead to policy changes that are more frequent, but have less depth (affecting fewer pre-existing policies) and less depth (relating to fewer topics). I then leverage a unique dataset of environmental laws and regulations from 25 years of policymaking in France, Germany, Italy, and the United Kingdom to empirically test these hypotheses. Provisional results indicate that ministerial fragmentation leads to greater environmental regulatory change, but less depth and breadth. Results are less conclusive with regard to environmental legislation.

Persistent Patterns of Discriminatory Housing Policy and Inequity: A Spatial Analysis
Anna White, Industrial and Operations Engineering
Co-authors: Tom Logan, Seth Guikema

Racial discrimination by housing and lending institutions was legal and widely practiced well into the 1960s in the United States. Although such discrimination is now illegal, the scars of this system persist today in the form of highly segregated urban areas and pockets of inequality across cities. In this study, we propose a methodology to analyze spatial patterns between discriminatory maps drawn by the Home Owner's Loan Corporation (HOLC) to rate lending trustworthiness and current quality of life indicators including health, employment, education, and income. We use Bayesian Networks to understand the correlation between HOLC evaluations and today's lasting outcomes over three cities with very different populations. While existing literature focuses on case studies of particular cities and outcomes, this study aims to develop a methodology that can be widely applied to analyze nationwide patterns for redlining as well as other spatial relationships.

The wind siting paradox: Climate denialism in America's windiest places
Sarah Mills, Ford School of Public Policy
Co-authors: Rio Mizuno

Getting accurate estimates of attitudes in rural areas is notoriously difficult. Because less than 20% of the US population lives in rural communities, a "nationally representative" sample of opinion about any topic tends to capture only a small number of responses of rural residents. While for some topics this may not matter, in the transition to clean energy, most of the necessary infrastructure—including wind turbines, large solar arrays, and transmission lines—will be sited in rural communities. This research aggregates national survey data over 10 years to provide more robust estimates of attitudes about climate change in these rural communities, showing much higher climate denialism than national estimates would suggest. In the presentation, I'll discuss why those who wish to see more renewable energy sited might be well served to couch their arguments in economic, rather than environmental, reasoning.

Defining lines: Terminology, methods and influence toward an energy just society
Dominic Bednar, School for Environment and Sustainability

Fostering justice in the face of environmental, socioeconomic and political turmoil has captured the attention of academics and decision makers across countries, disciplines, sectors and scales. However, inconsistencies in energy justice terminology and use alongside inaccuracies in its definitions alter approaches and measurements required to effectively assess a household's energy deprivation level. Conceptual tensions present a threat to mitigating global energy injustices. This

paper reviews the scholarly literature on common energy justice terminology: fuel poverty, energy poverty, energy insecurity, energy security, energy vulnerability, energy deprivation, energy precarity, energy affordability and energy burden to better understand the varying approaches, definitions and objectives used to measure and assess energy injustices. It characterizes the commonalities and distinctions of the essence of each term its implications on developed and developing policies by presenting a novel framework. The literature review is aided by bibliometric analysis to show the influence and trajectory of scholarly/energy decision maker's uses of energy justice terminology.

Parallel Three: Urban Environments and Infrastructure

Post Rock: A New Composite Material for the Anthropocene Age
Thomas Moran, Taubman College of Architecture and Urban Planning
Co-authors: Meredith Miller

The recent discovery of plastiglomerate, a rock formed from plastic pollution fused with mineral aggregates, signals the need for new design strategies that can turn the global excess of plastic waste into a building resource.

Post Rock is our version of plastiglomerate, reproduced in our studio by combining and thermocasting post-consumer polymers with sand, rock, and other inorganic materials. As two architects with expertise in plastic fabrication and environmental building strategies, we see many advantages to building with Post Rock. Plastic can always be locally sourced. Post Rock not only diverts this plastic from waste streams, but its aesthetics are linked to its context. As a building material, Post Rock combines the inherent properties of plastic and stone, making it durable and highly insulating.

Do the Benefits Outweigh the Costs? Life Cycle Assessment of Connected & Automated Vehicle Subsystems
Jim Gawron, School for Environment and Sustainability and Ross School of Business
Co-authors: Gregory A. Keoleian

Although recent studies of connected and automated vehicles (CAVs) have begun to explore the potential energy and greenhouse gas (GHG) emission impacts from an operational perspective, little is known about how the full life cycle of the vehicle will be impacted. We report the results of a life cycle assessment (LCA) of Level 4 CAV sensing and computing subsystems integrated on internal combustion engine vehicle (ICEV) and battery electric vehicle (BEV) platforms. The results indicate that CAV subsystems could increase vehicle primary energy use and GHG emissions by 3-20% due to increases in power consumption, weight, drag, and data transmission. However, when potential operational effects of CAVs are included (e.g., eco-driving, platooning, and intersection connectivity) the net result is up to a 9% reduction in energy and GHG emissions in the base case. Overall, this study shows the potential of CAVs to have net positive impacts on the environment.

U3D-DSS: A Novel Decision Support System for Community Directed Green Infrastructure Design
Mark Lindquist, School for Environment and Sustainability

Green infrastructure (GI) can have a positive ecological and social contribution in urban environments and is also seen as an essential component in efforts to rebuild the resilience of legacy cities. Despite the recognized importance of GI there is a missed opportunity to more fully involve residents in GI planning and design. Integrating the concept of ecosystem services (ES) into public participation processes can enhance outcomes but requires robust decision support systems (DSS) that can more effectively incorporate community needs. Complicating this integration is the challenge that the value of specific ES will vary greatly both between and within

cities. As such, collaboration and engagement with community members to specify the ES that are important and meaningful to them must be a part of any GI imitative and requires a DSS that is flexible and adaptable to different communities and contexts. This project describes the development of a novel DSS that uses Structured Decision Making to identify stakeholder needs which are then incorporated into a 3D DSS using the Unity game engine. The DSS is presented and discussed in the context of a Greenway planning and design project in the City of Detroit that included multiple stakeholders with varying interests and the success of the DSS assessed.

Exploring household willingness to participate in solid waste collection services in Liberia
Stefania Almazán, School for Environment and Sustainability
Co-authors: Jose Alfaro, Steve Sikra

Liberia faces increasing challenges with solid waste management as more than 70% of households abandon their waste in unauthorized sites. Urbanization and population growth will increase Liberia's need to develop an effective waste management system. We performed 240 household surveys in Paynesville to explore residents' waste management strategies and their satisfaction with waste collection services. Survey results point at household dissatisfaction with existing services. Burning or burying waste were common waste management practices, and few households separate or recycle waste. Our study included a choice experiment (CE) to assess household's valuation of specific attributes of waste collection services. Estimates of an alternative specific conditional logit model (asc logit model) suggest that households highly value having waste collected at home. These findings highlight the potential for improving Liberia's solid waste management by structuring reliable services around household collection.

The native bees of Detroit's neighborhoods: how human social variables influence native bee communities
Austin Martin, School for Environment and Sustainability

Urban areas can provide havens for insect pollinator species richness and diversity. As urbanized land expands, lawns and lawn care chemicals expand in tandem and the role cities play in pollinator conservation and restoration becomes increasingly important. Socio-economic demographics may factor into patterns of lawn care and cultivated plant diversity, which could affect pollinator communities in ways urban ecologists are only beginning to grasp. Here I present a study in which I analyze relationships between census data and wild bee species richness and abundance, sampled in lawns across the socio-economic spectrum of Metropolitan Detroit. The findings have potential relevant policy suggestions for dealing with lawn chemicals and initiatives on the municipal level to create and preserve urban green spaces and gardens.

Parallel Four: Land Use and Land Cover Change

Remotely Sensed Solar Induced Fluorescence for Spatiotemporal Monitoring of Terrestrial Ecosystems

Manish Verma, Consulting for Statistics, Computing and Analytics Research (CSCAR)

Terrestrial ecosystems drive the food chain and play an important role in dampening the perturbations to the carbon cycle and climate system due to human and natural processes. As ecosystems are exposed to natural and human-induced stress, remote sensing technologies and data are becoming the cornerstone of society's effort to monitor, understand, and manage them across a range of scales. Remotely sensed variables such as vegetation indices (VIs), fraction of absorbed photosynthetically active radiation (FAPAR), and leaf area index (LAI) provide reliable information of vegetation greenness and leaf area, but are not sensitive to ecophysiological processes that exert a key control on carbon sequestration and photosynthesis.

Recently, it has become possible to sense solar-induced chlorophyll fluorescence (SIF) from space using the principle of the in-filling of Fraunhofer line depth. SIF provides a functional link with dynamic changes in photosynthetic carbon assimilation. By integrating SIF with field measurements, other remotely sensed variables, and mechanistic models we are able to monitor and understand spatiotemporal variations in ecosystem structure and functions better. In this presentation, I will share some recent results about how SIF is improving our understanding of vegetation phenology and photosynthesis that can lead to better policy and management strategies.

Identifying Optimal Locations for Production of Cellulosic Ethanol for Use in the Transportation Sector in Ghana

Ripudaman Singh, Mechanical Engineering
Co-authors: Francis Kemousour, Kwame Nkrumah, and Margaret Wooldridge

Ethanol produced from cellulosic feedstock has gained interest in Ghana due to the high availability of crop residues in country. Further, concerns over energy security and higher greenhouse gas abatement potential of cellulosic ethanol derived from crop residue (compared to conventional ethanol produced directly from food crop) has made it more favorable. This work was directed towards estimating (a) total and regional cellulosic ethanol production potential in Ghana considering residues from 11 major crops; (b) the total and regional required ethanol volumes to meet the demand created by automotive fleet if E10 (10% of ethanol by volume) were to be chosen as a fuel blend for use in transportation sector of country. With regional production and demand volumes estimated, the study further expands to identify optimized locations for setting up bio-refineries for production of cellulosic ethanol, based upon costs involved in transporting feedstock from fields to refinery and produced ethanol in refineries to demand cities.

Using remote sensing to estimate the effects of reforestation policy in the fight against desertification in China

Cynthia Gerlein-Safdi, Climate and Space Sciences and Engineering
Co-authors: Denise Mauzerall, Feng Wang

Desertification in Northern China is an issue that plagues the large eastern cities with regular dust storms and air pollution. In an attempt to stop the southward expansion of the desert, the Chinese government set up a large scale reforestation project called the Three-North Shelterbelt Program, which subsidizes reforestation projects across northern provinces to stabilize slopes and decrease dust lifting by winds. Unfortunately, many issues have been pointed out by the scientific community regarding the execution of the project, from the choice of ill-adapted species, to the planting methods. However, it is difficult to correctly estimate tree survival rates because vegetation in drylands ecosystems does not present the "greenness" that many remote sensing products rely on to estimate plant productivity.

Here, we combine active microwave remote sensing and solar-induced chlorophyll fluorescence, two new types of remote sensing characterization of vegetation to measure changes in vegetation cover in Northern China. We compare the results to an extensive archive and literature review of reports of reforested areas showing that there is indeed a clear mismatch between planted and forested areas. We explain how the method developed here could provide yearly surveys to estimate the success of the Three-North Shelterbelt Program and improve reforestation policy guidelines.

Approaches and challenges to connecting exposure to air pollution from wildland fire emissions to cardiopulmonary health

Patricia Koman, Environmental Health Sciences
Co-authors: Michael Billmire, Nancy French, Sumi Hoshiko, Colleen Reid, Brian Thelen

The American Heart Association identified air pollution as a preventable source of cardiovascular disease contributing to the global burden of disease. An important source of air emissions from wildland fire is increasing due to climate change and settlement patterns, making previous air pollution and public health management approaches obsolete. Nearly 46 million persons in the western US were exposed to wildfire smoke over a recent six-year period, yet the impact on human health of smoke is only beginning to be understood. Spatial data and modeling challenges to epidemiology studies are reviewed. First, we critically assess the state of wildland fire emissions and smoke modeling relevant to air quality and exposure assessment; second, we discuss challenges of geospatial atmospheric modeling with regard to air pollution exposure; and third, we review health outcome data sets available for quantifying wildfire pollution concentration-response functions and the spatial information gaps inherent in these data for California. This initial study created smoke exposure maps and developed modeling methods. This research serves as an example of how complex process-based models of fire emissions and smoke dispersion can be combined with a statistical modeling approach to determine concentration-response functions and assess the impact fire could have on human health.

Distinguishing the effects of climate change: primates, their habitat, and their food
Andrew Bernard, Department of Anthropology

The effects of climate change on ecological systems and species is a rapidly expanding field. However, there is a large disparity of research effort among taxa. Many more publications target insects and birds, for example, than mammalian species. Underlying this disparity is an increasing awareness that the effects of climate change across species are heterogeneous, leaving some more vulnerable to local extirpation than others. For example, range shifts along elevational or latitudinal gradients are commonly forecasted as a mechanism for species to track movements in their habitats; however, constraints like geographic barriers, species interactions, social system, or body size may impact species' ability to move freely. Specifically, nonhuman primates are among the most vulnerable taxa to rapid climate change, but few empirical studies address this. In this vein, I consider why primates may be challenging target species, and aim to review our current state of knowledge in the field. I separate predictions that address primates themselves, their habitats, and their important food sources. I also offer a framework that separates 1) temporal from spatial variability, and 2) direct from indirect effects. By clarifying what is generally subsumed under the umbrella of "climate change" research, I identify gaps in our knowledge that are vital to address.

Parallel Five: Energy Norms and Futures

Can ecological theory help us fuel and feed the world with algae?
Patrick Thomas, School for Environment and Sustainability

We must sustainably intensify the production of agricultural crops to meet the challenge of feeding and fueling humanity in the coming century. One potential solution to address this challenge is the cultivation of biomass from microalgae, which have much greater yields than conventional crops and require only a fraction of the land. Implementation of this strategy for sustainable intensification has been slow mainly due to economic constraints, as growing algae is currently prohibitively expensive for lower-value products. The single most effective approach to enhance the economics of algal cultivation is to increase annual productivity in the system. While many forces are known to determine biomass productivity of microalgae, I will focus on factors that have been largely ignored, yet may play a significant role. Specifically, I seek to identify how traits in algae related to release of inhibitory compounds may affect productivity. I hypothesize that this will be important for maximizing productivity because: 1) reducing algal self-inhibition will increase productivity, 2) maximizing the production of compounds that inhibit pests like grazing zooplankton and pathogens (viruses, bacteria and fungi) will also increase productivity. Optimizing these chemical interactions may inform practices to advance the future role of sustainable algal foods and fuels.

Technical and economic feasibility of climate intervention in the U.S. electricity sector with direct air capture
Tae Lim, Mechanical Engineering
Co-authors: Sarang Supekar, Steven Skerlos

We evaluate the private costs, technological transformations, and net CO2 emissions to achieve sector-specific CO2 emission target in the U.S. electricity sector by 2050 when direct air capture (DAC) technology is available to cure excess emissions. Results show that while DAC makes achieving emissions target feasible beyond 2025, this expanded timeframe for climate action extends only till about 2030 considering 1% of GDP as a cutoff value for abatement costs, and till 2035 if the cutoff is 2.5%. The total abatement cost for a cure would be 3-10 times costlier than that of prevention through a timely transition to low-carbon alternatives, assuming climate action is initiated between 2025-2030 for the cure and 2015-2020 for prevention, respectively. Should we need to cure with DAC we need 9-15 years of a preparatory period to expand total capacity, in addition to rapidly decarbonizing the grid by pre-maturely retiring inefficient fossil capacity and replacing them with low-carbon alternative. Contrary to past studies, our systems-level analysis shows DAC can be deployed starting 2038 in a least-cost fashion, tolerating about 23% of natural gas capacity. Fossil fuel-based carbon capture and sequestration technologies are outcompeted by a combination of renewable energy and DAC, suggesting the importance of zero or negative emissions in a carbon-constrained world.

Stability of Increasingly Renewable Grids
Stephanie Ross, Electrical Engineering and Computer Science
Co-authors: Johanna Mathieu

This work considers the stability of electrical power systems (i.e. the grid) that source 100% of their power from renewable generators, such as wind turbines and photovoltaics. Currently the grid's dynamic stability is dominated by the characteristics of the thermal turbines and synchronous generators of conventional power plants, such as nuclear, coal, and gas. However, as more and more renewable plants are connected, the dynamics of the grid will change. This work specifically investigates the scenario of a grid entirely fed by electronic-interfaced sources; this type of grid is referred to as "inertia-less" because none of the generators have turbines whose rotational inertia is directly coupled to the grid. The project has two main components: first we show that electronic-connected generators have an intrinsic energy storage component of similar per-unit size compared to that stored in the rotational inertia of conventional generators; and second we propose a control method for tapping into this energy storage for the initial stabilization of an inertia-less grid after a disturbance. Through simulations and small-signal analysis, we will show that the proposed control mechanism improves the stability of an inertia-less grid compared to the leading mechanisms in the literature.

Non-Invasive Personalized Normative Messaging Intervention for the Reduction of Household Energy Consumption
Kwonsik Song, Civil and Environmental Engineering
Co-authors: SangHyun Lee, P. Sol Hart, Kaitlin Raimi

Behavioral intervention has been promoted to reduce energy consumption in residential buildings due to its significant energy saving potential with a relatively less investment in cost and technologies. Until recently, substantial efforts have been undertaken to investigate the effect of normative feedback message on energy use behaviors of consumers. Unfortunately, current knowledge and practice regarding normative feedback has poor comparative reference group selection and limited understanding of its effect on reliability, durability and the role of norm messaging disaggregation. Therefore, this research attempts to advance our understanding of how personalized normative messaging intervention influences residential occupants through field experiments using readily available energy consumption data in a non-intrusive manner. The preliminary analysis finds that the characteristics of energy use patterns of occupants can be separated into daily AM heavy users, weekday AM intense users, and consistent energy consumers. Further, it was discovered that each reference group have a wide range in actual energy consumption between heavy consumers, mean household and efficient households. These results will provide a significant foundation for personalized normative messages to be most effective.

Concept 22/26, Future of high performance Buildings
Lars Junghans, Taubman College of Architecture and Urban Planning
Co-authors: DeokOh Woo

The built environment accounts for 30–40% of the industrialized society's total energy demand. Current high-performance buildings are costly because they use expensive high efficient heating, cooling and ventilation systems.

Recent research work at the Taubman College of Architecture at UM takes a different road from these other near -zero energy building design by eliminating all conventional heating, cooling and ventilation systems. The building is built according to research work at the Taubman College and involves following technology: (1) Novel building automation strategy to control the thermal household of the building, (2) Use of an extraordinary large amount of internal thermal mass to avoid overheating problems and to store solar heat gains, (3) Integration of a model predictive control strategy to control passive night cooling effects. Since its completion in the year 2014, the "Concept 22/26" is used as an office building. Measurement results are demonstrating that the building provides comfortable room conditions in more than 99% of the occupied time.

The ongoing research work includes: (1) Use of an IR array sensor in combination with artificial intelligence, (2) Development of high performance insulation panels with flexible R-value, (3) Development of small-scale air handling unit, (4) Improvement of building automation algorithms.

URBAN COOL, Heat, Health and Habitat in the Anthropocene
Doug Kelbaugh, Taubman College of Architecture and Urban Planning

An illustrated presentation on an upcoming book discussing the role good urbanism can uniquely play in the war against global climate change and over-population. Urban Heat Islands, which are heating up our cities roughly twice as fast as their hinterlands and the planet as a whole, can more urgently motivate people to act on strategies that simultaneously mitigate and adapt to both local and global overheating. The four antidotes are to enhance solar reflectivity (albedo) of roofs and pavements; reduce waste heat from tailpipes, chimneys and air conditioners; avoid deep, hot street canyons; and create cool micro-climates with trees and other vegetation. While urban-dwellers in the developed world have smaller per capita carbon and eco-footprints than their suburban counterparts, total carbon footprints in developing countries are decreased by the ongoing rural migration to cities, which results in a voluntary reduction in the high birth rates that have led to explosive population growth. And the world over, urbanism that is compact, walkable, bike-able, leafy and transit-served also promotes lifestyles that are healthy, happy and culturally rich, as well as diverse, creative and productive.

Parallel Six: Sustainable Food and Agriculture

Anticipating the Effects of Emerging Technologies on Food System Sustainability
Brent Heard, School for Environment and Sustainability
Co-authors: Shelie Miller, Morteza Taiebat, Ming Xu

The food system is connected with many facets of sustainability, and is also an area experiencing a number of technological changes. Understanding the full scope of the food system's environmental impacts and the way that technologies can influence these connections is a critical research task for informing sustainable policy and action.

Emerging technologies are modeled with considerations of both direct and indirect effects, analyzing not only the technology itself, but also incorporating the effects of behavior change and other structural changes to the food system. This presentation examines the influence of expanded refrigerated supply chains on food loss emissions in the developing world and the use of autonomous vehicles in food shipping and delivery as quantitative and qualitative applications of this approach. In both cases, considerations beyond the immediate effects of each technology prove to be critical for characterizing what factors most-influence changes in food system sustainability.

This research provides insights into key factors influencing food system sustainability and discusses future research and policy needs. These results also highlight how modeling a technology without incorporating anticipated changes in behavior and other system elements will not consider many of the elements which most-influence sustainability outcomes.

Health risks from exposure to untreated wastewater used for irrigation in the Mezquital Valley, Mexico: A 25-year update
Jesse D. Contreras, Department of Epidemiology
Co-authors: Rafael Meza, Christina Siebe, Sandra Rodríguez-Dozal, Yolanda A. López-Vidal, Marisa Mazari-Hiriart, Irma Rosas Pérez, Horacio Riojas-Rodríguez, Joseph N.S. Eisenberg

Wastewater reuse for agriculture is a common practice worldwide. Wastewater treatment is rare in many countries, leading to high exposure to harmful pathogens. The Mexico City-Mezquital Valley system is one of the largest wastewater reuse systems worldwide and was the site of key epidemiologic studies on wastewater conducted in the 1990s. We conducted a cross-sectional study of diarrheal disease and wastewater contamination in the Mezquital Valley to provide an updated assessment of the health risks associated with wastewater and to inform an update of the 2006 World Health Organization guidelines on safe reuse. We surveyed 314 households among communities that use wastewater for irrigation and communities that irrigate with well water to compare the prevalence of self-reported diarrheal disease in children under five years old. Communities exposed to wastewater had a higher one-week prevalence of diarrhea (10%) compared to unexposed communities (5%). This association remained in an adjusted modified Poisson model (PR = 2.31, 95% CI 1.00, 5.31), but the association was not as strong when limited to households engaged in agriculture. While overall diarrheal prevalence has declined when compared to studies conducted over 25 years ago in the same region, the association between diarrheal disease and wastewater exposure has remained and possibly increased.

Cover Crop "Cocktails" for Conservation: Ecological Nutrient Management in Mixtures vs. Monocultures

Alison Bressler, School for Environment and Sustainability
Co-authors: Jennifer Blesh

The convergence of global climate change with food, energy, and water crises has called new attention to the sustainability of agriculture, particularly to the broad reaching impact of nutrient management on climate change and water quality. In the U.S. Midwest, excess application of nitrogen (N) fertilizers to corn-soy fields has resulted in decades of nitrate leaching from farms, producing toxic algal blooms in water ways. Excess reactive N also leads to increased nitrous oxide (N2O) emissions, a potent greenhouse gas. Ecological nutrient management practices such as the use of cover crops may reduce risk for farmers in a rapidly changing climate by reducing erosion, retaining soil nutrients, and building soil organic matter. Adding N-fixing legumes to grass cover crops can help couple N and carbon (C) cycling to enhance inorganic N cycling and reduce agricultural nutrient losses. Interest in planting cover crop mixtures is growing, but there is still very little scientific data to support farmers in making cover crop management decisions. My study seeks to evaluate the impact of mixtures vs. monocultures of grass and legume cover crops on nutrient cycling in southern Michigan. I hypothesize that adding legumes to grass cover crops enhances coupled N and C cycling, decreasing N surpluses and losses while providing more N for future cash crops.

Shedding light on the shade: leaf litter decomposition in shaded coffee agro-ecosystems

Lauren Schmitt, School for Environment and Sustainability
Co-authors: Ivette Perfecto

A vast body of research has demonstrated the ecological implications of different coffee management systems, but less is known about the implications of management decisions on nutrient cycling. Nutrient cycling is especially important in shade-grown coffee systems where coffee is grown in the understory of larger (“shade”) species and a variety of leaf litter types are present. Previous research has shown that the species of coffee and the location of decomposition effect decomposition rates. To assess the relative decomposition rates of Coffea arabica leaf litter in the presence and absence of two common shade species, tethered line decomposition experiments were conducted at an operational coffee farm in Chiapas, Mexico. One nitrogen fixing shade species, Inga micheliana and one species that does not fix nitrogen, Alchornea latifolia, were used. Tethered lines with factorial combinations of the three species were placed in areas where coffee is grown and in a forested control site. In both locations, C. arabica decomposed more quickly in the presence of I. micheliana. These results demonstrate the importance of leaf litter diversity and suggest that management decisions, including which shade tree species to plant, have important implications for nutrient cycling on coffee farms.

A Chayanovian analysis of tree management among Panamanian farmers

Mariana Valencia, Ecology and Evolutionary Biology
Co-authors: Lesli Hoey, John Vandermeer

In Latin America cattle ranchers have been depicted as people that perceive that the forest is incompatible with pasture management. A closer look at the cattle pastures in Central America indicates that some farmers incorporate trees into pasture management but at different densities. I employ the Chayanovian Peasant Balances framework to analyze the role that trees play in the process of farm management. Chayanov proposes that the family farm is governed by a balance that farmers make between the utility of producing one more item, with the drudgery (or hardship) involved in producing that item. In 2014 I visited fifty four farms primarily dedicated to pasture management across 3 provinces in the Republic of Panama. Without a pre-determined framework I developed a semi-structured questionnaire to understand farmers' motivations and obstacles to tree management. Farmers' make decisions about tree management by balancing the utility of trees for cattle production, with the drudgery (or hardship) involved in maintaining desired tree species through planting and weeding. Other balances emerged, for example, farmers choose to manage trees today to reproduce the farm operation in the future. The farmers see trees as a valuable resource within the farm, challenging the idea that ranchers necessarily perceive incompatibility between trees and pasture management.

Parallel Seven: Perceptions of Science and the Environment

Historical Trends in Ideological Polarization of Science: Evidence from the NSF Survey of Public Attitudes Toward and Understanding of Science and Technology 1979-1990
Caitlin Drummond, Erb Institute | Business for Sustainability

Recent research suggests that Americans' attitudes toward controversial science and technology issues pertaining to sustainability, including climate and energy, are related to their religious and political ideologies (Funk & Alper, 2015; Funk & Kennedy, 2016; Drummond & Fischhoff, 2017). We examine the historical antecedents for political and religious polarization of science, using data from the NSF-sponsored, nationally representative Survey of Public Attitudes Toward and Understanding of Science and Technology, conducted biennially starting in 1979. Using historical data from 1979-1990, we examine the extent to which public attitudes toward controversial scientific issues including nuclear power, genetic engineering, and food additives are related to religious and political ideology as well as to scientific knowledge and demographic variables. Preliminary results suggest that both ideology and knowledge are related to public opinion on these issues. We discuss the implications of our findings with regards to science communication and education.

Conceptually mapping middle school students' knowledge of climate change science
Jennifer Carman, School for Environment and Sustainability
Co-authors: Michaela Zint, Juliana Lisuk

Understanding how scientists gather evidence about climate change is an important component of students' climate change literacy. Our team therefore developed an educational intervention, Climate Change and Michigan Forests, to teach seventh grade students (ages 12-13) how scientists develop predictive models of climate change's effects on local forests, including activities where students build simple computer-based models using real-world data. We hypothesized that this unit would improve students' conceptual knowledge of both climate change science and their meta-modelling knowledge, i.e. their knowledge of how scientific models are constructed and used. We measured changes in students' knowledge in these two areas using conceptual content cognitive mapping (3CM) interviews administered to students before and after the unit. This technique uses a card-sorting exercise in which students fit multiple pre-generated concepts together in their personal mental map. Seventh grade students (n=32) from three teachers' classes in Ann Arbor Public Schools were interviewed before and after the unit, and results were analyzed using hierarchical cluster analysis. Preliminary results indicate students already had basic knowledge of the scientific process, but after the unit they developed more sophisticated maps of climate science concepts.

Lyme Disease, "Nature," and Environmental Risk in the United States
Abigail A. Dumes, Department of Anthropology

In the United States, the expansion of suburban development into forested areas and a growing deer population (tick carriers) have led to more frequent encounters between humans and ticks. Ticks carry human pathogens, including the bacterium that causes Lyme disease, which is the most

prevalent vector-borne disease in the United States. To prevent tick bites, individuals enact and promote a range of bodily practices, including tick checks, tucking pants into socks, applying repellants, and bathing after coming indoors. These practices are situated within emerging fears of the risks of one's own backyard. However, these fears are often also accompanied by an attraction to "nature's beauty" and an abiding desire to spend time in or near "nature." Tracing the historical production of an aesthetic of nature in the United States, I draw on eighteen months of ethnographic research among Lyme patients, physicians, and scientists throughout the northeastern United States to explore how bodily practices related to tick bite prevention shape ideas about environmental risk, nature, and the "self."

Analyzing Stakeholder Uncertainty Perceptions to Advance Collaborative Sustainability Science: Case Study of the Watershed Assessment of Nutrient Loads to the Detroit River Project

Robert Goodspeed, Taubman College of Architecture and Urban Planning
Co-author: Annika Van Eyl

Addressing many sustainability challenges requires conducting integrated assessments, which utilize complex computer models to analyze natural systems. These projects often encounter the difficult question of how to most effectively communicate with diverse stakeholders, especially around questions of uncertainty. One such project is the Watershed Assessment of Nutrient Loads to the Detroit River study, led by the UM Water Center, which aims to model the nutrient dynamics within the watersheds that drain into the St. Clair and Detroit rivers. This presentation will present preliminary results of a qualitative analysis of interviews conducted with the project's advisory group members to better understand the perceived sources of uncertainty in the project and assess their information needs. This analysis is guided by the uncertainty matrix proposed by Walker et al. (2003), which has not previously been empirically validated, despite its official adoption by the PBL Netherlands Environmental Assessment Agency (Petersen et al., 2011; van der Sluijs et al., 2008). The preliminary analysis will contain a description of the specific uncertainty concerns raised by different categories of stakeholders, a discussion of how they might be addressed, and an assessment of the usefulness of the Walker et al. (2003) matrix to analyzing uncertainty in environmental assessments.

Mental Maps, Envisioning, and Community-based Climate Adaptation in Coastal Connecticut

Katie Williamson, School for Environment and Sustainability
Co-authors: Raymond De Young, Adam Whelchel

The goal of this study is to understand how individuals envision their community becoming more self-reliant if faced with a future scenario of climate change impacts, limited natural resources, and little external support. The threats of climate change and resource decline present an immense challenge to human health and well-being now and in the coming years; it is necessary that communities plan for adaptation. While there will certainly be physical, social, political, and economic effects on communities, it is important that we also recognize the significant psychological and behavioral impacts as a result of adaptation. 68 participants representing 18 towns in coastal Connecticut were interviewed and asked to complete a mental mapping exercise,

Conceptual Content Cognitive Mapping (3CM), on community self-reliance. The results revealed a diverse set of community visions and features as well as individual priorities, challenges, learning opportunities, skill sets, and emotions when processing this scenario and community contexts. The findings of this study may help future practitioners and community leaders better understand the many dimensions of community-based adaptation and strategize to help their communities be better prepared for uncertainty through exploring new behaviors, learning opportunities, and ways of thinking.

Sustainable Living Experience's Evaluation of Themed Residential Housing as an Influencer to Students' Sustainability Awareness and Behaviors

Jacqueline Cardoza, School of Public Health
Co-author: Emily Canosa

This survey aims to evaluate the impact of the new Sustainable Living Experience (SLE) theme community on first year undergraduate students. In addition to seeking to collect information on sustainability awareness and behaviors, the survey also asks questions related to student success, exposure to particular high impact learning practices, and inclusion on campus.

The digital survey will be distributed each fall and spring (May 2017 – July 2019) by email to our cohort of approximately SLE participants, all other students at Oxford Houses who did not sign up for SLE, and a comparable random sample of first year students at other residence halls on campus. The survey platform used is Qualtrics that has built in data analyzing features which includes frequency and count data. Statistics will further be drawn to compare different subgroups within the data. This survey aligns questions, with permission, from existing surveys such as the Sustainability Cultural Indicators Program (SCIP) and the Michigan Learning Community Survey, commonly known as the Whitaker Assessment, and also consulted briefly with members of the DEI/Campus Climate research team.

Poster Session

Using OCO-2 observations and Lagrangian modeling to constrain urban carbon dioxide emissions in the Middle East

Emily G. Yang, Climate and Space Sciences and Engineering
Co-authors: Eric A. Kort, John F. Ware, Xinxin Ye, Thomas Lauvaux, Dien Wu, John C. Lin, Tomohiro Oda

Anthropogenic carbon dioxide (CO_2) emissions are greatly perturbing the Earth's carbon cycle and are the main contributors to climate change. Rising emissions from the developing world are increasing uncertainties in global CO_2 emissions. With the rapid urbanization of developing regions, methods of constraining urban CO_2 emissions in these areas can address critical uncertainties in the global carbon budget. In this study, we work toward constraining urban CO_2 emissions in the Middle East by comparing top-down observations and bottom-up simulations of total column CO_2 (X_{CO2}) in four cities (Riyadh, Cairo, Baghdad, and Doha), separately and in aggregate. We quantify the relationship for all data from September 2014 to March 2016 between observations of X_{CO2} from the Orbiting Carbon Observatory-2 (OCO-2) satellite and simulations of X_{CO2} using the Stochastic Time-Inverted Lagrangian Transport (STILT) model coupled with Global Data Assimilation System (GDAS) reanalysis products and multiple CO_2 emissions inventories. We discuss the extent to which our observation/model framework can distinguish between the different emissions representations and determine optimized emissions estimates for this domain. We also highlight implications on the fidelity of the bottom-up inventories used, and how these implications may inform the use of OCO-2 data for quantifying global urban emissions.

How accessible are our cities? A comprehensive analysis of green space access in the USA

Tim Williams, Industrial and Operations Engineering
Co-authors: Tom Logan, Connie Zuo, Kevin Liberman, Seth Guikema

Adapting our cities requires us to resolve the contentious issue of social justice in access to core urban services. Green spaces provide a wide range of health and community benefits, and their access has been subject to much analysis. However, the generalizability of many existing conclusions is limited by both scope and resolution of analysis. Here, we develop and implement a method to evaluate access to green space in multiple US cities to:

a) Investigate whether systemic inequity exists across US cities; and
b) Demonstrate the benefits of measuring accessibility at fine resolution.

We find that inequity between racial groups exists, but is not consistent across the cities studied. Additionally, we provide compelling motivation for future researchers to conduct their analyses at a fine scale.

Spatial and socio-economic drivers for urban gardens and native bee communities
Ben Luliano, Ecology and Evolutionary Biology
Co-authors: Paul Glaum

Burgeoning urban agriculture initiatives in American cities have raised questions about where gardens get established and what effects they have on local ecosystems. Socio-economic demographics may factor into patterns of garden location and local ecological traits, leading to changes in biotic communities. Some changes are potentially beneficial; for example, increased floral resources might benefit declining pollinator species. However, connections between socio-economic drivers and ecological effects are poorly understood. This study demonstrates effects of urbanization and wealth on community gardens in southeast Michigan, with consequences for floral resources and native pollinator communities. We created socio-economic profiles of communities surrounding gardens using census land cover data to discern patterns in garden placement. A subset of these gardens was then sampled for floral resources and wild bees. Results show that while gardens are evenly dispersed across socioeconomically diverse communities, availability of undeveloped land is a greater determinants of garden location. Socio-economic variables significantly correlate with garden floral characteristics, which may have implications for urban pollinator support. Overall, we present a novel combination of techniques to connect social and ecological components of sustainability.

Thermoelectric Pipe Insulation for Wireless Sensing
Brian Iezzi, Materials Science Engineering
Co-authors: Krishnamraju Ankireddy, Mark Losego, Jesse Jur

The Internet of Things (IoT), coupled with advanced analytics, is poised to revolutionize manufacturing maintenance and efficiency. However, a practical route to powering these many IoT devices remains unclear. In this work, flexible thermoelectric generators (TEGs) were fabricated from low cost, screen printed silver and nickel inks before being integrated into a novel form factor device based on commercial steam pipe insulation. Through optimization of internal resistances and total device design, this 420-junction TEG device produced 308 μW of power at a temperature difference of 127 K. This was sufficient to power a temperature sensing circuit with wireless communication capabilities. We have demonstrated that, after an initial 4 hours of charging, the TEG device could power a standard RFduino microcontroller for 10 minutes while sending temperature readings every 30 seconds via Bluetooth Low Energy (BLE) to a cell phone. Additional optimization and scaling could further increase system efficiency and provide a viable route to powering an industrial wireless sensing network (WSN).

Assessing Non-Economic Loss & Damage from Climate Change: Partnership with Bad River Band of Lake Superior Chippewa
Ansha Zaman, School for Environment and Sustainability
Co-authors: Sarah Swanz, Adam Osielski, Katie Proudman, Stephanie Dooper

Potential non-economic losses and damage (NELD) from climate change or other environmental stressors include factors such as adverse health impacts, reduction in biodiversity, loss of knowledge and language, as well as the loss of identity or sense of place resulting from changes in culturally important landscapes or built sites. These factors are not effectively addressed in

national or international climate policy frameworks, although researchers and policy-makers have begun to recognize their importance. We set out to develop a framework for analyzing NELD and a proof-of-concept field test with an indigenous community facing environmental threats. We conducted 20 ethnographic interviews of members of the Bad River Band of Lake Superior Chippewa in northern Wisconsin. Working with the Tribal Historic Preservation Office and the Department of Natural Resources, we sought to assess participants' overall connection to the environment, past and current involvement in traditional practices. These include wild rice harvesting, hunting, fishing, gathering, and other practices that involve the use of natural resources on the reservation and within the ceded territories.

Development of a Fuel-Based Oil and Gas Inventory of Nitrogen Oxide Emissions

Alan Gorchov Negron, Climate and Space Sciences and Engineering
Co-authors: Brian C. McDonald, Stuart A. McKeen, Jeff Peischl, Ravan Ahmadov, Joost A. de Gouw, Gregory J. Frost, Meredith G. Hastings, Ilana B. Pollack, Thomas B. Ryerson, Chelsea Thompson, Michael Trainer

The rapid rise in oil and natural gas production over the last 15 years has driven an increase in important air quality and greenhouse gas emissions. In this study, we constrain the emissions of nitrogen oxides (NOx), which are precursors to ozone formation, from U.S. oil and gas production with atmospheric measurements. We develop an alternative Fuel-based Oil and Gas (FOG) inventory of carbon dioxide (CO2) and nitrogen oxides (NOx) from oil and gas production using publicly available fuel use records and emission factors reported in the literature. FOG is compared with the official 2014 National Emissions Inventory (NEI) and with new top-down estimates of NOx emissions derived from aircraft and ground-based field measurement campaigns. Compared to our top-down emissions, the NEI overestimates NOx by a factor of 2.5 across the four basins, while FOG is consistent with atmospheric observations. Challenges in estimating oil and gas engine activity, rather than uncertainties in NOx emission factors, may explain gaps between the NEI and top-down emission estimates. Lastly, we find a consistent relationship between ambient methane (CH4), a potent greenhouse gas, and reactive odd nitrogen species (NOy) across basins with different geological characteristics and in different stages of production. This offers the potential to develop a new method to estimate CH4 emissions.

Evaluating Heat Fluxes and Evaporation in the Great Lakes

Lindsay Fitzpatrick, School for Environment and Sustainability
Co-authors: Ayumi Fujisaki-Manome

Turbulent latent and sensible heat fluxes are important physical processes that influence elements across the North American Great Lakes including climate, weather, energy and water levels. The water budget consists of precipitation, run off, and evaporation components across the massive fresh water lakes. Evaporation observations were non-existent until 2008 when the Great Lakes Evaporation Network (GLEN) was established. GLEN consists of six flux towers mounted on top of offshore lighthouses across the five Great Lakes and record meteorological elements such as air and sea surface temperature, humidity, wind, solar radiation and heat fluxes. Recently, the first ever comparison of state-of-the-art modeled heat fluxes to these observations was conducted. Agreement between modeled and observed fluxes notably varied during the study based on

geographical locations of the stations. Continued evaluation and improvement will attempt to increase model accuracy in predicting climate change, lake effect snow, and water levels across the region.

Optimal Replacement of Residential Lighting for Cost and the Environment
Lixi Liu, Mechanical Engineering and School for Environment and Sustainability
Co-authors: Gregory Keoleian, Kazuhiro Saitou

Artificial lighting is an integral part of modern society but requires a significant use of electricity. In the U.S., 10% of the electricity is used towards lighting but can be cut in half by upgrading to light emitting diode (LED) technology. However, high initial cost has hindered the adoption of LEDs. As the technology continues to evolve rapidly, estimating the right transition time to LEDs can maximize cost, energy, and greenhouse gas emissions savings. However, timing is seldom considered in lighting replacement decisions.

This study provides specific replacement strategies for residential lighting. By considering how the lighting technologies and the electric grid change over time, the study finds that all incandescent and halogen lamps should be replaced immediately with compact fluorescent lamps (CFL) or LEDs. No replacement is advised for existing CFLs and LEDs. At an average use of 3 hr/day, LED adoption is optimal today in terms of emissions. Whereas, delaying the adoption until 2020 with CFL use is optimal in terms of cost and energy. In regions of high electric rates and of high grid carbon intensity, lamps should be replaced more frequently to leverage efficacy improvement. Increasing product durability should be secondary to energy efficiency improvement in lighting R&D, since replacement benefits from early product retirement rather than retirement at burnout.

Using University of Michigan Buildings as Batteries
Aditya Keskar, Electrical Engineering and Computer Science
Co-authors: Sina Afshari, Paul Giessner, David Anderson, Ian Hiskens, Jeremiah Johnson, Johanna Mathieu

The vast thermal storage capability of commercial building Heating, Ventilation, and Air Conditioning (HVAC) systems can potentially be used to manage grid anomalies arising due to the stochastic nature of renewable generation. The goal is to exploit this storage capability so that buildings can respond like batteries, decreasing and increasing consumption with respect to their baseline to balance grid net load forecast error. However, a recent study showed that buildings providing these services tend to consume more energy resulting in a low effective round trip efficiency.

To explore this phenomenon further, experiments have been conducted on three buildings on the UM campus: the Rackham Building, Weill Hall, and the Bob & Betty Beyster Building. The buildings were instrumented in early summer 2017 and the thermostats were perturbed through predefined patterns, emulating services to the power grid and enabling detailed investigation of the resulting electrical power consumption. In addition to quantifying the responses of the buildings to battery-like operation, the research has helped in developing a better understanding of each building's energy consumption and identifying opportunities for energy efficiency.

Tourism Sustainability Evaluation in Southeast Michigan
Jianan Zhang, Taubman College of Architecture and Urban Planning

Tourism has become a vital sector of economic development in Southeast Michigan. However, not many researches on tourism have been conducted in this area. With the abundance of natural resources and industrial heritages, tourism in Southeast Michigan deserves more attention. This project aims at the evaluation of tourism sustainability in Southeast Michigan. It will first develop a set of maps showing the existing patterns of tourism attractions, demographics, economics, and natural resources to demonstrate the social-economic environmental for tourism development in Southeast Michigan. Then this project will develop an indicator matrix to evaluate the sustainability of tourism in Southeast Michigan.

Creating Children Books as Educational Tools towards Sustainability
Sara Adlerstein, School for Environment and Sustainability
Co-authors: Nicolas Curotto, Helen Gutierrez, Albany Jacobson Eckert, Jiayang Li, Rika Novayanti, Jillian Mayer, Iris Partland, Priscila Papias, Indigo Rockmore, Janet Skrbine, and Brooke McWherter

Climate change and environmental degradation are pressing environmental challenges facing the planet and addressing the issues requires education. As impacts are caused by humans, part of the solution is influencing behavior towards sustainability. Best intervention to promote shifts is early education and a way to achieve it is through picture books. These can be effective tools to begin discussions while providing children the opportunity to express their feelings and learn about actions they can take to reducing human impacts on the earth. Through children's books, adults can also learn as they engage in discussions with children. These concepts are embraced in, Nature, Culture and Landscape, a course offered at the School for Environment and Sustainability. It incorporates science, arts and humanities, examines layers of nature/human relationships and how art can help conservation. One assignment is creating picture books used as educational tools. The goal is that it will inspire children to make environmentally sound choices. The poster will present the wonderful books student created exploring ways to connect children to nature and engage them and parents on environmental stewardship topics. Contents raise awareness about causes and consequences of climate change and importance of personal behavior and provide examples of actions children can take to minimize impacts.

The Sinis Archaeological Project: Colonial Interactions, Resource Exploitation, and the Environment in Ancient West-Central Sardinia
Linda R. Gosner, Department of Classical Studies
Co-authors: Alexander J. Smith, Jessica Nowlin

This poster introduces the Sinis Archaeological Project, a new multi-scalar regional survey that explores the impacts of colonial interactions on resource exploitation, landscape use, and settlement patterns in ancient west-central Sardinia. In antiquity, this island was home to the Nuragic people who constructed monumental stone towers across the landscape, and later to foreign colonizers and traders (Phoenicians, Carthaginians, and Romans) who came to exploit the island's rich resources during the 1st millennium BCE. Most investigations of colonial presence on the island have focused on urban centers, and especially port cities. Our project, by contrast,

investigates the colonial impact on land use and the extraction of resources in the rural landscapes using the Sinis Peninsula as a case study. Over the next five years, we will survey four distinctive environmental zones: the agricultural plains surrounding the largest prehistoric site called S'Urachi, the coastal region with its seasonal lakes and salt flats, the metal-rich Monte Ferru mountains, and the hill crests that separate the coast and inland plains. In doing so, we hope to shed light on the complex and varied roles that resource exploitation played in the negotiation of colonial settlement and trade, as well as the long-term impacts that ancient exploitation had on the Sardinian landscape.

Space-based observations of CO2 fluxes and photosynthetic fluorescence
Allison Hogikyan, Climate and Space Sciences and Engineering
Co-authors: Gretchen Keppel-Aleks

Atmospheric CO2 is the main driver of global warming, yet uncertainties remain in our understanding of the global carbon cycle. A variety of factors such as anthropogenic emissions or climate-induced variations in plant photosynthesis or respiration could affect interannual variability (IAV) in the amplitude of the seasonal cycle in CO2. Terrestrial gross primary production (GPP), or ecosystem scale photosynthesis, is the largest global land carbon flux. By better understanding the relationship between rates of GPP and CO2 growth rate IAV, we may improve our ability to predict carbon cycle feedbacks to climate change. Recently, a new method to infer GPP from satellite-based measurements was developed by exploiting the fact that during photosynthesis, some of the sunlight absorbed is re-emitted at longer wavelengths. Solar-induced fluorescence (SIF), as this re-emitted light is called, closely tracks the seasonal cycle of GPP but it is uncertain how much information SIF provides about IAV. In this study, we find a complex relationship between space-based CO2 and space-based SIF observations, suggesting that other processes in the Earth system may play an equally significant role in modulating CO2 growth rate variability.

Hurricane Power Outage Prediction with Out of Bag Feature Selection Approaches
Sara Shashaani, Industrial and Operations Engineering
Co-authors: Seth Guikema

Predicting hurricane power outages facilitates natural hazards response decisions. However the spatial data is largely zero-inflated with a sizable number of explanatory variables, and finding statistical models that can provide reliable predictions remains to be a challenge. We study a feature selection approach by minimizing the out of bag error of the selected features. Our experiments on predicting the power outages of the old central gulf coast data show promising improvements in the predictive power compared to the existing methods.

Summer Cover Crops: Functional Traits and Ecosystem Services
Etienne Herrick, Program in the Environment
Co-authors: Jennifer Blesh, Jeremy Moghtader

Planted in windows between primary crops, cover crops present a valuable opportunity for improving the sustainability of food production through their potential to increase on-farm biodiversity, and consequently ecosystem service provision. In fact, cover crops may hold the

capacity to enhance multiple ecosystem services simultaneously (multifunctionality), particularly when multi-species mixtures are designed to harness contrasts in plant traits. This study uses a trait-based approach to investigate the influence of inter- and intra-specific interactions in summer cover crop mixtures and monocultures on functional trait expression and ecosystem service delivery. Employing a trait-based approach may elucidate mechanistic links between agroecosystem structure and resulting ecosystem services. Preliminary results reveal both height and specific leaf area (SLA) for the legume and broadleaf species were significantly lower in monoculture than in the legume-grass-broadleaf mixture, indicating possible facilitation occurring between these species due to the legume's nitrogen fixation capabilities. These results and others support the application of trait-based ecology for strategically increasing agroecosystem diversity, which could enhance multiple ecosystem functions, reduce external inputs to farms, and increase agricultural sustainability.

Understanding the impacts of unsustainable hunting on ecosystem services - Role of large-bodied vertebrates as seed dispersers

Swapna Nelaballi, Department of Anthropology
Co-authors: Andrew J. Marshall

Many plants in tropical forests depend on animals for seed dispersal. Animals are thus critical for maintaining plant diversity. Hunting, however, is decimating animal populations in the tropics. Large-bodied animals, including important seed dispersers, are disproportionately targeted by hunters. They are particularly susceptible to population decline via hunting as they naturally occur at low densities and have low reproductive rates. The loss of large-bodied animals may result in the loss of large-seeded tree species, whose seeds are most likely dispersed by a few large animals. These trees are known to sequester disproportionately large amounts of carbon. When dispersers of such plant species are removed via hunting, it is expected that these large-seeded tree species will be outcompeted and replaced by woody climbers and low wood density trees that store relatively less carbon. Hunting is thus likely to cause pervasive changes to forest structure and function, leading to possible declines in local tree diversity over time, and may subsequently alter important ecosystem services. But understanding the precise ways that animals, plants, and ecosystem services are linked requires further examination. As a first step, I am assessing the role of large-bodied animals (a) as seed dispersers and (b) in the maintenance of forest structure and function in Indonesian Borneo.

Translating Climate Education

Priscila Papias, School for Environment and Sustainability

After decades of forewarning, much of the world's population is beginning to directly experience the impacts of climate change on their livelihood. Since the 1970's climate scientists have been warning the public about the consequences of high greenhouse gas emissions, along with the simultaneous destruction and exploitation of natural resources. The myriad of future consequences by increasingly intense climatic events, has given way to a number of mitigation and adaptation efforts meant to address and respond to climate change. Amongst these efforts include infrastructural, institutional, and behavioral changes. Of particular importance is behavioral change, which can be initiated through environmental education.

The roots of environmental education can be traced to the early eighteenth century with the popularity of natural studies. As the field has evolved over time, it has been moved away from simply observing nature to include different models of environmental education with varying emphasis. These include: sustainable education, multicultural education, and place-based environmental education. In my presentation I explore environmental education and behavior change within the Spanish speaking in the United States, highlighting lessons learned from developing a climate education course for a Spanish literacy program based in Ann Arbor, MI.

Post-occupancy Evaluation for the Chicago Riverwalk
Ho Hsieh, School for Environment and Sustainability
Co-authors: Shui Wang, Xuehan Li, Yifei Wu, Allen Burton, Victoria Campbell-Arvai, Mark Lindquist

The main branch of the Chicago River has been highly engineered and channelized for navigation use and had low accessibility to the riverfront for the public. The Chicago Riverwalk, designed by Sasaki Associates, is an open, pedestrian waterfront spanning six blocks between State Street and Lake Street in Chicago that aims at bringing people closer to "Chicago's second coast". Besides designs that increase the accessibility to the river, ecological elements like the floating wetlands, constructed fish habitats, and all-native species plantation are incorporated in the Riverwalk. This post-occupancy evaluation study hopes to understand how the Riverwalk performs against its social and ecological design goals and how the space is perceived by the user as an urban greenspace. Public surveys, on-site observations, experts interviews, and river sediments test are used to understand how the Riverwalk performs from social and ecological perspectives.

Soil for Sustainability: Impacts of urban agriculture on soil health
Katherine Grantham, School for Environment and Sustainability
Co-authors: Jennifer Blesh, Joshua Newell

Urban agriculture is growing in popularity around the world, transforming vacant parcels into flourishing farms and gardens. While urban agriculture is typically associated with positive environmental, social, and economic benefits, multiple challenges and barriers to urban agriculture still exist. In many post-industrial landscapes, soil lead contamination poses a real threat to agriculture, with potential implications for human health as well as impacts on other aspects of soil health, such as fertility and microbial activity. The addition of compost, use of cover crops, or management practices in urban gardens have the potential to reduce lead bioavailability and can simultaneously improve soil fertility and health; however, little is known about the impact of these management practices on urban soil health. This project seeks to further understand the relationship between urban farm/garden management practices and soil health, including soil lead content. In order to fully understand the environmental impacts of urban agriculture, and its contribution to city sustainability, urban soil health and lead content must be considered.

Generating a new historical record of the Laurentian Great Lakes water balance utilizing a Bayesian Network
Joeseph P. Smith, School for Environment and Sustainability – Cooperative Institute for Great Lakes Research
Co-authors: Scott Steinschneider, Jacob Bruxer, Andrew Gronewold

Historically, hydrological data for the Laurentian Great Lakes basin have been generated from multiple sources and methodologies. These data are often analyzed to gain insights into causes of dramatic water level change. However, no combination of estimates has been able to close the water balance, and set a foundation for defensible conclusions about primary contributors to a particular water level rise or fall. This presentation discusses the Large Lake Statistical Water Balance Model (L2SWBM), a Bayesian Network that assimilates different estimates of water balance components, gauges their biases, and through Markov Chain Monte Carlo methods, produces new estimates of water balance components, quantifying their uncertainty. Importantly, the network closes the water balance, allowing for defensible insights into hydrological change in the Great Lakes. We discuss how the model generates a new historical record for the water balance from 1950 through 2015, along with other features of the model.