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## Tuesday, June 12

### Keynote Plenary

**Susanne Moser**  
**Susanne Moser Research & Consulting**

#### **No bystanders! On the roles, tasks and capacities of the researcher in societal transformations to sustainability**

A large volume of existing scientific literature on spanning the boundary between science, policy and/or practice focuses on the type of research, the ways of doing research, and the obstacles to doing transdisciplinary (co-designed, co-produced) research. A far smaller body of work focuses on the roles and identity/ies of the researcher doing such work, and how it changes in the course of doing transdisciplinary work. Other, mostly pedagogical work, focuses on the changing educational needs to adequately prepare young researchers for work at the boundary, but less of it focuses on the inner capacities needed to stand between science and policy/practice. This is even more relevant to explore in the context of doing transdisciplinary research in the midst of societal transitions and transformations, particularly transformations toward ecological, economic and socially just sustainability. This keynote address will explore the challenges of working at the science-policy-practice interface not through an institutional or topical, but through a psychological and ethical lens, and identify roles, tasks and capacities needed to successfully work in this space of utter discomfort and - sometimes - great fulfillment.

### Contributed Talks by Theme – Session B

#### ***under Stress: Emerging Infectious Diseases in Ecological and Social Systems Under Stress***

Human-mediated disturbances to natural ecosystems, including landscape change, climate change, species invasions, and loss of biological diversity, are stressors that can promote infectious disease emergence or otherwise negatively impact human health. Harmful impacts to human health can in turn place considerable stress on ecological systems, for example by motivating increased use of pesticides for control of vector-borne diseases. However, there have been few efforts to integrate understanding of these coupled natural-human systems dynamics, and a framework is needed to predict the social consequences of environmental change and explore potential feedback loops between changes in human health and changes to the environment. In this session, we investigate the intersection between stressors that negatively impact human health and the feedbacks to ecological and social systems. We seek to develop a new, more holistic framework for tracking how social and environmental stresses are connected to human health outcomes.

**Brian Allan**  
**University of Illinois**

The 21st century presents escalating challenges in the form of public health consequences of human-mediated environmental change. While there has been considerable effort, for example, to document the effects of landscape and climate change on infectious disease dynamics, few studies consider the feedback loop between environmental change impacts on human health and the consequences of those human health impacts for additional change to environmental processes. Such feedbacks may be an important source of stress in socio-ecological systems, considerably altering human interactions with their environment. In this session, speakers will offer multiple

perspectives on socio-ecological interactions with ramifications for human health, including potential feedbacks between natural and social processes. To begin, I will describe ongoing research using the introduction and spread of mosquito-borne Zika and chikungunya viruses in the Americas as case studies, to describe efforts to understand the coupled dynamics of mosquito-borne disease transmission and human mobility patterns that likely determined the course of both outbreaks. Recent outbreaks of mosquito-borne diseases in the Americas, specifically the outbreak of Zika virus in 2015-2016 and the outbreak of chikungunya which preceded it, exemplify our lack of understanding of the feedbacks between the human and the natural drivers of the system. But they also provide an opportunity in the form of rich data sources to better understand how outbreak dynamics may be driven by both biophysical and social processes, including travelers' health risk perceptions and changes to decision-making processes regarding travel decisions that may have affected the course of both outbreaks.

**Andrew MacDonald**  
**Stanford University**

The demands of a growing human population for food production and economic development has driven widespread conversion of natural lands for human use and resource extraction. While these activities have had benefits to human societies, land use and land cover change has also fundamentally altered ecosystem service provision (e.g. freshwater, clean air, nutrient cycling) with consequences for human well-being. Not least among these consequences is the emergence of infectious diseases. While land use change has been implicated in both the emergence and spread of human infectious diseases, from Lyme disease to childhood diarrheal diseases, the direction and magnitude of these effects remain challenging to elucidate and fiercely debated. One key and often overlooked challenge in identifying the effects of land use change on human disease is the possibility that disease risk may feedback to drive land use decisions and future land conversion. Here, I will illustrate how human settlement and land clearing decisions are in part determined by infectious disease risk, using Lyme disease in North America and malaria in the Brazilian Amazon as case studies. This body of work improves our understanding of the ecological and land use drivers of disease, as well as demonstrates how infectious disease can be both a cause and consequence of land use change. These case studies highlight both the urgent need for environmental interventions that produce win-win solutions for health and the environment, as well as identify promising policy directions to achieve these socio-environmental goals.

**Esther Onyango**  
**Griffith University Australia**

#### **Climate Change and Malaria: An Integrated Risk Assessment of Rural Communities in East Africa**

About half of the world's population, are at risk from malaria and under climate change projections this number could rise to 1.8 million by 2050. While climate change influences the global distribution of malaria, its occurrence within regions is also determined by local land use and other non-climatic factors. This study examined the risk of malaria infection to a highland and a lowland rural community in East Africa, in the context of climate change, land use and other local factors, and explored potential adaptation strategies. A trans-disciplinary systems approach was used incorporating climate change science, malaria ecology and epidemiology along with social science and public health considerations and stakeholder engagement and contributions at different levels. A mix of quantitative and qualitative data were collected, analysed and integrated using Bayesian belief network models to estimate risk of malaria infection under current conditions and future scenarios and to evaluate the efficacy of different adaptation options in reducing this risk. Adaptation options were examined that could potentially reduce the risk of infection and the results suggested that key considerations include: community engagement; multi-sectoral collaboration, integrated early warning systems; and gender-differentiated vulnerability. The study highlighted the importance of tailoring adaptation strategies to local circumstances and the implications for health policy.

**Margot Parkes**  
**University of Northern British Columbia**

**Integrative approaches to health, ecosystems and society: New tools and processes to address the cumulative determinants of health impact and the land-water-health nexus.**

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Calls for integrative approaches to health, ecosystems and society are not new. They reflect an ongoing tension in response to complexity: a need to disaggregate issues into manageable parts, and a corresponding imperative to put things back together, to address whole, interrelated systems that influence personal, public and planetary health. This ‘integration imperative’ poses opportunities and challenges across academic disciplines, policy sectors, and knowledge cultures, and also fuels recognition for the precedents and ongoing leadership of Indigenous knowledge. The need for integrative approaches becomes especially relevant when addressing the cumulative determinants of health impacts, in relation to social *and* ecosystem change, over space and time. This involves pathways of influence that extend beyond the typical purview of the health sector, where ‘upstream’ includes places, waterways, landscapes and drivers of change, that require collaboration across health, ecological and social considerations.

A focus on the land-water-health nexus recognises that socio-environmental systems connect within landscapes and waterways, and encourages attention to “upstream” and “downstream” determinants of health, especially within watersheds. This presentation explores these themes in relation to early insights from a five-year international research project, based in Canada and Oceania, known as the ECHO (Environment, Community, Health Observatory) Network. The project focuses on working together across sectors to understand and respond to the cumulative health, environment and community impacts of natural resource management. The presentation will focus on lessons arising from use of integrative tools and processes that research partners are using to “take notice for action” in response to the integration imperative and the cumulative determinants of health impact.

### ***in Transition: Social-Ecological Transitions in Response to Large Infrastructure Projects***

**Dan Kramer**  
Michigan State University

The world is witnessing an unprecedented boom in large infrastructure projects, typically in tropical and subtropical developing nations and often financed by foreign actors. In the Amazon, Congo, and Mekong river basins alone, more than 450 dams are planned. New road construction over the next thirty years could total 25 million kilometers in length, 90 percent in developing countries. Other examples include sea ports, intercontinental canals, railroads, mining operations, and energy facilities. While large infrastructure projects offer the promise of meeting increasing demand for food, energy, and water, there are also environmental and social costs. Large infrastructure projects are often directly responsible for modified hydrological regimes, altered nutrient flows, loss of habitat and biodiversity, and increased air and water pollution. Indirectly and often working synergistically, new infrastructure can have profound effects on the local institutions, livelihoods, ecosystem services, and governance processes of rural people and remote communities. This session will examine the social and ecological effects of large infrastructure projects, responses and adaptations of local people to these changes, and strategies to build resilience in natural and human systems.

**Jack Friedman**  
University of Oklahoma

Boundary spanning in the U.S.-Mexico Rio Grande/Bravo (RGB) basin is critical for understanding how and why the socio-environmental systems is understood to be teetering on “permanent drought” (Dettinger et al., 2015). The RGB is engineered/managed to maximize the transfer of water from natural systems to human uses (e.g., agriculture consumes >85% of surface water). Efforts to rationalize hydrological resources of the region were to meet international (U.S.-Mexico) and interstate (CO, NM, TX) treaty obligations and growing/changing human demands for water; however, it has also contributed to profound fragmentation – hydrological, ecological, political-legal, cognitive, and ecosystem service/management – across the basin, in turn contributing to reinforcing boundaries between segments of the basin. Fragmentation is reproduced across science in the RGB, too, with little attention paid to the linkages between and across segments of the RGB. We report on two years of ethnographic fieldwork and cross-disciplinary collaboration to model socio-eco-hydrology across the entire RGB basin – from the headwaters in Colorado to the Gulf of Mexico, including Mexico’s Rio Conchos. We show how attempts to reduce stress on the RGB socio-environmental system have, in fact, increased fragmentation and shifted cascading dysfunctions and stressors to different ecozones and human communities, often following lines of political economic

power and perceptions of the value of ecosystems services. We describe how boundary spanning – conceptually, methodologically, analytically – in our cross-disciplinary collaboration revealed possibilities for “whole river thinking” as a solution to chronic stress on water and the socio-environmental systems that depend on that water in the RGB basin.

**Steve Leisz**  
**Colorado State University**

### **Transportation Corridor Development and Livelihood, Land-Use, and Land-Cover Changes in Southeast Asia**

Starting in the 1990s the Asian Development Bank spearheaded the development of cross-border transnational corridors in the Greater Mekong Subregion with the aim of increasing the economic integration of the region. During the past 10 years the infrastructure and policy mechanisms that are needed to facilitate the operation of these corridors has been completed. Based on fieldwork carried out over the past four years in one of these corridors, the East-West Economic Corridor, from Da Nang, Vietnam, to Khon Kaen, Thailand, this presentation examines the impacts of the corridor’s development on rural livelihood systems, rural land-use and land-cover. Findings are that the corridor is facilitating cross-border trade between Thailand, Laos, and Vietnam, and also attracting investment in urban and rural areas from beyond the corridor. The investment in the urban areas and border regions has led to the development of new enterprises, including factories and retail businesses, in both urban and rural parts of the corridor, and also increased demand for agricultural products from the rural areas to supply the new enterprises. As a result, livelihood activities and agricultural practices in the rural communities are changing. The observed impact on the land-cover in the corridor is mixed as the changing livelihood activities are leading to changing land-use patterns, including changing fallow lengths in the swidden / fallow systems, the introduction of new crops, and in some cases increasing tree cover.

**John Matthews**  
**Alliance for Global Water Adaptation**

Human dependence on freshwater resources intensifies as economies develop, while both ecosystems and water infrastructure are exposed to profound climate impacts given their long lifetimes and the challenges of managing under conditions of deep uncertainty. However, the threat of ongoing impacts on long-lived infrastructure and institutions provides an opening to reassess the relationship between ecosystems, management approaches, and economic development globally. Through a new approach for water agencies developed with SESYNC support that includes quantitative ecological resilience parameters within a widely adopted analytical methodology for assessing engineering related climate risks, decision makers can negotiate tradeoffs between joint ecological, infrastructure, and social resilience. This approach has been recently applied at a national level in Mexico for environmental water allocations and the adaptation services they provide at a river basin level, while the method has also been featured in a resilient water management decision support system developed by a global set of leading global and Euro-American water management institutions for engineering-oriented water managers and planners. Indeed, these methods have also supported work with finance processes for water infrastructure, such as for development bank loans and the global bonds market. To date, several billion USD have been influenced through SESYNC support for integrating quantitative approaches to eco-hydrological resilience.

**Manoj Misra**  
**Hankuk University of Foreign Studies**

On April 4, 2016 four people died and more than 30 were injured when police fired at a group of displaced villagers who were demonstrating against a proposed China-funded coal-fired power plant in Banshkhali, Bangladesh. A few days earlier, a coalition of environmentalists organized a 145-kilometre, four-day protest march from Dhaka to Rampal, the site of an Indo-Bangla coal-fired power plant. This latter project not only violently evicted thousands of poor locals and endangered the livelihoods of many more; ecologists fear that the plants will also endanger the Sundarbans mangrove forest, a UNESCO world heritage site and tiger habitat. The Sundarbans acts as a natural defence against soil erosion and saltwater intrusion from the Bay of Bengal and shields the mainland from the

devastating impacts of tropical cyclones and tidal waves. Constructing these power-plants in such delicate coastal ecologies will not only cause immediate displacements but will also weaken the long-term adaptive capacity of surrounding communities by chemically contaminating their livelihood sources. Importantly, the build-up of coal-fired power plants in Bangladesh is connected to the regional rivalry between Japan, India and China with the latter's pursuance of the Belt and Road Initiative. These power plants have lately attracted national-transnational environmentalist movements' attention at the expense of the voices and concerns of grassroots communities. In this context, this research interrogates: How do understandings of environmental risks, crises, problems, and their entanglement with social injustices and gendered political-economic inequalities diverge or converge across local, national, and transnational scales of movement organization?

**by Design: Designing uncertain socio-environmental futures.**

As climate change intensifies in coming decades, new levels of environmental variability will require complex multi-scalar responses. These responses will need to account not only for what is known and predicted about the future, but also for the great uncertainty about what this future will hold. This multi-disciplinary panel of scholars will consider a variety of qualitative and quantitative approaches to the design of socio-environmental future under conditions of change and uncertainty. Topics will include: the monitoring and restoration of natural resources; changing livelihood systems in variable environments; conservation across boundaries; and, environmental governance of and adaptation to a changing climate. Panelists will draw from a variety of perspectives to consider what it means to design the future, including unique challenges and exciting possibilities. Together, panelists will consider how to include a multitude of stakeholder perspectives across a variety of scales in efforts to promote sustainable and just socio-environmental futures.

**Jamie Shinn**  
West Virginia University

**Toward Anticipatory Adaptation: Transforming social-ecological vulnerabilities in the Okavango Delta, Botswana**

The ability of people to successfully respond to climate change will be partially determined by existing social vulnerabilities. At the same time, dominant policy and scholarly approaches to adaptation pay inadequate attention to the links between structural vulnerability and adaptive capacity. This paper builds on the emerging field of transformative adaptation to emphasize the need for anticipatory approaches to adaptation. This approach identifies existing vulnerabilities and creates adaptation measures that strengthen adaptive capacities in advance of extreme climate-related events. The paper is empirically grounded in a mixed-methods research project conducted in the dynamic wetland environment of the Okavango Delta, Botswana. The project investigated responses to higher than average annual flooding events in 2009-2011, which displaced hundreds of residents and inundated floodplain agricultural fields past the point of production. Findings reveal that government responses to the floods intersected with long-term issues of marginalization of ethnic minorities in the region, reducing the overall adaptive capacity of already vulnerable groups. Using an anticipatory adaptation approach, the paper concludes by identifying potential transformations that could increase adaptive capacities in advance of continued increases in flooding variability. In so doing, it argues for the design of anticipatory adaptation measures to respond to future environmental uncertainty.

**Alexander Belyakov**  
Peace and Biodiversity Dialogue Initiative

**Peace Parks Solutions for Socio-Environmental Systems Design: Case of the Peace and Biodiversity Dialogue Initiative**

The proposed case study demonstrates a role of peace parks in socio-environmental systems. It also analyses what kind of challenges exist and how to overcome them in such complex system design.

During the 12th meeting of the Conference of the Parties to the Convention on Biological Diversity, the Republic of Korea launched the Peace and Biodiversity Dialogue Initiative (PBDI), as a potential solution to global concerns about conflict areas. The Korean Demilitarized Zone Ecology and Peace Park are targeted at strengthening international cooperation for protected border areas. An important outcome was bi-lateral meetings of the Republic of Korea and the Democratic People's Republic of Korea on potential collaborative activities.

PBDI also monitors a situation between Sierra Leone and Liberia. The joint 'Trans-boundary Peace Park' project was launched by the Presidents of Sierra Leone and Liberia. PBDI is working closely with government officials in Eastern Europe (Ukraine) and Caucasus (Georgia) observing how conflict disputes there influence transboundary conservation. PBDI promotes environmental diplomacy, shared sovereignty of environment and environmental security.

The lessons learned from PBDI will be helpful in assessing governance, the role of involved societal stakeholders, planning, infrastructure development, outcomes of engineered landscapes and protected areas design. Conservation of ecosystems could create socio-environmental opportunities to alleviate conflicts in transboundary areas. At the same time, there is so much to be done since it would be difficult for institutions working in socio-environmental systems in isolation to succeed.

**Meghan Daly**  
**University of Leeds**

Knowledge is widely considered a key determinant of societal capacities to adapt to climate change. However, questions remain about what knowledges are included in decisions about climate adaptation, including who has the authority to decide what knowledges 'count.' In recent years, the concept of co-production has been widely advanced as a deliberate, instrumental approach to enable more collaborative and legitimate processes of knowledge production for adaptation. However, in the field of science and technology studies (STS), the idiom of co-production is applied as a critical analytical lens to understand the mutual constitution of knowledge, power, and social orders. In this presentation, I will draw on empirical case studies of attempts to instrumentally co-produce knowledge for climate adaptation. Using a critical co-productionist lens, I will examine the how these processes themselves recursively shape (and reshape) understandings of 'adaptation,' as well as the socially constructed boundaries between science and other ways of knowing – in ways that are sometimes positive, sometimes problematic. As such, I argue that broader efforts to co-produce knowledge for adaptation are not just an epistemological project, but are productive of new science-society relations, often with important material consequences for the lives and livelihoods of those who are likely to be most affected by climate. I conclude that it will be vital to continuously pay attention to the ontologies of instrumental co-production and the ways in which these may influence new trajectories and possible futures under climate change.

**Edu Effiom**  
**Forestry Commission, Government of Cross River State, Nigeria**

REDD+ (reducing emission from deforestation and forest degradation, the plus signifies multiple benefits from land use) seeks to advance workable sustainable forest management (SFM) practices that enhance the capacity of tropical forest to provide environmental, socio and economic benefits to humans especially the rural community. This has become urgent due to the ongoing conflicts between humans and biodiversity conservation initiatives over access to and use of forest resources especially in developing nations.

We combined socio-economic and ecological data from 4 villages and relevant government agencies in Cross River State, Nigeria to 1. Access the level of rural households dependence on forest resources 2. We ask which indirect driver of deforestation poses the greatest risk to the implementation of REDD+ relevant policies and measures (PAMs). We found a significant difference between the consumption of bushmeat and farm animals among the villages. Three out of the four villages studied showed high preference for bushmeat despite the proximity of two of these villages to major roads which gives them access to other options. We also found that inadequate participation of forest dependent communities in the design and implementation of REDD+ relevant PAMs was the greatest risk to PAMs implementation compared to institutional/capacity or financial inadequacies.

Our results calls for a multiple land use design that connects all the land-use sectorial priorities to enhance the attainment of environmental and human livelihood sustenance towards bridging the human-biodiversity divide.

**Auriel Fournier**  
**Mississippi State University**

The Gulf of Mexico is a dynamic system, under various natural and anthropogenic stressors, including one of the largest oil spills in the world. In response to the Deepwater Horizon oil spill a strong light was cast on the lack of large scale monitoring of most natural resources across the Gulf, including birds. The Gulf of Mexico Avian Monitoring Network (GoMAMN) - a group of conservation partners including state/federal agencies, NGOs, and academics - was formed to coalesce a community of practice and define the values of the community to framing the role of bird monitoring in response to the critical information needs highlighted by the Deepwater Horizon oil spill. We used a Structured Decision Making (SDM) process to develop a set of fundamental objectives along with an explicit objectives hierarchy and value models to qualitatively and quantitatively define stakeholder values and goals related to avian monitoring along the Gulf of Mexico. We are using a decision support tool to bring together the GoMAMN community values along with decision maker constraints for allocating funds and we have used the SDM framework to establish priorities for future work related to how ecological process drive bird populations. Here, we will demonstrate how the SDM framework can be used to guide the development of a Gulf of Mexico-wide plan for all 500+ species by bringing together community values, existing knowledge and decision constraints to make an individual funding decision, and set priorities for the next two decades of monitoring and restoration work.

**Emilie Lindkvist**  
**Stockholm Resilience Centre, Stockholm University**

Fish populations that span or move over large regional scales often represent fisheries with high uncertainty or high variability in access. The appearance of such transient regional fisheries is known to trigger the mobility (or migration) of fishers, who can change their fishing patterns in response to such temporary, higher incentives. Local fisheries, which operate in spatially explicit fishing regions, may experience reductions in effort during times that transient regional fisheries are present. We study the effects of differing fisher behavior between these different resource types (transient versus local) on the resources themselves as well as the local human populations that rely on them as a source of livelihood. We applied an Agent-Based Modelling approach based on the empirical case of the Gulf of California, Mexico, to investigate the effect of the interactions between local and regional fisheries on: i) the exploitation levels of local resources and ii) the economic inequality and resilience between local communities with different fishery types and between fishers that have different capacities to move to fish transient regional fisheries. Understanding the movement patterns of fishers that emerge when transient fishery resources are present will help us highlight which circumstances lead to changes in resilience caused by shifting exploitation patterns and subsequent changes in revenue gains and recovery potential of local fish stocks. Our work has important implications for the design of regulations such as those that limit or enable fishing access particularly with respect to communities in transition.

## **Plenary Lunch Discussion: Expanding Representation & Access**

**Banu Subramaniam**  
**University of Massachusetts, Amherst**

### **Alien Becomes Exotic: Gender, Race, and the Practice of Science**

What do morning glory flowers or alien plant and animal species have to do with the histories of gender, race or eugenics? In this interactive workshop, Banu Subramaniam will trace the genealogies of ecology, evolutionary, and environmental biology, to demonstrate how foundational ideas of "variation" in the life sciences are inextricably connected to ideas of "diversity" and "difference" in our social worlds. Making a passionate case for interdisciplinary work across the humanities and natural and social sciences, this workshop explores how histories of gender and race shape contemporary scientific theories and what lessons we can learn about the relationships between natures and cultures. The workshop will explore two main questions: (1) How can we transform work

cultures to make them more inclusive and welcoming of difference? (2) How can we move from studying nature and culture as separate realms of knowledge, to create more interdisciplinary frameworks of studying the many socio-environmental borderlands of naturecultures?

## Lightning Talks - Session B

### *Socio-Environmental Systems under Stress*

**Patrick Bixler**  
University of Texas

Contemporary environmental problems, such as climate change, loss of biodiversity, and resource depletion (quantity and quality of water, energy, etc.) present formidable challenges for 21st century resilience. Transition to resilience is a particularly salient idea for cities, which are often conceptualized as complex socio-environmental adaptive systems. Urban sustainability transitions must include “society,” however, the pathways that social and ecological conditions shape individual levels of concern and interest in sustainability transitions remain poorly conceived. This presentation seeks to shed light on the intersection between environmental concern, social capital, and transitions through research conducted in Austin, Texas. Austin is a demographic and climatic hot spot. In the 21st century, the region is projected to undergo a doubling of its population and a shift to a more drought-prone climate. This poses synergistic challenges for the region’s hydrological and ecological resources, geographically shifting inequality, culture and system of governance for the region. This research examines the six-county Austin area as a socio-environmental system in transition, analyzing the directional change between urbanization, gentrification, poverty, food insecurity, and water availability. As part of the Austin Area Sustainability Indicators ([www.austinindicators.org](http://www.austinindicators.org)), the analysis uses multi-level linear modeling techniques to combine longitudinal survey data with environmental and social change in the region. Results demonstrate the effect of changing socio-environmental contexts on pro-environmental concern and behavior. Understanding these effects, and how social capital mediates, is important in shaping sustainability transitions. This research is part of the Planet Texas 2050, a University of Texas-Austin grand challenges initiative.

**Kelly Boyer Ontl**  
Michigan Technological University

The financial crisis of 2008 sparked a global shift in the artisanal small-scale gold mining (ASGM) sector. In Senegal, ASGM had long been a traditional and largely supplementary livelihood. As gold prices increased, the practice became a pervasive and permanent presence that has reconfigured cultural, economic, and ecological systems. Southeastern Senegal is home to the nation’s largest ASGM site, Kharakhena, as well as the critically endangered West African chimpanzee (*Pan troglodytes verus*). Kharakhena’s gold rush of 2012 shifted the local human population from 150 to 20,000+ people over a six-month period. Mining activity has continued to intensify through 2017. The resulting stress to the ecosystem and the resident chimpanzees has been multi-pronged. The socio-environmental system has endured the intensification of land use practices (i.e. palm wine collection, timber harvesting, and gold mining), hydrologic impacts from groundwater use in the arid environment, widespread biotic and abiotic mercury pollution (i.e. in the water, soil, and termites), and home range reduction and nest-site abandonment by the Kharakhena chimpanzee community. To study and understand the system, I collaborated with biogeochemists, biologists, and anthropologists; however, continued efforts are needed to understand how to effect change and help conserve the endangered ape population. Future work will look to leverage previous community engagement programs in Kharakhena to understand community perspectives on chimpanzee conservation initiatives

**Joel Carr**  
United States Geological Survey

Questions related to human rights and the existing unequal distribution of food resources have taken on greater urgency. International trade provides a mechanism to redistribute food resources, yet no framework exists with which to evaluate how individual links impact geographic patterns and variability in food availability (estimated by

per capita dietary energy availability). To examine these impacts, a method was developed which allows for quantifying individual link contributions to inequality. Application to country scale food production and trade data (1986-2011) reveals that global trade reduces inequality in food availability by 25-33% relative to the distribution of food production. Roughly 59% of the trade links each year reduce inequality, with 4% of the links responsible for 95% of the reduction. In contrast, the links causing 95% of the increase in inequality rose from 2.6% in 1986 to 4.1% in 2011. Links that reduced inequality were mostly associated with staple food products (cereals), while those links which increased inequality were often comprised of “cash” crops and “luxury” food products. The broad picture is that trade overall reduces inequality among countries relative to the distribution of food production (e.g. moving food from countries with higher, to countries with lower food availability). However, trade patterns reflect the co-evolution of populations, institutions and technologies, and thus may indirectly contribute to the emergence of those inequalities in the first place. The ability to examine impacts of individual links on inequality presents future opportunities to explore how human rights and global-scale patterns of resource redistribution are intertwined.

**Adriana Flores-Díaz**  
**National Autonomous University of Mexico**

Located at particular interfaces in the landscapes, riverine forests are systems under high pressures, by drivers coming from both terrestrial and aquatic means. By means of terrestrial human activities, riparian systems are pressured by land use changes; and by means of water, rivers and riparian are receiving wastewater and losing their water pulses and flows. Addressing these issues should be most locally since: (a) socially accepted protocols to manage water and land are rooted in culture, making sense for local people, and letting respectful human-nature relationships; (b) water decisions need for co-management agreements among social actors and scales, since rivers are crossing different land tenure and land politics systems; (c) connectivity is associated with the resilience of the fluvial system, and of the social one, too. Since every river patch counts, local decisions on each piece of the riverine forest can enhance the entire basin connectivity. By talks and walks with farmers in Mexico, questions are emerging about the availability of tools for integrating local knowledge and concerns with regional context dynamics, and for making visible the mismatching between the local and national decisions. Understanding drivers for local river-riparian governance and for the miss-matching between scales is at the core of the fluvial systems conservation. Pressures on riparian systems are atomizing not only the fluvial corridor but the possibility to effectively integrate land management plans, since the lack of recognition of the impacts that broad environmental politics has on it. Can we enhance locally driven processes without encouraging the politics of atomizing?

**Kristofer Lasko**  
**University of Maryland**

**Improving estimates of agricultural burning emissions and better accounting for harmful impacts to human well-being.**

Agricultural residue burning, practiced in croplands throughout the world, combines with urban pollution to adversely impact public health and nutrition via poor air quality and reduced crop yields. Monitoring and quantifying agricultural residue burning and resulting emissions is difficult due to lack of field data, hazy conditions obstructing satellite remote sensing imagery, and small field sizes. This research synthesizes field data, remote sensing, and modelling to improve knowledge of the extent of biomass burning in Southeast Asia in particular. In doing so, results rectify remote sensing datasets that previously underestimated emissions values from smallholder agricultural landscapes. Overall, findings demonstrate the value of incorporating region-specific factors into generalized remote sensing datasets, and signal the need for decision-makers to mitigate this unexpectedly significant emissions source. Results also suggest that the deleterious effects of this widespread agricultural practice on human health and well-being are likely much greater than expected.

**Jonathan Long**  
**USDA Forest Service Pacific Northwest Research Station**

Tribal communities in the Pacific Northwest USA have long-standing relationships to ancestral lands now managed by federal land management agencies. In recent decades, federal and state governments have increasingly

recognized tribal rights to resources on public lands and to participate in their management. In support of a new initiative to plan sustainable land management, we reviewed publications that examined relationships between tribal socio-ecological systems and public lands in the region. We identified key ecocultural resources, impacts to those resources and associated forest ecosystems, and strategies that have been piloted to redress those impacts. We found that stress resulting from colonization by Euro-Americans have engendered social-ecological traps that have inhibited tribes from continuing traditional stewardship activities that supported their well-being and maintained ecological integrity. These stress factors include legal and political impositions on tribal access and management; declining quality and abundance of forest resources due to disruption of natural fire and indigenous tending regimes; competition with non-tribal users; species extirpations and introductions of invasive species; and erosion of tribal traditional ecological knowledge and relationships that are important for revitalizing resource use. As a consequence, both supply and demand for these forest resources have been reduced, as have the resilience and diversity of these ecosystems. Simply permitting resource harvest by tribal members does not sufficiently address the underlying constraints in ways that will promote tribal well-being. Cooperative restoration efforts between land management agencies and tribes can holistically address a gamut of ecological and social constraints to escape these traps.

**Connie Maxwell**  
New Mexico Water Resources Research Institute

### **Agriculture as a System for Managed Aquifer Recharge for Deserts by Restoring Hydrologic Connectivity to Floodplains and Aquifers**

In the American Southwest, what underlies both drought and increased flooding as social crises is a water storage problem. Alternative water management strategies that replenish groundwater and soil storage systems have increasingly become critical. Optimizing available water storage will require land managers to develop innovative solutions to handle stormwater supplies that arrive in fewer and increasingly intense monsoonal bursts. Historically, floods along the Rio Grande River network in New Mexico were more connected to more richly vegetated floodplains, which resulted in watersheds retaining more their water and soil resources. Agriculture supported that natural dynamic through systems of stormwater harvesting and by spreading flood flow onto floodplains (floodplain connectivity) which resulted in infiltration into shallow (aquifer connectivity). Today management has lost many of these system functions, and communities are seeking solutions to watersheds “leaking” their resources of water and soil. For the Hatch and Mesilla Valleys of southern New Mexico, we developed a remote sensing and system dynamics modeling approach to identify and predict high priority areas for restoring an optimum level of floodplain and aquifer connectivity. We synthesized hydrologic flow data, satellite images, spatially explicit models, and generalized linear models into a system dynamics model to predict landscape behavior responses. The evaluation resulted in identification of interventions with the potential to achieve the optimum level of ecosystem service benefits. Nearly forty percent of the global land surface is managed in agriculture, and with potential innovative adaptation, agriculture can once again become a system for recharging our aquifers and restoring our watersheds.

**Christopher Trisos**  
SESYNC

Abrupt transitions to unprecedented climates for global biodiversity: Threats to biodiversity from climate change increase with the magnitude of warming, and yet the capacity for species to adapt and persist depends as much on the timeframe available for adaptation as on the total magnitude of change. Thus, to make informed decisions about climate adaptation we need to know how biodiversity is affected by not only the magnitude but also the timing of climate change. Studies now predict that by 2100 most regions will experience yearly temperatures that permanently exceed the bounds of recent natural variability. However, when, where, and how the timing of such climate emergence affects biodiversity remains unknown because previous assessments have not included information on the natural variability under which species persist. Here, we present an index of climate emergence for biodiversity: when, for how many species, and how suddenly the projected climate of a given ecosystem exceeds the bounds of natural variability for resident species. Globally, most locations experience an abrupt transition to novel climates for biodiversity. The climate emergence of ecosystems is most rapid and abrupt in the tropics, where a third of locations have an abrupt transition to novel climates for over 20% of their local biodiversity before 2070 (under RCP8.5). By

the end of the century 65% of marine and terrestrial species populations will be living outside the bounds of recent natural variability (RCP8.5). Such rapid climate emergence has implications for the placement of protected areas and for the benefits people obtain from ecosystems.

**Tamara Wong**  
**University of Hawaii**

Societies worldwide heavily rely on ecosystem services provided by forests, such as carbon sequestration, water security, food, medicine, cultural, and aesthetic benefits, which have been estimated at \$23.3 trillion annually. The socio-ecological value of the ecosystem services provided by Hawaiian watersheds depends crucially on tropical forests. These watersheds are in critical need of assessment and protection given their vulnerability to climate change and species invasion. Integrating climate change adaptation, land and water use policies and corresponding invasive species control in support of watershed resilience are important resource management strategies for island ecosystems. In order to improve our understanding of how ecosystem services of Hawaiian watersheds respond to future climates and species invasion, we applied a socio-ecological systems approach. We combined distributed hydrological and plant species distribution models, with ecosystem services valuation using meta-analysis. Our results suggest that water security will decrease under various climate change and species invasion scenarios, resulting in significant economic losses in ecosystem services provision. This novel approach spatially delineates regions of concern and highlights potential water security adaptation and mitigation measures. We show that preventive management may help to mitigate potential socio-economic losses and reduce the negative impacts on socio-ecological resilience in the future.

### ***Socio-Environmental Systems in Transition***

**Bryce DuBois**  
**RISD**

Beaches and littoral zones are cultural places in transition and transitioning spaces due to changes in habitat from sea-level rise and coastal erosion. These are also intended to be public spaces; for all submerged land below high tide is held in the public trust in the US. This is further reinforced by US coastal law, which encourages access to beaches for recreation and a consideration of coastal areas of environmental, historical, esthetic, ecological or cultural value. However, restrictive management of beaches and hierarchical decision-making practices along the coast are concerning for their potential to be a homogenizing force, rather than creating coastal places where a wide variety of people of different gender, class, culture, nationality, and ethnicity intermingle and live nearby. In this flash presentation, I will draw from literature on the social sustainability of urban parks to analyze the case of beach restoration in Rockaway, following Hurricane Sandy. Social sustainability is a subset of cultural sustainability and refers to the maintenance of social relations and meanings that reinforce cultural systems. Drawing from ethnographic research (52-interviews, two years of participant observation, and field notes), I will show and describe the material aspects of the beach that were preserved, how the cultural ecology of the beach shifted following the restoration, and describe themes related to the politics of meaning and cultural values represented in the beach restoration work. In closing, I will advance an argument around coastal resilience planning that emphasizes social sustainability and cultural diversity of coastal public spaces.

**Kathleen Ernst**  
**University of Tennessee**

Cities are facing numerous pressures on their water systems related to climate, environmental, social, and economic changes. In response to these pressures, some cities have transitioned towards more sustainable water management practices. Did any factors influence these transitions; and if so, how? Also, do any commonalities exist across cities that made their water systems more sustainable? We answer these questions using Miami, Las Vegas, and Los Angeles as three case studies of cities that have undergone transitions to increase the sustainability of their water systems since 2005. To answer these questions we: 1) quantified exposures theorized to affect transitions, 2) assessed the influence of system structure on exposure patterns, and 3) characterized windows of opportunity for transitions towards sustainability. Transitions towards more sustainable water management unfold over decades, so

data from 1991-2014 were collected and analyzed. Within each transition, we identified and focused on a period of accelerated change (PoAC), when a city makes multiple policy and infrastructure changes. Our results indicate that biophysical, regulatory, and political exposure alignment produce a window of opportunity for cities to transition towards more sustainable water management practices. However, differences in case context produce variations in the individual exposure thresholds that, when combined with other context-specific exposure thresholds, create a window of opportunity to introduce changes that increase system sustainability.

**Amy Freitag**  
NOAA National Centers for Coastal Ocean Science

### **Ocean Tipping Points: Wetland Loss and Ecosystem Service Provision**

Tipping points in marine systems have been documented in cases at many scales around the globe. According to resilience theory, crossing these tipping points leads to regime shifts in the ecosystem that may be irreversible. For the Gulf of Mexico Large Marine Ecosystem, the Integrated Ecosystem Assessment team is monitoring social and ecological indicators across the system and are now looking for nonlinearities between wetlands and other socioecological system components and how those changes are related in space and time. Has wetland loss caused a non-linear response in ecosystem services such as commercial fishery yield and ocean economy jobs? Is it possible through restoration or landscape engineering to recover the ecosystem services by bringing the system back over the tipping point? Does crossing one tipping point, say for loss of wetland area, lead to other nonlinear changes to be pushed over their tipping point, like for human population displacement? Using long-term monitoring data for the Gulf of Mexico, we explore these questions and attempt to detect nonlinearities in ecosystem indicators, observe tipping points, and deduce how these tipping points are related.

**Jessica Gephart**  
SESYNC

Seafood is a nutritionally important resource, providing nearly 20% of animal protein consumed globally, as well as omega-3 fatty acids and essential micronutrients. Levels of seafood consumption depend on rates of production and are mediated by geographical, social, institutional, and economic access. Seafood consumption and availability will be affected by environmental change, highlighting the importance of fisheries management, trade policies, and economic wellbeing, which create uncertainty in the future supply of, and access to, seafood. Scenario analysis provides a method to explore these potential futures and prompt discussion about how to achieve desirable nutrition outcomes from fisheries. Scenario analysis does not aim to forecast the future, but instead aims to capture uncertainties to bound plausible futures. In order to explore future scenarios of climate change impacts on fish catch, fisheries management, trade patterns, and dietary shifts, we developed a model that links environmental, economic and nutritional aspects of fish consumption. We then developed scenarios that bound plausible futures for both global and selected national analyses. The environmental component of our model builds on previous research that spatially projects catch declines under climate change scenarios, whereby sea temperature rise will force fisheries away from the equator and toward the poles. Within the economic model, projected catch declines can lead to changes in seafood trade and dietary shifts (including shifts to more aquaculture consumption). Finally, we analyze the nutritional impacts of these responses harnessing a nutritional database developed within our group.

**Theresa Ong**  
Princeton University

Urban gardens are temporally dynamic systems, with many systems (e.g., the Victory Gardens in the U.S. following WWII), sprouting, then quickly disappearing in history, while others (e.g. the urban and periurban gardens of Cuba and Germany) seem more resistant to change. To understand why transitions to urban gardens are more permanent in some cases than others, I developed a replicator-mutator model of land-use transitions where agents choose between a given set of land-use strategies (vacant lots, gardens and developed land) based on rates of land-use change (e.g. land tenure) and perceptions of utility. Relaxing static impressions of utility so that they change with economic conditions leads to interesting dynamic consequences for urban gardens similar to those we see across different socio-political contexts. These behaviors include limit cycles in land-use, which feedback to cause

destabilization in market dynamics. Increasing separation between markets and land-use may also adversely affect stability in land-use change.

**Rachel Zuercher**  
**University of California Santa Cruz**

Small-scale fisheries such as California's nearshore groundfish fishery play a pivotal role in many coastal communities, but are sensitive to environmental and socioeconomic changes. The nearshore fishery takes place in a dynamic biophysical region, and has undergone sharp decreases in fishery participation following a suite of regulatory changes over the past 20 years. Using Ostrom's framework for analyzing social-ecological systems, we are building better understanding of the shifting human-environment interactions in the nearshore fishery over two decades of change in the fishery management regime. While management aims to ensure a sustainable fishery, major questions remain about how to ensure social and economic sustainability both statewide and among the associated communities while also sustaining the natural resources on which the fishery depends. We use fishery landings data, information collected from semi-structured interviews with fishermen and fish buyers, and synthesized data on biophysical conditions in the nearshore environment to characterize and identify potential explanations for changes in the fishery over the course of the transition in its governance. We assess changes in the spatial distribution of effort, catch composition, and operations and practices in the fishery. Further, we explore the ways in which ongoing regulatory change has influenced nearshore participants' engagement in and consequences for other fisheries in the region. Altogether, this work highlights the complex and widespread social and ecological implications of ongoing changes in fishery governance, and provides insights for adaptive management of the nearshore fishery.

### ***Socio-Environmental Systems by Design***

**Ken Bagstad**  
**U.S. Geological Survey**

The nation's economic accounts provide objective, regular, and standardized information routinely relied upon by public- and private-sector decision makers. But they are incomplete. The U.S. and many other nations' economic accounts do not address the natural capital — such as the forests, grasslands, wildlife, soils, and water bodies— upon which all other economic activity rests. Natural capital accounts (NCAs) standardize, regularly repeat, and aggregate diverse natural resource and environmental data and allow those data to be linked to economic information already captured by GDP, jobs reports, and other national tracking data. NCAs can help guide and potentially save investment dollars by helping businesses and governments understand the critical role of nature's inputs to the economy when evaluating the past, peering into the future, innovating, and planning for shocks.

This lightning talk, based on the work of a SESYNC/Powell Center Working Group on Natural Capital Accounts, will highlight key results of initial NCAs in the U.S. for land, water, and ecosystems, potential policy applications, and opportunities to advance NCA. Further, it will explain why the development and use of NCAs can help to quantify key linkages between nature and the economy, providing the information needed to design systematic and sustainable policy solutions that address environmental, economic, and social dimensions of society.

**Erin Beller**  
**San Francisco Estuary Institute & University of California-Berkeley**

There is growing interest in the role urban landscapes can play in supporting biodiversity while also benefiting human well-being. Yet green spaces in cities often bear little resemblance to the ecosystems they replaced, and the character and extent of transformation in these now-urban ecosystems is often not well documented. We used Silicon Valley, California as a case study to explore how a historical perspective on ecosystem change can provide new insights into the design of more ecologically functional and resilient urban landscapes. We synthesized hundreds of early (ca. 1750-1900) cartographic, textual, and visual accounts to reconstruct the extent, structure, and composition of oak woodland ecosystems in Silicon Valley prior to major Euro-American modification. We then compared the historical structure and composition of the oak woodland to contemporary survey, street tree, and

canopy data to quantify the extent of ecosystem transformation. Our research shows that the structure, composition, and diversity of Silicon Valley's urban forest has been dramatically altered by urbanization, while canopy cover has remained relatively consistent. These findings highlight opportunities to "re-oak" Silicon Valley: that is, to re-incorporate elements of the region's former oak woodland back into the urban landscape, with potential benefits to both local biodiversity and human well-being. Early adoption of project guidance is currently taking place in the region by regional agencies, non-profits, open space conservancies, and corporations.

**Janae Davis**  
Clark University

#### Perspectives for Overcoming Racial and Class Bias in the U.S. Environmental Movement

Over the last three decades, scholars, journalists, and activists have increasingly criticized U.S. environmental organizations for the lack of racial diversity on their staffs, boards, and populations targeted in outreach programming. These criticisms have prompted a range of responses by environmental groups. Some have fully immersed their institutions in work around diversity, equity, and inclusion (DEI), others have engaged their staff and board members in conversations about the possible benefits of diversifying their organizations (with few tangible results), while many groups maintain the status quo. Organizations that actively engage DEI frequently encounter barriers that often result in the decline or indefinite suspension of these efforts. In order to effectively diversify the U.S. environmental movement, we must first understand why a more diverse movement is needed at this moment in our socio-ecological history. We must also gain a better understanding of the historical conditions that produced the movement's racial and class homogeneity and how they continue to shape the ways that environmental organizations operate today. This presentation will provide background on the origins of racial and class bias in the U.S. environmental movement and the ways in which they continue to inform environmental organizations' missions and practices. It will also highlight the practical imperatives of engaging DEI, identify common and often overlooked obstacles, and offer perspectives for thinking about ways to develop more effective DEI initiatives.

**Eric Goldfischer**  
University of Minnesota

How do socio-environmental projects in urban areas intersect with the thorny problem of homelessness? Through what I call "ecological renewal projects," exemplified by places such as New York's High Line and Baltimore's Inner Harbor, planners and architects attempt to spur ecological renewal through public-facing designs that simultaneously provide social benefits to counteract the effects of abandonment. Based on my ongoing dissertation research in New York City, I suggest that ecological development--projects whose benefits are articulated in ecological terms, even when that is not the explicit thrust of the design--have become increasingly prominent as a mode of development in hyper-gentrified cities. In this form of socio-ecological design, homeless people are treated very differently than in previous development projects which focused on policing them and removing them from the landscape. Instead, I argue, ecological design in New York City has created a new form of visibility--one which produces ways of seeing which make homeless people less present without actively removing them from the landscape. This has crucial implications for urban political ecology and socio-nature studies, as researchers grapple with the exclusions and inclusions (both human and non-human) brought forth by ecological design processes.

**Bianca Lopez**  
SESYNC

As technology allows people to spend more time indoors and in front of screens, city dwellers are increasingly disconnected from nature, a phenomenon known as the extinction of experience. However, biodiversity conservation efforts in cities can provide opportunities for people to experience and learn about the natural world. In this study, we used publicly available data on observations of birds from three different social media and crowdsourcing websites—eBird, iNaturalist, and Flickr—to identify locations where people observe birds in Chicago. These websites have different aims and users, and together data from these sites provide information about three sets of people: birders, biodiversity enthusiasts, and photographers. We pulled georeferenced data on bird observations from these sites within a bounding box around the city of Chicago, and used land use data from the Chicago

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Metropolitan Agency for Planning (CMAP) to categorize the locations where these observations took place. Most observations were on public lands, but we found differences in the types of locations where people observed birds in the three datasets, with eBird users more frequently observing birds in residential areas and a much higher proportion of iNaturalist observations occurring on conservation land. In contrast, more than half of Flickr photos of birds were taken in open space that is primarily used for recreation. These results provide insight into the appreciation of biodiversity in cities, and may be useful for guiding targeted urban conservation and education efforts.

**Bruce Strouble**  
**Florida A&M University**

In the 1980s, some researchers began to identify social capital as the facilitative force that allows for efficient collective action and enhanced community resilience which have both been identified as requisite characteristics for environmental justice (EJ). Using a system thinking framework "EJ communities" are understood as socially vulnerable communities that are also impacted by one or more environmental stressors. Social capital refers to the resources, benefits, and networks created and shared by members of social entities that people utilize to solve individual and collective problems. Recent research suggests there are debilitating socio-economic disparities existing in various EJ communities. This is likely a result of the lack of the specific types of social capital that are generally accompanied by social vulnerability. Furthermore, much of the research suggests that EJ communities are disparately impacted by environmental stressors. Researchers have attributed the disparity of social capital between American communities to several factors including socio-economic status, community ethnic diversity, racial diversity, and even level of education. The aim of the proposed lightning talk is to review the literature and theory that explores the theoretical linkages between social capital indicators and social vulnerability in "EJ" communities.

**Kelly Turner**  
**University of California Los Angeles**

Urban planners and architects have proposed alternatives to conventional sprawl development to enhance the environmental sustainability of cities through design. Yet, the ability of such green alternatives to address major urban environmental challenges is not well understood. This research asks: how can we plan, build, and manage cities in ways that generate quantifiable improvements in environmental outcomes over conventional development? It deploys an urbanization science framing that casts design alternatives as complex social-ecological systems, uses built examples as urban laboratories, and emphasizes empirical connections between social theory and biophysical patterns and processes. Specifically, a land systems science approach is leveraged to quantify the direct ecological benefits of sustainable design using remote sensing and spatial analysis, assess the institutional capacity to deliver those benefits using existing land planning and development tools, and draw connections between proximate and distal institutional drivers and environmental outcomes. This approach is applied to master planned developments that deploy New Urbanist and Conservation Subdivision Design in Tucson, AZ, Austin, TX, and Grayslake, IL. These design approaches generated modest improvements in microclimate regulation and water quality over conventional development in the case study communities. Stakeholders were able to make incremental adjustments to conventional planning and development tools to achieve design goals in some instances, but also made substantial design concessions working within conventional institutional frameworks that undermined ecosystem service delivery. These findings suggest that novel design also requires novel institutional arrangements to enhance institutional fit and better enable design-oriented approaches to address urban environmental challenges.

## **Contributed Talks by Theme – Session C**

***under Stress: For adaptive, evolving systems, how much stress is too much?***

**Naomi Tague**  
**University of California Santa Barbara**

Most systems experience stress, or conditions where the function of that system is by some criteria sub-optimal. For many systems, frequent levels of stress also lead to adaptations to that stress. Both pulse stresses, such as disturbances like fire, and floods, and long-term sub-optimal conditions such low water availability lead to a myriad of adaptive strategies. Fire-adapted ecosystem, drought and flood tolerant vegetation are ecological examples, the provision of flood insurance or the construction of dams are human system examples. The impacts of stress, however, may be more problematic when the frequency or magnitudes of stress change at rates beyond which the system can adapt and still maintain its underlying structure. If we are to understand how human resource and land use and climate change - are influencing socio-ecological systems, we need to monitor, model and understand how responses to prior stress events impact responses to subsequent stress events. In this session we look at studies that uses measurements, empirical analysis and models to track how responses to stress are related the prior frequency and magnitudes of stress.

**Tamma Carleton**  
**University of California Berkeley**

### **Valuing the global mortality consequences of climate change accounting for adaptation costs and benefits**

We construct global estimates for the full value of changing mortality risk due to climate change. To the best of our knowledge, this is the first high-resolution, probabilistic, and globally comprehensive valuation derived from empirical estimates that are plausibly causal. It is also the first empirical estimate for any type of non-market climate damages to take into account both the benefits and costs of adaptations that populations will likely undertake to protect themselves against higher temperatures. Assembling the most exhaustive micro-data set on mortality and climate to date, we develop a unified approach to (1) predict dose-response surfaces for regions of the world where mortality data are unavailable while simultaneously (2) modeling adaptation costs and benefits. We find a clear nonlinear global relationship between mortality and temperature, with hot and cold days both leading to excess mortality---but less so in richer locations that experience these temperatures more frequently. This indicates the existence of substantial adaptation opportunities that are achieved at positive cost. We combine these findings with standard projections of income and population along with novel probabilistic climate change projections to estimate the full damages of excess mortality risk imposed by warming, accounting for these adaptations and their cost. We estimate the total mortality related costs of climate change range from 1.7% (RCP4.5, low emissions scenario) to 6.8% (RCP8.5, high emissions scenario) of projected global GDP at end of century, with substantial spatial heterogeneity in impacts arising from large differences in adaptation across regions of the world.

**Adrian Das**  
**US Geological Survey**

### **Tree Mortality and the California Drought: A preview of the future?**

California has recently experienced a drought of historically unprecedented severity, putting California forests and woodlands under extreme stress and resulting in the mortality of tens of millions of trees. Given the possibility that such droughts may occur more frequently in the future, what can we learn from the current mortality event in California and what does it tell us about our ability to assess future vulnerability in these systems? Here we take advantage of two datasets from a lower mixed conifer forest in the Sierra Nevada to ask: Which trees died during the drought? What were the direct agents of mortality? And how did prior stress influence mortality risk? We found that bark beetles were the primary agents of mortality during the drought and that their host selection appeared to substantially affect which trees died. Prior stress influenced risk of mortality for some subsets of trees but not others. We also found that organisms not typically considered major agents of mortality may become prominent players when a system is under severe stress. Broadly speaking, our results suggest that forecasting how forest systems may respond to severe drought requires an understanding not just of direct physiological stress on trees but also the biology of the organisms that attack them.

**Alex de Sherbinin**  
**Columbia University**

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This presentation will examine spatial vulnerability assessment and modeling of climate migration to demonstrate how spatial data integration across the social and environmental sciences can help illuminate ways in which socioenvironmental systems are under stress from climate change. This presentation will review results of the SESYNC Pursuit on climate change vulnerability mapping, and describe what mapping can reveal about the social and environmental underpinnings of climate vulnerability and risk. Hotspots of climate vulnerability are places where transition (adaptation) strategies are most need. The presentation will explore migration as an adaptive response to climate change impacts and vulnerability. The data integration and modeling methods behind a World Bank report, "Groundswell - Preparing the Way for Internal Climate Migration" (release Feb 2018), will be described, and the implications of migration as a societal response and a potential strategy to manage socioecological systems in transition will be explored.

**Ariel Lugo**  
US Forest Service

### **Who responds the quickest after hurricane wind stress: the social or the ecological systems?**

After hurricane Hugo, I concluded that social systems, with access to fossil fuel energy, were quicker to respond and recover than forested systems with access to only solar energy, a diluted energy source. Hurricane María, with large-scale effects on both social and ecological systems, tested this hypothesis, and gave me an opportunity to comparatively measure the response of the social ecological systems of Puerto Rico to hurricane winds and rain. The response of social ecological systems to hurricanes is complicated and my observations are preliminary, but it appears that different sectors of social ecological systems have different responses to onetime stressors and exhibit different speeds of response over time. For example, ecological systems after a hurricane have components such a greening that respond quickly and others that take decades to return to initial conditions, such as some animal populations in a forest. The same is true in a city, where the recovery of water service is much faster than the recovery of lost economic activity. However, I found evidence that falsified the original hypothesis and relate the explanation to the condition of slow variables after the stress event. Slow variables are those variables that turn over slowly and provide resilience to systems. After María, some key slow variables of forests were intact, while key ones in the social system were depleted, causing the ecological system to respond with greater resilience than the social system.

**Max Moritz**  
University of California Santa Barbara

### **When does fire, a natural ecological disturbance, become "stressful"?**

Much of the research on fire-prone adaptive responses, of either individual species or complex ecosystems, has focused on fire as an episodic natural disturbance. Characterizing the long-term historical range of variation in such disturbances is typically done by quantifying the fire regime of an ecosystem, namely the statistical distribution of fire sizes, intensities, frequencies, and seasonalities; the spatial patterns of these characteristics is also important. This is very different from chronic and suboptimal stress conditions, which can lead to reduced productivity or functioning by some criteria. Tipping points and threshold transitions may therefore be qualitatively different, depending on whether a natural disturbance regime is being disrupted or a chronic stress has become too severe. It is also likely that particular interactions between disturbances and stresses (i.e., their timing and/or sequencing) will lead to more pronounced and permanent consequences than others. I will attempt to illustrate these differences through examples that include fire, drought, and land use change.

### ***in Transition: Livelihoods in Transition***

Agriculture, forestry, mining, and fishing for internationally traded commodities collectively comprise a majority of the Earth's land and marine use and are primary contributors to global climate change, biodiversity loss, and water pollution. The value chains for these resources generate billions in revenue to the firms involved in their extraction,

processing, and export, yet, a majority of the people who live in areas affected by commodity expansion remain impoverished, often depending on precarious or illicit activities for their livelihoods. Income, education, and health levels in rural and remote areas often remain well below those of urban areas, even as national economies grow from the value of exports derived from rural regions. For major development and conservation initiatives to deliver anticipated benefits to rural and remote regions it is necessary to better understand the enabling conditions that can help catalyze pathways to improved well-being for all inhabitants of these land- and seascapes, not just large-scale producers and traders of export commodities. By bringing together experts with a wide range of geographical and topical expertise, this session will explore how climate change, international institutions, domestic policies, and shifts in cultural norms are influencing land and marine use practices and human wellbeing.

**Rachael Garrett**  
**Boston University**

### **Market-based conservation initiatives, deforestation, and rural livelihoods**

The production of food commodities is one of the largest drivers of forest loss and degradation in the tropics. As understanding of the diverse negative outcomes of deforestation for these “forest-risk” commodities has increased, companies have adopted a wide range of conservation policies, including both incentive-based sustainability standards (e.g. conservation certifications) and market-exclusion mechanisms (e.g. deforestation bans and moratoria). There is emerging evidence that these sustainability standards have had only limited effectiveness in conserving forests in the regions where they are implemented due to selection bias and leakage of deforestation activities. What remains less clear is how differential uptake of (or exposure to) market-based conservation initiatives influences rural livelihoods. Here we review the existing conceptual and empirical research base to highlight two potential pathways by which market-based conservation initiatives either transform or entrench existing land use practices and livelihood outcomes. In the transformative pathway, market-based conservation initiatives can help farmers “upgrade” their land use and livelihoods to achieve improved production practices, greater organizational capacity, enhanced social status, and higher incomes. In the alternative pathway, voluntary conservation policies remain out of reach of smallholders, while mandatory policies (such as market exclusion mechanisms) create an additional financial and managerial burden that renders compliance unattainable. Both of these situations can push small and remote farming households into even more environmental degrading, lower income, and potentially even illegal activities, resulting in even greater rural inequality.

**Ed Carr**  
**Clark University**

### **From sustainable to resilient livelihoods**

Since the introduction of the Sustainable Livelihoods Approach (SLA) in the early 1990s understandings of livelihoods and their attendant socio-ecologies have evolved greatly. The current rise of resilience in development and adaptation communities, however, comes with a significant risk of rolling back two decades of innovation in livelihoods studies. I argue that these communities’ uptake of resilience from the natural systems literature has created a problematic framing of resilience as an emergent property of a socio-ecological system. Such a framing elides the power relations and social processes at play in these systems and obscures two decades of theoretical and empirical work demonstrating the importance of these variables to social and environmental outcomes. Reframing resilience as a project of rule integrating and governing both social and environmental outcomes creates a richer understanding of the livelihoods decisions and outcomes we see in an era of change and transformation.

**Mimi Lam**  
**University of Bergen**

### **Explicating values to resolve conflicts in fisheries and socio-environmental policy**

Often missing in fisheries and socio-environmental policy is the explication of values to resolve trade-offs and conflicts that emerge when stakeholders have competing interests. In such resource conflicts, it is important to extend the peer community beyond scientists and policy-makers to involve in the decision-making process local experiential and indigenous knowledge holders, marginalized stakeholders, and the public. We analyzed the Pacific herring fishery conflict in western Canada using post-normal science, where facts are uncertain, values are in dispute, stakes are high, and decisions are urgent. The scientific basis for management of this fishery is uncertain, as complex ecosystem interactions link herring to its predators and prey. Local and indigenous communities are in dispute with the industry over the government's policy decisions of how to balance the economic, ecological, and cultural values of herring. Stakes are high, as Pacific herring is a pelagic forage fish species that supports commercial fisheries, coastal indigenous and local communities, and marine ecosystems. Meanwhile, harvest quotas are set annually, which makes decisions urgent and often contested among stakeholders. To foster collaborative solutions, we developed an innovative, participatory value- and ecosystem-based management approach that combines practical ethics, ecological modelling, art, and video. Interviews with local indigenous community and herring industry members identified how alternative fishery management scenarios reflected their values, while ecosystem modelling estimated the scenarios' fishery impacts and sustainability. By explicating values and promoting inclusive, transparent, and accountable governance, our approach facilitates conflict resolution and science-policy decision-making designed to create more sustainable and ethical socio-environmental systems.

**Jason Roberts**  
University of Texas at San Antonio

**'We Live Like This': Local Inequalities and Disproportionate Risk in the Context of Extractive Development and Climate Change on New Hanover Island, Papua New Guinea.**

This study examines the local processes, effects, and responses to large-scale logging and agricultural development efforts in subsistence communities on New Hanover island, Papua New Guinea (PNG). Recently, New Hanover became the site of three special agricultural and business leases (SABLs) that combined to cover 79% of the island. The proliferation of SABLs within PNG is an outcome of national development initiatives promoting a significant increase in the production of commercial agricultural crops such as oil palm. Accordingly, SABLs are designed to develop sustainable agricultural industries across the country through the conversion of forested lands and the simplification of communal land tenure, for the purposes of private lease. However, SABLs have simultaneously provided a convenient loophole around more restrictive national forestry policies and thereby become attractive to traditional logging interests in the Asian/Pacific region. Consequently, many SABLs across PNG have failed to produce viable agricultural development or broad local benefit. It is within this context that this study combines interests in political ecology and coupled human-ecological systems to inform our understanding of the relationships between extractive development, forest sustainability, and horticulturalist resilience. This study adds to interests in neoliberal frontiers of land and resource control by examining these SABL landscapes on New Hanover as contemporary examples of land grabs and documenting the real local level consequences of this phenomenon. The study is also particularly significant in light of the growing threats to forests and forest-dependent livelihoods and the recognition of the importance of local forest practices to global sustainability.

**Ximena Rueda**  
Universidad de los Andes

**Globalization of agricultural trade and rural livelihoods**

High demand for agricultural commodities has been one of the main drivers of land use change in tropical regions. Understanding the impacts of globalization on rural livelihoods requires not only an understanding of the structural processes at work (i.e., globalization of value chains, government policies, environmental governance mechanism) but also a comprehension of the micro-processes that occur at the local level that configure the way in which rural households respond to trade liberalization. In this presentation I attempt to show how global forces are shaping land uses across tropical regions, and how local land-users, particularly smallholders, have been able to respond to those forces, building upon their assets and creating new ones to engage in global trade. Using global value chain analysis

and detailed household surveys, our studies are able to connect global forces with local processes, unravelling the mechanisms through which upgrading occurs, and what socio-economic and environmental benefits can be derived from smallholders' participation in global value chains.

***by Design: Complex Sciences applied: Understanding S-E complexities and designing outcomes with models***

**Alex Godoy-Faundez**

A big challenge is to understand the complexities of socio-environmental systems, as well as its structure, components, and their connections between sub-systems. To understand those systems, Complexity Science, by using new theories that let us look at age-old problems with a fresh perspective by the use of powerful computation and large datasets. Today, we have different modeling approaches that have been applied to the study socio-environmental systems such as statistical, system dynamics, equilibrium, and agent-based modeling. However, as the first step, all researcher needs to apply systems thinking to modeling as a way of approaching to understand how various elements of a system influence one another. As a systems thinker you will ask about relationships to other activities within the system, look for patterns over time, and seek root causes. If we can understand the systems, we can leverage resources to drive the dynamic toward a desired outcome. This panel will bring together scholars whose work considers how we can modeling socio-environmental futures based on system thinking for uncertain conditions, and leverage resources to achieve the desired outcome.

**Tatiana Filatova**  
**University of Twente**

**Complexities in the Anthropocene era models: getting a human actor on board.**

The integrated understanding of social-environmental systems (SES) dynamics in the Anthropocene is challenged by a major mismatch of scales between human actions and global environmental responses or forcing. Currently, many formal models that analyze SES dynamics take a major aggregation step to represent dynamics of socio-economic actors as generic social drivers at the scale that fits natural system processes. Alternatively, the natural processes and feedbacks of environmental systems are reduced to serve as boundary conditions or as a resource base for social systems. Yet, by encompassing the Anthropocene perspective and the understanding that coupled SES may undergo regime shifts, requires a detailed modelling of natural and social processes and feedbacks between systems at their native scales. After providing a brief critical assessment on the ability of various modeling approaches to represent non-linear dynamics of coupled systems, I discuss alternatives for capturing human dimensions in SES. The talk further focuses on the recent progress and limitations of agent-based models applied to study coupled SES. I also deliberate on the options for matching models operating at different scales. In conclusion, I would like to open a discussion on the perspectives of a multi-scale integrated models for understanding the origin and consequences of non-linear dynamics of coupled SES

**Tu Nguyen**  
**Oregon State University**

Interest in habitat restoration has climbed significantly in both science and policy. Much wildlife habitat has been lost due to human activity and requires active management to recover. Despite billions of dollars of investment in habitat restoration, limited success has been achieved. One reason for this disparity is that the current framework used for conservation models habitat as a single static variable, leading to suboptimal conservation policies. In reality, however, habitat is made up of complex processes and interactions. I design an integrated model that takes into account dynamics of habitat characteristics and their interactions, using knowledge from economics and restoration ecology. The model lets the resource manager manage these characteristics to yield long-term recovery of a wildlife population. An application of the framework to the Greater sage grouse, for example, shows that it is most effective to vary investment rates in different habitat characteristics, as well as in the same characteristic over time. My research advances the field by providing a framework to guide conservation management and by exploring

how to balance conservation and economic interests. The main challenge my research faces is the common assumption that resource managers possess perfect information of the ecological system when making decisions. Such information is not always available. This research presents an opportunity for collaboration among economists, ecologists, and population biologists to identify the dynamic forces composing a habitat and to design management actions to restore that habitat so that resources are ensured to be channeled effectively.

**Gary Polhill**  
**James Hutton Institute**

### **Might there be different kinds of complexity in social-ecological systems?**

Complexity is often discussed as though it is a single phenomenon, when it often used essentially to describe phenomena that cannot adequately be modelled using traditional methods. There may be several ways in which such phenomena can occur, and indeed several classes thereof. The context of social-ecological systems brings this in to sharp focus as there can be complexity arising from interactions of heterogeneous entities within and across the social and ecological subsystems, and from the macro (landscape / government) to the micro (patch / land owner). This talk will report on an analysis of multiple runs of a coupled agent-based and species metacommunity model of biodiversity incentivization, with a view to identifying whether different patterns of complex dynamics are associated with the presence or absence of feedback loops in the model.

**Alexey Voinov**  
**University of Technology Sydney**

### **How wicked are wicked problems and how do we model them**

The concept of 'wicked problems' has emerged more than 50 years ago, and has been later on explored in numerous publications and applications, and produced further theories such as the post-normal science. All the policy and planning problems in pluralistic societies have been identified as wicked, which means that they cannot be properly defined, cannot have any single solution, moreover, they cannot have any correct or false solutions at all. Systems modeling, especially participatory modeling have been proposed as useful tools to use when dealing with wicked problems. Attempts to address the 'wickedness' also gave rise to justifying further increases in complexity of models to be built. While being a stimulating philosophical concept, the idea that certain problems simply cannot have solutions creates forms of escapism that may justify inaction. In reality most of wickedness is a product of wrongly identified system boundaries and lack of understanding of hierarchies involved. We find that in much too many cases we tend to ignore the elephant in the room, trying not to look at the system at other scales, where the solution is quite obvious, but is contrary to the preferences and values of some stakeholders. We make problems wicked when we assume that only win-win solutions are acceptable, or when we try to make only popular decisions.

## **Posters**

### ***Socio-Environmental Systems under Stress***

**Ginger Allington**  
**George Washington University**

Temperate grasslands, including those of northern Eurasia, are among the most imperiled ecosystems on Earth. Eighty percent of Mongolia's land area is rangeland, where interacting climate, land-use and changes in governance threaten the sustainability of the social-ecological system. Particularly concerning are the potential ecological impacts of changing pastoral grazing practices—namely declining use of grazing reserves and pastoral mobility. However, like other grazing practices globally, there have been no empirical studies to evaluate the effects of specific Mongolian grazing practices on ecological function at a management scale. We collected data on the grazing practices of 130 pastoral households across 4 ecological zones and sampled ecological conditions in their winter pastures. We used a novel social-ecological analysis process to 1) develop integrated, holistic indicators of

ecological function using exploratory and confirmatory factor analysis, and 2) assess the effects of individual grazing practices on these indicators using statistical matching to control for confounding management and contextual factors. We identified two latent factors related to ecological and pastoral resilience: Factor 1 represents resource retention and soil stability and Factor 2 represents species richness and functional diversity. Using these two factors as response variables, we found that the values of both resilience factors were higher in pastures where households made fall or winter otor migrations or set aside grazing reserves. This study provides the first management-sc ale empirical test of the ecological response to specific grazing practices. Our findings highlight ecological and pastoral resilience are conferred by traditional pastoral practices of mobility and grazing reserves.

**Noelle Beckman**  
**Utah State University**

Global change affects the ecology and evolution of dispersal, limiting the ability of species to move or adapt to global change events. Due to the long-term and spatially-complex dynamics of plant populations, understanding and predicting their responses to global change is empirically and mathematically challenging. I apply recent advances in the study of species' movement to assess the risk of plant extinction in response to climate change in continuous landscapes. Using a Bayesian approach, I synthesize existing data on dispersal, functional traits, and demography to generate virtual species with realistic dispersal kernels and life-history strategies. I sample these virtual species to parameterize integrodifference equations and approximate population spread in continuous landscapes. Using this approach, I obtain predictors of risk that are related to easily measurable functional traits that can inform the types of species least likely to track a shifting climate. This research will help identify species at greatest risk and aid the development of conservation strategies to ensure their persistence under global change.

**Krissy Hopkins**  
**U.S. Geological Survey**

Retention of sediments and nutrients in floodplain areas provides critical ecosystem services to downstream communities. Lidar mapping, field data collection, and modeling were integrated to quantify the ecosystem service of sediment and nutrient retention that floodplains provide in the Delaware River watershed. The mapping component of this project resulted in the development of the Floodplain and Channel Evaluation Toolkit (FACET) to identify features and calculate key metrics describing channel and floodplain geometry from high-resolution bare-earth elevation data in the Delaware River watershed. Field data collection employed dendrogeomorphic techniques to estimate rates of stream bank erosion and floodplain sediment deposition at fifteen sites in the watershed. These two datasets were combined to develop predictive models estimating sediment trapping and export for each stream reach within the non-tidal portion of Delaware River watershed. This assessment of floodplain net sediment flux and associated ecosystem services will help identify areas for targeted management to maintain areas with high ecosystem service values, and to restore areas that could provide the most ecosystem service benefits.

**Zhao Ma**  
**Purdue University**

Water availability stress will expand with climate change in arid and semi-arid agricultural settings. Farmer adaptation studies have relied on empirical observations, which are time-consuming and not possible in every situation, or model simulations, which often rely on agent-based models (ABM) and tend to use rational actor or decision pathway modeling approaches. While both approaches lead to valuable insights, neither has demonstrated great potential to produce theoretically and empirically grounded, generalizable models. We investigate the functionality of theory-driven, empirically-supported ABMs as a tool for examining agricultural adaptation in the context of the Eastern Snake Plain Aquifer Comprehensive Aquifer Management Plan (CAMP) in Idaho. Instituted in 2015, CAMP required an average 13% groundwater use reduction across eight groundwater districts. This policy change serves as an introduced water availability stress. To adapt, groundwater districts and farmer irrigators have to change their water and farm management practices. We built three farmer adaptation ABMs driven by three decision-making theories respectively: bounded rationality, theory of planned behavior, and integrative agent-centered framework. We parameterized the models with secondary data and developed decision-making algorithms guided by these theories and groundwater manager and farmer interviews. Next we compare our model outcomes to

farmer adaptation survey data. Preliminary analysis suggests that our approach holds promise as a tool for rapid appraisal of adaptive capacity, adaptation options, and the associated adaptation outcomes over time in water-stressed agricultural systems. Our approach can also serve as a first step to guide empirical data collection to test hypotheses arising from decision-making theory.

**Jeremy Ross**  
**University of Oklahoma**

Extreme weather hazards can inflict damages across socio-ecological systems. Such effects have often been studied in terms of direct human health and economic impacts, and less-so in terms of response and resilience of organisms and their habitats. This oversight has been especially prevalent among airborne life forms, which is likely driven by limitations in observation. Recent advances in tracking devices and radar technology have allowed researchers to overcome this limitation and systematically document the impact of extreme weather on birds and other organisms that populate the aerosphere. This growth in "radar aeroecology", along with advancements in social science theory, research methods, data collection, and analysis, are allowing us to now examine the direct effects of extreme weather on birds while simultaneously gauging public perceptions and concerns regarding these ecological impacts. We present a novel approach to addressing this previously unstudied part of the socio-ecological system using a combination of georeferenced panel surveys of randomly-selected residents known as the Oklahoma Meso-Scale Integrated Sociogeographic Network (M-SISNet), analysis of national radar network (NEXRAD) severe weather indicators, and a reanalysis of existing and under-reported datasets that measure avian impacts during extreme weather events. We discuss this approach in terms of its implications for gaining public support toward bolstering the resilience and recovery of birds in the face of changing severe weather regimes.

**Kristen Steele**  
**University College London**

#### **Eel fishing and the Brexit blues**

The European eel is listed as "Critically Endangered", yet is still commercially fished in the United Kingdom, creating tension between conservation goals and economic incentives. Over centuries, this socio-environmental system has adapted to gradual changes in regulations, habitats, eel abundance, cultural food preferences and available markets. With the upcoming departure of the UK from the European Union ("Brexit"), eel fisheries face an uncertain future, ranging from abrupt closure to massive expansion of trade. This study aimed to assess the response of key actors in the system to this political stress and the potential consequences of Brexit for eel conservation and fishery management. Participant observation, interviews and surveys were conducted throughout the UK in 2016 and 2017 with fishers, buyers, retailers and regulators. Positive or negative perception of Brexit was found to be related to the position of actor within the fishery. For example, juvenile eel fishers in England displayed more optimism about the regulatory outcomes of Brexit than adult eel fishers in Northern Ireland. The fishery was also found to be making irreplaceable contributions to eel conservation, such as providing supply and infrastructure for restocking in depleted areas. National political upheaval and lack of communication within the fishery has led to widespread confusion about possible ways forward and panic in some instances. Successful co-management, involving fisher participation, was observed in several areas. If sufficiently institutionalized, these cooperative arrangements could influence Brexit-related regulations and increase resilience of the fishery to future political

**Thomas Timberlake**  
**Colorado State University**

Forested ecosystems throughout the United States are experiencing stress due to climate change and wildland fire. In response to these challenges, resilience represents a promising paradigm given its emphasis on flexible approaches to management and responding to disturbances. However, implementing resilience may conflict with existing policies. Furthermore, criticisms of the concept of resilience highlight its ambiguous meaning and lack of adequate treatment of social dimensions. The incorporation of resilience into the U.S. Forest Service's land management policies offers an opportunity to empirically examine how land managers operationalize resilience in specific social-ecological contexts. This poster highlights findings from case study research, including qualitative interviews, on the

recent forest plan revision for the Kaibab National Forest in northern Arizona. In this context, implementing resilience aligns with the restoration of fire-adapted ecosystems. As Forest Service staff and key partners noted, the Kaibab has successfully navigated a complex institutional setting to produce a plan with requisite flexibility to achieve these objectives. This success benefits from partnerships that offer capacity and legitimacy in support of innovation. Our research provides evidence of field-level managers creatively working with their institutions to pursue forward-thinking approaches. However, “antiquated rules,” coupled with the constant need to meet deadlines, reined in progressive planning activities. From a theoretical perspective, this case study sheds light on the value of substantive empirical treatment of the interactions between actors and institutions in making sense of ambiguous goals, like resilience, in contexts defined by the uncertainty that climate change brings.

### ***Socio-Environmental Systems in Transition***

**Stephen Balogh**  
US EPA

Urban populations continue to increase globally and cities have become the dominant human habitat. However, the growth of cities is not universal. One in six cities globally is losing population. Shrinking cities share common attributes such as decreased household income, reduced property values, and decreased tax revenue. Increasingly sparse population creates inefficiencies and higher costs for infrastructure maintenance and the provision of public amenities. Population losses and economic distress are not equal in all neighborhoods; rather, they are distributed heterogeneously across the landscape. Broader statements about the trajectory of a shrinking city may mask underlying differences in economic, cultural, and environmental impacts as well as the ability of some neighborhoods to be resilient and adaptive to social and environmental disturbances. For example, nutrient loading to waterbodies may vary based on population change and access to sewers. Abandoned homes can lead to changes in green cover due to a lack of landscaping, which can impact water demand and/or the delivery of ecosystem services like flood prevention. Projects to remediate contaminated sites or restore natural areas may be delayed or cancelled. This paper examines the impact of population loss at the city, watershed and neighborhood level in San Juan, Puerto Rico prior to Hurricane Maria. Specifically, I investigate effects on the provision of ecosystem services, material and energy flows, and ecological impacts from 2000 to 2014, using public data and data collected previously in two household surveys, and discuss the potential implications for post-hurricane Maria recovery.

**Neil Carter**  
Boise State University

### **Multi-model approach to understanding human-wildlife systems.**

Inadequately addressing feedbacks in social-ecological systems (SES) can limit the effectiveness of conservation policies. Mechanistic SES modeling has a high potential to overcome this limitation. To illustrate the utility of mechanistic SES modeling to wildlife conservation, I present findings from two interrelated agent-based models of human-wildlife interactions. The first model investigates the effects of human disturbance on the globally-endangered tiger (*Panthera tigris*) in Nepal’s Chitwan National Park. The second model investigates human-wildlife conflict, such as crop raiding and livestock depredation, along a simulated interface of wild and agricultural lands. Unanticipated model outcomes provide crucial insights on ways to improve conservation strategies in shared landscapes. By simulating both ecological processes and human decision making, multi-model approaches foster transferability of gained insights to other contexts and case studies that prevail in the Anthropocene.

**Abril Cid**  
National Autonomous University of Mexico

Coastal socio-environmental systems vulnerability is increasing worldwide and has been exacerbated by the growing population and the intensification of economic activities. Due to the expected greater damage from climate change hazards, the interest in risk reduction, informed development, resilience and adaptation of coastal systems has become a priority across the world. In this context, coastal managers face the challenge of foster sustainable development and, simultaneously, reduce climate change vulnerability. In developing countries, such as Mexico,

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this challenge increases under conditions of a generalized lack of data, rather limited technical capacities in the responsible agencies, and scarce resources for adaptation. To tackle these challenges, there is an urgent need to develop practical approaches and tools capable of quantifying vulnerability to climate change. These approaches and tools should entail transparent and replicable processes, so that it conveys useful information for policy-making on how vulnerable coastal systems are to specific stressors and provide the means to identify priority areas to allocate scarce resources for adaptation. Here, we present a procedure to analyze coastal vulnerability tailor-made to operate under conditions of limited resources, lack of data, and technical capacities. We illustrate our procedure with a case study in the North Pacific coast of the Baja California Peninsula, Mexico. The outcomes of this study were a spatially explicit vulnerability index and six vulnerability groups. The design of this study focused on providing technical elements to coastal managers and the results were used to generate regulatory criteria in the Marine Spatial Planning of the California Current.

**Davide Danilo Chiarelli**  
**Politecnico di Milano**

### **Rubber impacts on water and food security**

Fresh water resources are experiencing high pressure due to human activities and climate change, influencing the water cycle as well as fresh water availability. A key role in modifying natural water fluxes is played by land use change and by the intensification of irrigated agriculture. In South East Asia rubber plantations, requiring up to three folds the water needed by staple food crops, are experiencing a rapid increase. They often replace other crops or forest ecosystems altering hydrological response and fresh water resource availability. We used a spatially distributed soil water balance model to assess effects of land use change due to rubber plantations on local water availability and river discharge. We investigate the extent to which the ongoing increase in rubber production is competing with food systems and affecting the livelihoods of rural communities living in the production areas. Our results show rubber plantations have strong impacts on the hydrological response. We quantified a potential decrease up to 70% of river mean annual discharge in small basins highly exploited and in up to 50% increase of monthly water scarcity in dry period. Thus, natural rubber plantations are increasing the competition for water resources appropriation between food and industry sectors and threatening the local water and food security.

**Bradford Dubik**  
**Duke University Marine Lab**

Fisheries are a socio-environmental system characterized by highly mobile resources and resource users. Climate driven ecological change is causing locational shift in a wide variety of commercially important fisheries, highlighting the important role the mobile nature of these systems plays in determining effective governance. While shifts in the location of fish stocks have been documented in many systems, the degree to which fishing activity patterns have changed is less understood, limiting consideration of linkages between ecological and social change in these systems. In this lightning talk, we explore these challenges through examination of locational shifts in fishing activity aggregated across a range of scales on the US East Coast, including the human community, fish species, and governance units. Across these scales fishers have dramatically shifted in the average catch location for a variety of important commercial species. We characterize these locational shifts through a mixed-methods approach combining spatial ecology and qualitative interviews, to describe how these locational shifts shape, and are shaped by, the governance systems in which they are embedded.

We hope to present these results to initiate further discussion of how different types of mobility (e.g. resource, harvester, policy, access rights) influence each other to generate outcomes in the case we have presented, as well as to explore similar cases or systems with others at the symposium.

**Kimberly Fornace**  
**London School of Hygiene and Tropical Medicine**

Deforestation and associated land use changes alter human-environment interactions, influencing exposure to infectious disease vectors and wildlife reservoirs. Within Northern Malaysian Borneo, an area undergoing rapid

environmental change, the emergence of the zoonotic malaria *Plasmodium knowlesi* is hypothesised to be due to increased spatial overlap between people, mosquito vectors and primate hosts at the forest edges. However, although movements into macaque and mosquito habitats determine disease risks, little is known about individual mobility patterns relative to different land cover types and how these may be affected by future development. To explore the role of local movements in *P. knowlesi* transmission, we used GPS tracking devices to map movement patterns in endemic areas. A total of 243 individuals were included in this study, with over 3.4 million GPS points collected. Applying methods from animal ecology, we characterise individual utilisation distributions and develop hierarchical Bayesian models of human resource use. During the same period, longitudinal mosquito sampling was also conducted during representative habitat types and used to parameterise Bayesian spatiotemporal models of biting rates of the main vector. Using methods from environmental epidemiology, we calculate relative exposure risks as a derived quantity from human resource and mosquito models and identify characteristics of individuals and land use types associated with increased probability of exposure. Results illustrate how quantifying human behaviour relative to environment is critical for informing disease control and identifying the people and places with highest risks. Preparing for future disease risks requires understanding how human space use adapts to changing environments.

**Luisa Galindo**  
**University of Massachusetts**

The effect of uncertain future scenarios on local communities' decisions about the protection of ecosystem services in the Orinoco River Watershed

Ongoing development plans impact the provision of ecosystem services and augment the local competition for resources. Consequently, tensions among local communities grow and governing institutions struggle to maintain sustainable social-ecological dynamics. Uncertainties about the future availability of ecosystem services is an important driver in this process, therefore, investigating the effects that these uncertainties have on local perceptions about management priorities will be important for effective governance. Levels of future uncertainty were estimated for four towns in the Colombian portion of the Orinoco River Watershed using spatial analysis. Differences in opinions between Indigenous peoples and non-Indigenous communities were assessed through semi-structured surveys and interviews. The results indicate that uncertainty has an effect on what resources are prioritized for sustaining future socio-ecological dynamics. Furthermore, larger disagreements in opinions were found between Indigenous peoples and non-Indigenous communities in those towns where uncertainty was higher. Accounting for the effects of uncertainty on local decisions will be important for maintaining future governing mechanisms at local scales, also, decision makers will be able to create better mechanisms for closing the gaps between local groups.

**Rebecca Ingram**  
**NOAA Pacific Islands Regional Science Center**

The Hawaiian Islands are home to a complex and dynamic marine ecosystem that serves as a backbone to the state's economy and society's well-being. The marine ecosystem currently faces numerous threats that undermine ecosystem integrity and compromise valuable ecosystem services. The complexity of the region invokes immediate need for Ecosystem Based Management (EBM). The National Oceanic and Atmospheric Administration's West Hawaii Integrated Ecosystem Assessment (IEA) program is grounded in EBM and recognizes the importance of understanding human-environment interactions. We began initial IEA stages with participatory methods to gather expert and place-based knowledge from resource managers, scientists, and community members. Using information collected, we developed Conceptual Ecosystem Models that identify and quantify the strength of social-ecological interactions. The models illustrated the complexity of system dynamics, highlighting connectivity between pressures and the ecosystem, with direct implications for ecosystem services. Importantly, many identified pressures occur at local scales, presenting an opportunity for local management to directly affect ecosystem status. This study also highlighted both the importance and lack of understanding of the links between ecosystem services and human well-being, particularly services that enhance and maintain cultural connections to a place. Without an understanding of these links, it is almost certain that crucial ecosystem services will be left out of management strategies, as has been witnessed in numerous regions globally. I will present how we are working to better incorporate human dimensions into the IEA, focusing on understanding how culture is affected by changes in the marine environment and the implications of these changes.

**Hogeun Park**  
**Michigan State University**

## Deciphering the complexity of urbanization in transitional economy

In response to dramatic changes in the human and natural environments, Mongolia has experienced dramatic urbanization. While various researchers have discussed the drivers of urbanization, the household-level analysis remains limited. Since urbanization relies on diverse stakeholders' aggregated behaviors corresponding to multiple changes and events, a more nuanced understanding of household-level decision-making processes is vital for quantitatively examining why and how rural-to-urban migration occurs. This paper attempted to answer: (1) what quantitative contributions have socioeconomic change and climate variability made to recent rural-to-urban migration?, and (2) how different households' characteristics affect on their migration decisions? A combination of RS, household surveys, and statistical modeling was conducted to analyze multi-spatiotemporal scales. By using household surveys ( $n=239$ ) and RS product, the SEMs measured the contributions of socioeconomic changes and climate variabilities to the rural-to-urban migration. Household surveys' results quantified the importance of the social, economic, environmental, and political reasons behind rural-to-urban migration—by Likert scale from Not at all influential (1) to Extremely influential (5)—with mean (std) scores of 3.51(1.21), 3.42(1.21), 2.89(1.31), and 1.23(0.75), respectively. These results indicate that the socioeconomic factor is relatively more important than environmental and political factors. While the political reasons are less weighted on the survey, the SEM reveals its importance (as a mediator) among underlying driving forces of rural-to-urban migration. Thus, the finding may conclude that political reasons, e.g., land-use policy and legal ownership, can be considered a major tool in regulating/controlling the rural-to-urban migration, despite their not being viewed as a primary factor in the household surveys.

**Jennifer Selgrath**  
**Stanford University**

The location and intensity of small-scale fishing is dynamic over time, greatly shaping ecosystems. However, historical information about fishing effort and fishing gear-use, and the influence of governance on those changes, are often unavailable. Within a marine biodiversity hotspot in the Philippines, we characterized spatio-temporal dynamics of fishing (1960–2010) using fisher interviews with participatory mapping. First we considered fishing gear use and found that fishers greatly diversified their use of fishing gears. Moreover, fishing intensified through escalating use of non-selective, active, and destructive fishing gears. Over the same period, we found that policies promoting higher production over sustainability influenced the use of fishing gears, with changes in gear use persisting decades after those same policies were stopped. Next we considered changes in fishing effort and fishing spatial dynamics. Individual fishing effort (days per year) was fairly steady over the study period, but total effort greatly increased. Our non-spatial estimate indicated that fishing increased 2.5 fold, reaching 1.3 million fishing days per year in 2010. Yet, spatial estimates showed fishing effort increased  $>20$  fold, with the highest effort in 1990. By 2000, fishing extent grew 50% and small-scale fisheries affected over 90% of the coastal ocean. The expanded fishing area coincided with a greater spatial overlap among fishing gears. The expansion and intensification of fishing shown here emphasize the need for spatial approaches to management that focus on intensive, and often illegal, fishing gears. Such approaches are critical in targeting conservation actions (e.g. gear restrictions) in the most vulnerable areas.

***Socio-Environmental Systems by Design*****Zachary Brown**  
**North Carolina State University**

Gene drives are a set of technologies for the intentional spread of a target genetic trait throughout a population of sexually-reproducing organisms. Researchers are currently developing gene drives for controlling insect pests and disease vectors, including prominent agricultural pests. We analyze the first statistically representative survey of U.S. attitudes on gene drives to control insect crop pests, and find a majority of adults support some type of gene

drive application. Yet over 70% want to know more about the risks, and support depends heavily on scientists' ability to control drive spread and perceived health and ecological impacts. Consumers of organically certified food are apprehensive about certification in the presence of modified insect material. We also analyze results from an economic stated-choice experiment, eliciting consumers' willingness to pay for food produced using gene drives.

**Nate Jones**  
SESYNC

Depressional wetlands provide many ecosystem services, ranging from critical habitat provisioning to water quality improvements and regulation of streamflow. In wetland-rich landscapes like the Prairie Pothole Region and southeastern Coastal Plain, wetlands are thought to act as hydrologic capacitors, mitigating both low and high stream flows. However, because of the pervasiveness of wetland loss across many landscapes, this function has largely been lost. Using a combination of empirical hydrologic data, geospatial analysis, and process-based modeling, we examine the potential effect of wetland restoration on water resources across the Delmarva Peninsula. Specifically, we explore the spatial distribution of potential wetland restoration sites, associated effects on both downstream hydrology and recharge to groundwater resources, and management options available to public drainage associations, highlighting the potential to optimize water resources for agriculture and wetland ecosystem services.

**Yasuhisa Kondo**  
Research Institute for Humanity and Nature

This poster introduces a new three-year meta-research project based at the Japan's Research Institute of Humanity and Nature (RIHN), and calls for international collaborators. The ultimate goal of this project is to develop a methodology of open team science as a new research paradigm for socio-environmental cases, by integrating open science and transdisciplinary team science theories.

Social issues caused by environmental degradations are usually so complex that solution-oriented research is always team-based and involves research experts from different domains and practitioners such as government functionaries, funders, industries, non-profit organizations, and civil members. Such team science is often disrupted by information asymmetry among participants with differing knowledge, values, and socioeconomic status. In our working hypothesis, information asymmetry can be reduced through a combination of (1) framework-shifting to transform the source of existing conflicts or obstacles among actors by exploring a common goal to tackle together; (2) participation and empowerment of marginalized (or "small voice") actors; (3) fair data visualization; and (4) dialogue. These approaches are usually applied in combination, such as in civic tech, a participatory co-production of solutions for local issues by self-motivated civic engineers using information and communication technologies and open data.

This working hypothesis is tested on specific socio-environmental cases in collaboration with RIHN's allied projects, including community-based waterweed recycling in the Lake Biwa catchment area, Japan. The effect of information asymmetry reduction is assessed through participatory observation, semi-structured interviews, and periodic questionnaire surveys, with special attention to participants' perceptual transformation as well as the project's performance.

**Subhashni Raj**  
University at Buffalo

Land-use planning decisions affect availability of and access to water and food in cities and their surrounding regions. Although food systems and water management discourse concerns have gained prominence in planning scholarship, the links among food, water, and land-use planning in a changing climate remain understudied. I use mixed methods to understand how local governments are integrating food and water considerations into land-use decisions in the context of drought. First, I examine data from a national survey of planners to understand how local governments in drought and non-drought US states are using planning tools to address water- and food-system issues. Next, I evaluate local government plans in one drought-affected area, Doña Ana County, New Mexico. The

national trends indicate that while some differences exist among local governments in drought and non-drought states, most local governments across the country are doing little to protect water resources or to help farmers adapt to climate change. The results also indicate that local governments tend to address water resources more than food-system considerations. In addition, the plan-evaluation results show that integration of water- and food-system considerations in land-use plans remains uneven. To develop policies that better reflect the connections across the food-water nexus, I recommend that planners develop stronger relationships with water management and agrarian communities. Connecting water, food, and land use can itself help to improve synergy among local government and water plans. A planning process in which the food-water-land nexus is front and center in all decisions is one avenue to consider.

**Chelsie Romulo/Heidi Huber-Stearns**  
**University of Northern Colorado/University of Oregon**

By 2030, 60% of the world's population will live in cities, intensifying demand for drinking water, increasing pressure on source watersheds, and creating a need to design novel policies for sustainable water management. Investments in Watershed Services (IWS) are one such policy, wherein downstream water users compensate upstream water suppliers for beneficial land use practices. Globally in 2014, IWS represented upwards of \$170 million of investment in over 4.3 million ha of watersheds, providing water to more than 230 million people. However, it is not clear which factors contribute to the establishment and sustainability of IWS, and are therefore critical for design and adaptation of programs. As IWS increase in number, scale, and investments, there is an opportunity to understand which conditions correlate with the development and persistence of IWS. As one of the first SESYNC graduate student pursuits, we conducted a representative global analysis of 416 of the world's largest cities, including 59 (14%) with IWS. Using random forest ensemble learning methods, we evaluated the relative importance of social and ecological factors as predictors of IWS presence. IWS are more likely present in source watersheds with more agricultural land and less protected area than otherwise similar watersheds. Our results suggest potential to expand IWS strategies for drinking water protection and contribute to decisions regarding suitable program locations. With better understanding of conditions enabling IWS programs, practitioners can design more effective programs, select locations where they are more likely to succeed, and encourage favorable conditions in target areas.

**Heather Sander**  
**University of Iowa**

In today's human-dominated world, conservation must occur in anthropogenic landscapes, including urban landscapes. Implementing conservation in such settings raises questions regarding how to manage cities to both conserve species and support human well-being. This study demonstrates an approach for identifying similarities in urban human and bird habitat preferences, thereby identifying landscape attributes that could be managed to support both species conservation and human quality-of-life. I focus on Iowa City, Iowa, USA and develop a hedonic pricing model using spatial regression techniques to identify relationships between environmental attributes and home sale prices and use results to indicate urban homeowner habitat preferences. I develop a second model using geographically-weighted regression to identify spatial variation in these preferences. To identify bird habitat preferences, I construct generalized linear mixed models of bird species abundance using field-collected data and attributes similar to those used in hedonic pricing. I compare identified preferences to assess overlap in urban human and bird habitat characteristics. Wide variation exists in habitat preferences among bird species and spatial variation occurs in human preferences, complicating identification of common attributes that could be managed to support human well-being and bird conservation city-wide. However, within different zones of urbanization, I find similarities among bird and human habitat preferences. Based on these results, I describe a targeted approach for supporting urban bird conservation and human well-being focused on enhancing human and bird habitat in particular zones of urbanization.

**Jess Vogt**  
**DePaul University**

CommuniTree is a new, multi-organization, community urban forestry partnership that engages in tree planting in underserved, post-industrial Northwest Indiana communities. Coordinated by the U.S. Forest Service and modeled after Collective Impact, the partnership involves public (federal, state, and municipal), private, nonprofit, and university partners. CommuniTree organizes grant- and privately-funded urban forestry in communities that would not otherwise be able to plant and care for trees. Urban trees provide benefits including stormwater management, energy conservation, air pollution reduction, human health, and even increased social capital. However, benefits may be under-realized in post-industrial communities where high vacancy rates depress municipal tax bases and thus threaten provision of municipal services such as tree planting. For Northwest Indiana, socio-economic issues are compounded by environmental challenges posed by the unique dune and swale ecosystem along Lake Michigan.

This poster describes the beginning of a long-term applied, transdisciplinary research project to evaluate the socio-environmental outcomes of CommuniTree. The evolution of the structure and operations of CommuniTree is an experiment in an informal cross-sector tree-planting partnership. Results from interviews with CommuniTree stakeholders and from a survey of tree-planting volunteers reveal the motivations for, desired outcomes from, and benefits from involvement of organizations and individuals in CommuniTree.

Partnerships like CommuniTree are relatively rare in urban forestry. CommuniTree is not a formal organization; it has no administrative budget and no permanent staff. Yet tree planting, care, and engagement with communities happens. Studying CommuniTree will help generate a model for decentralized boundary-spanning collaboration across sectors that perpetuates sustainable urban forestry.

**Landon Yoder**  
**Indiana University**

Agricultural nonpoint source pollution remains a pressing challenge worldwide. In contrast, water quality in the Florida Everglades has improved over the past 20 years. While the 1994 Everglades Forever Act required farms draining into the Everglades to change their management practices, surprisingly little is known about how these regulations have facilitated this success story. Complicating the picture is that the regulations rely on a shared phosphorus pollution cap that requires all Everglades Agricultural Area farms to jointly reduce their collective phosphorus loads. This devolves responsibility to farmers to generate sufficient participation and combat free riding. While state oversight has documented that collective reductions in phosphorus loads are 55% lower than before the regulations, we do not know whether this represents the efforts of a few large farms or widespread collective action among most farms.

This research examines whether the law's collective incentives have generated farmer cooperation to restore water quality. It combines state administrative water management data at the farm level and 65 semi-structured interviews with farmers, regulators, and other stakeholders to examine how regulations impact the social-ecological system. We find that two-thirds of farms have improved their phosphorus loads. Interview responses reveal that procedural fairness, reputations and monitoring data, benefit-cost tradeoffs of on-farm conservation practices, and farms' mutual flood risks facilitate information sharing and shift social norms around good management. These findings demonstrate that collective incentives are essential to generating cooperation where environmental problems exist beyond the scale of any one farm's boundaries.