International Colloquium on *Ecosystem Science for the 21st Century: In Celebration of 50 Years of the NREL, November 14-15*
Tuesday, November 14
4:00-6:00 P.M.
Ballroom D, Lory Student Center, Colorado State University

Research Ignite Talk Abstracts

Advancing US GHG Inventory by Incorporating Survey Data using Machine-Learning Techniques
Cody Alsaker, Stephen Ogle and F. Jay Breidt

Crop management data are used in the National Greenhouse Gas Inventory that is compiled annually and reported to the United Nations Framework Convention on Climate Change. Emissions for carbon stock change and N2O emissions for US agricultural soils are estimated using the USDA National Resources Inventory (NRI). NRI provides basic information on land use and cropping histories, but it does not provide much detail on other management practices. In contrast, the Conservation Effects Assessment Project (CEAP) survey collects detailed crop management data that could be used in the GHG Inventory. The survey data were collected from NRI survey locations that are a subset of the NRI every 10 years. Therefore, imputation of the CEAP is needed to represent the management practices across all NRI survey locations both spatially and temporally. Predictive mean matching and artificial neural network methods have been applied to develop imputation model under a multiple imputation framework. Temporal imputation involves adjusting the imputation model using state-level USDA Agricultural Resource Management Survey data. Distributional and predictive accuracy is assessed for the imputed data, providing not only management data needed for the inventory but also rigorous estimates of uncertainty.

Culturing Sustainability - or - How I stopped worrying and learned to love the Anthropocene
Trevor Lee Even

The Anthropocene is increasingly understood by both laypeople and scientists as an era of mounting tragedy, with even the cleverest among us seemingly unable to do more than increase the resolution on the already terrifying image drawn out by global society's inability to constrain its capitalist, consumerist, and ecologically alienated offspring. Our power to affect the biosphere no longer in question, we now find ourselves faced with the horror of realizing that such power is out of control; in the face of such incongruity, our minds largely recoil. As a result, we find ourselves increasingly unable to envision a future that we actually want to live in, leaving many wholly rudderless in an era that demands immediate action, and yearning for gross over-simplification in a world that demands we face up to overwhelming complexity. In this rapid-fire presentation, I will attempt to draw together lessons from anthropological, philosophical, and social movements research that demonstrates why this madness may be precisely what we need: that, indeed, the challenges ahead may in fact be our best chance yet for developing cultural, moral, educational and normative architectures that bring to life a truly sustainable global socio-ecological system. Arguing that contemporary crises - be they of faith, infrastructure, institutions, or global governance - open a new space of dialogue regarding humanity's responsibilities toward the planet, I hope to demonstrate why engaging communities with examinations of global-to-local socio-ecological system dynamics has the potential to help us reinterpret what it means to participate in the Anthropocene.

Biochar soil amendments: A sustainable solution for Colorado agriculture?
Matt Ramlow and M. Francesca Cotrufo

Developing sustainable agricultural systems that optimize crop water and nutrient use efficiency while decreasing greenhouse gas (GHG) impacts is critical in the face of rising populations, growing demands on water resources and adapting to a changing climate. Biochar soil amendments are one technology that may be well suited for Colorado, delivering on multiple fronts. They can provide a market for woody fuels in overstocked forests, while improving water and nutrient retention, sequestering C and reducing GHG emissions on farmlands. In this presentation, we evaluate a beetle-killed pine biochar's ability to deliver on these multiple fronts, evaluating biochar's impacts through both lab incubations and field experiments. In deficits irrigation production systems, biochar soil amendments showed an ability to increase water retention yet failed to significantly decrease crop water stress resulting in minimal yield benefits. Biochar can impact soil mineral N availability with the bulk of studies indicating some N immobilization but potential to decrease NO3- leaching. Incubations indicate biochar has potential to deliver significant GHG benefits, with potential N2O reductions equivalent to its ability to sequester C, but laboratory and field results can differ dramatically in these regards. Biochar soil amendments thus offer opportunities to improve the sustainability of Colorado agricultural systems but required targeted application to maximize their potential benefits depending on the environment where they are applied.

Continuous Outreach and Education: Providing support for the users of the COMET-Tools.
Matthew Stermer, Keith Paustian, Mark Easter, Amy Swan and Kevin Brown

The COMET-tools are web based decision support tools, which are used by NRCS staff, a diverse group of farmers and ranchers, land managers, supply-chain initiatives, University researchers NGOs and others, to provide support for users through weekly webinars, YouTube videos, tutorials and demonstration projects. The COMET-Team also provides a Help-desk, which has provided over 40 hours of support to more than 50 COMET-Farm and COMET-Planner users. The focus of the Ignite Talk focuses on supporting and educating current and new users, and expanding the COMET-Tools.

Community Biomass Stoichiometry – One Cell at a Time
Michael Manzella and Ed Hall

Microbial biomass is composed primarily of carbon, nitrogen, and phosphorus. The ratio of these elements within a microbial community can affect whether that community will mineralize or mobilize environmental pollutants such as nitrogen and phosphorus. Yet, community biomass has historically been assessed at the bulk level, leaving the contribution of individual microbes and groups untested. Thus, it is necessary to measure C:N:P stoichiometry at the single-cell level. Energy-dispersive spectroscopy (EDS) enables this feat. EDS studies enable measurement of single cells to improve our understanding of microbial ecology. Within this project, polystyrene beads, acetyl-CoA, ATP, and ADP were used as standards to generate EDS calibration factors (peak area/fmole) for C, N, and P. Cell biomass stoichiometry was analyzed by both EDS and standard bulk measures to validate the technique. The stoichiometry determined by bulk measures differed slightly, albeit significantly, from those generated by EDS. However, these differences were not substantial enough to affect the conclusions drawn. Following validation, EDS was applied to (1) a microbial growth experiment at two C:P resource ratios, (2) a phylogenetically-diverse set of bacteria at three C:Pr resource ratios, and (3) natural microbial populations sampled from local waters. For each, it was found that the biomass stoichiometry between the bulk and EDS varied

slightly. However, EDS enabled the measurement and visualization of the wide range of microbial stoichiometries masked by bulk measures. Finally, the environmental samples demonstrate the power of EDS to measure microbial populations in situ, avoiding biases inherent in culture-based stoichiometry measures.

Participatory scenarios analyses in mountain social-ecological systems: A critical comparative synthesis review
Jessica Thorn, Claudia Capitani, Roman Seidl, Cara Stegar, Robin Reid, Catherine Tucker, Anne Nolin and Julia Klein

Unprecedented climate, social, economic and political changes predicted to occur in the next 30 years present a major challenge for long-term planning towards enhancing social-ecological resilience. Impacts are particularly pronounced in mountain systems, where features amplify vulnerability, such as topographic complexity, remoteness, high kinetic energy, and exposure to multiple hazards. In the face of uncertainty, participatory scenario planning has been established as a useful tool to envision plausible and desired futures, and thus improve adaptive systems thinking and capacity. Despite the increased application of PSP, many of benefits are assumed, while a critical synthesis is lacking of what pressures may develop in the future, what would be appropriate policy programs or management measures to be implemented to realize desired futures and whether PSP processes and outcomes meet the desired motivations and objectives. This research aims to systematically review the evidence base of participatory scenario planning situated in mountain socio-ecological systems. Systematic searches of peer-review research were conducted in bibliographic databases of Web of Science, AGRICOLA, CAB Abstracts, Academic Search Premier, and Social Sciences Full Text databases, targeted searches in 4 key journals and a call to the Mountain Sentinels Collaborative Network and grey literature from Google Scholar and 6 subject-specific websites. Searches identified 403 articles, and after screening over 44 studies were included. Preliminary results will be presented from an analysis of PSP case studies conducted in wide range of social-ecological settings by exploring: (1) the context subject (temporal scale, spatial extent), (2) motivations, goals and objectives (3) methodology (4) the content of the studies including storylines/narratives, critical drivers of change and impact variables, (5) identified envisioned desired/undesired futures, adaptation pathways and policy/management recommendations, (6) consistency analysis and validation, and (7) monitoring and evaluation of the process. Results may contribute to theoretical and empirical frameworks, and facilitate the appropriate uptake of such scenario tools in the future in mountain and other data-deficient regions.

Can clouds be detected through solar radiation measurements?
Melina Zempila, Wei Gao, John Davis, Chen Maosi and Sun Zhibin

The US Department of Agriculture (USDA) UV-B Monitoring and Research Program (UVMRP) is comprised of 40 stations over the North American region that provide solar measurements in the Ultraviolet (UV) and Visible (VIS) spectral range. With a suite of four solar radiation measuring instruments at each site, along with ancillary meteorological information obtained by secondary sensors, UVMRP has compiled one of the longest time series of solar UV and VIS records in United States.

With today's technology, a variety of methods have been developed to detect the presence of clouds (e.g. geostationary meteorological satellites, lidar systems, human observations, total sky imagers); however, most of the systems have relatively low temporal resolution, are reliant on weather

conditions or are observer dependent. On the other hand, clouds can be detected using a binary detection method from irradiance data which are normally available in high temporal rates, and thus can capture the variability of clouds.

The aim of this study is to introduce and analyze the performance of cloud detection through measurements in the UV and VIS spectral channels from the Yankee Environmental System (YES) UV and VIS Multi-Filter Rotating Shadowband Radiometers (MFRSR). Both instruments are equipped with a sun-tracking band that enables the measurements of the global (GHI) and diffuse (DHI) horizontal irradiances. Then the direct normal irradiance (DNI) is calculated based on simple mathematical equations. All three components in 7 UV and 7 VIS channels are offered in the form of 3-minute averages, thus providing the desirable high temporal resolution of the radiation scene at each station.

The benefits of the proposed cloud detection result from the fact that no model estimations are needed, while it can be also applied to the raw data of the sensor, providing a robust technique to identify the presence of clouds in high temporal analysis.

Using public grazing records to model Greater sage-grouse responses to livestock at broad scales
Adrian P. Monroe, Cameron L. Aldridge, Timothy J. Assal, Kari E. Veblen, David A. Pyke and Michael L. Casazza

Populations of Greater sage-grouse (Centrocercus urophasianus), an obligate sagebrush (Artemisia spp.) species, declined substantially over the last half-century. Sage-grouse require vast landscapes during their life history, and one land use type often implicated in their decline is improper livestock grazing because herbaceous cover is important for sage-grouse nesting and brood rearing. However, there is a lack of studies linking population responses of sage-grouse to livestock management at broad scales. The Bureau of Land Management (BLM) currently oversees livestock grazing on nearly 61 million ha of rangeland across the Western United States, and their records may provide a unique opportunity to assess sage-grouse responses to livestock management. We used grazing data collected annually by BLM from 1,096 grazing allotments in Wyoming, USA, and then used annual counts of displaying males from 743 lek sites (2004-2014) to evaluate sage-grouse population trends in response to the timing and level of grazing, and interactions with local vegetation productivity. We found that livestock records corresponded with both positive and negative trends among sage-grouse populations depending on the timing and level of grazing, although these relationships may vary local vegetation productivity. Our findings suggest a benefit of broad-scale analyses when evaluating effects of livestock management by revealing patterns not readily apparent from more fine-scale studies, which could provide new insights into this ubiquitous land use across sagebrush-dominated rangelands.

Greater Sage-grouse Population Trends Across Wyoming Management Areas
David R. Edmunds, Cameron L. Aldridge, Michael S. O'Donnel and Adrian P. Monroe.

To best determine local and regional trends for Wyoming greater sage-grouse (Centrocercus urophasianus), we modeled density–independent and –dependent population growth across multiple spatial scales (Wyoming Core Population Areas [Core Areas], Wyoming local Working Groups, Core Area status by Working Groups, and individual Core Areas by Working Groups). Our goal was to determine the influence of fine-scale population trends (Core Areas) on large-scale populations (Working Group Areas) and determine trends within management-relevant population boundaries. We modeled the natural log of change in population size (average peak male lek counts) to calculate the finite rate of population growth (λ) for each population of interest (1993–2015). We

found that when Core Area status (Core Area vs. Non-Core Area) was investigated within Working Group Areas, the two populations trended similarly and agreed with the overall trend of the Working Group Area. However, at the finer scale where Core Areas were analyzed individually, individual Core Areas within the same Working Group Area often trended differently and a few large populations drove the overall Working Group trend. We show that relatively close fine-scale populations can trend differently, indicating that large-scale trends can mask what is actually occurring across the landscape. Our approach of monitoring populations at different spatial scales will allow managers to focus efforts on small-scale populations (Core Areas located within specific Working Group Areas) that are doing the poorest and driving the larger scale population trends downward. A spatially-targeted approach alleviates unnecessary actions to large areas to maximize efficiency of management efforts.

Bayesian calibration of process-based models and estimating uncertainties
Ram B. Gurung, F. Jay Breidt and Stephen M. Ogle

Models are abstraction of reality and vary in complexity from simple regression models with few parameters and one model output to highly mechanistic process-based models coupling multiple processes with hundreds of parameters and many output variables. Often these models are used for environmental assessments and policy development. However, to inform a decision; the accuracy of model predictions (e.g. better R-Square, lower RMSE) needs to determined, and confidence intervals should be provided so that managers and policy makers understand potential for alternative outcomes. Bayesian algorithm and computational power of high performance computing clusters allow us to improve the quality of model prediction as well as quantify the uncertainty around the model estimates by determining the joint posterior probability distribution of model parameters using measured data. I will highlight real world applications of the method to improve model estimates and derive robust confidence intervals, in addition to the challenges in applying these methods to inform assessments related to greenhouse gas mitigation.

Fire consistently reduces biomass, abundance, and diversity of belowground communities
Yamina Pressler, John C. Moore and M. Francesca Cotrufo

Global fire regimes are shifting in frequency and severity as a result of climate change. Understanding responses of belowground communities to fire is key to predicting changes in the ecosystem processes they regulate. We conducted a comprehensive meta-analysis of 130 empirical publications to investigate the effect of fire on soil biota biomass, abundance and diversity. Fire had a strong negative effect on soil biota biomass, abundance, richness, evenness, and diversity. Fire reduced biomass and abundance by up to 96% for soil microorganisms and 88% for nematodes. Species richness, evenness and diversity were reduced by up to 99% for both soil microorganisms and fauna. We found little evidence for a clear temporal trend towards recovery within 10 years after disturbance. The unidirectional response of soil biota implicates fire as a driver of belowground community structure on decadal timescales. Interactions between variables often considered important for predicting soil biological responses to fire (i.e. biome, fire type, depth) explained few of these consistent negative trends. The literature primarily focused on physical and chemical changes to the soil environment as factors affecting belowground community recovery after fire. We suggest that biotic interactions and feedbacks between plants and soil communities play a key role in belowground recovery to fire. We frame our findings in the context of above- and belowground linkages in terrestrial ecosystems and suggest avenues for future research at the intersection of soil biology and disturbance ecology.

The mystery of moisture: DYI soil water monitoring
Erika J Foster, William Gallo, Jay Ham and M. Francesca Cotrufo

Nearly 40% of the global population faces physical or economic water scarcity (UN DESA, 2014). Increases in human population and higher frequency of drought will exacerbate this issue, with water stress projected to impact over two-thirds of the population within the next decade. Minimizing water use is critically important, especially in agriculture, a sector that uses over 70% of freshwater from aquifers, streams, and lakes (FAO, 2011). To decrease water use on farms, producers first need accurate accounting of soil moisture. However, real-time measurements with adequate spatial resolution are expensive. Without accurate information for decision making, farmers can easily default to over irrigating their fields. To better trace soil water content, without the high cost, producers and researchers are turning to DYI methods, combining inexpensive microprocessors and readily available capacitive sensors. Implementing existing technology, we built soil moisture sensors for $20 each, including data logger costs. The sensors are currently installed in a dryland agricultural site in eastern Colorado to monitor the effects of organic amendments on surface soil moisture. Aside from experimental research, these sensors can have widespread applications for home gardeners and farmers alike. Choosing the appropriate time and amount of irrigation begins with accurate measurements; this developing DIY technology in soil moisture sensing can help us use water more efficiently.

High-resolution multi-objective optimization of feedstock landscape design for hybrid first and second generation biorefineries.
Trung Nguyen, Julien Granger, Deval Pandya and Keith Paustian

Biofuels have been proposed as the potential solution for climate change mitigation. However, there exist several barriers, such as “food vs fuel” issues and technological constraints, preventing the sustainable commercialization of both first- and second-generation biofuels. Combining arable crops and their residues for hybrid first- and second-generation biofuels productions provide opportunities to overcome these barriers. This study presents a high-resolution and quantitative tool to support decision-making in feedstock planning for hybrid biofuel supply chains. We demonstrate this work with a case study on optimizing feedstock landscape design for a hybrid corn grain- and stover-based ethanol production system at Front Range Energy biorefinery (FRE), Windsor, Colorado, USA with a life-cycle approach. The case study considered three competing design objectives including the minimization of production costs, greenhouse gas emissions, and nitrogen leaching subject to constraints in land use and biofuel feedstock demand. Our results showed a broad win-lose Pareto surface among the three design objectives and various modulating patterns of the required feedstock area, management input investments, and corn grain- and stover-based ethanol ratio associating with optimum solutions on the Pareto surface.

Know the flow- crowd sourcing observations of streamflow intermittence
Kira Puntenney, Stephanie Kampf, Michael Lefsky, Greg Newman, John Hammond and Ry Weber

Streams that do not flow continuously in time and space support diverse aquatic life and can be critical contributors to downstream water supply. However, these intermittent streams are rarely monitored and often poorly mapped. Stream Tracker is a community powered stream monitoring project that pairs crowd-sourced observations of streamflow presence or absence with a network of streamflow sensors and remotely sensed data from satellites and aerial imagery to track when and where water is flowing in intermittent stream channels. This project utilizes mobile phone applications to allow participants to navigate to streams along frequented trails and roads and

contribute streamflow observations to an online database. A network of instream flow sensors provides a consistent record of streamflow and flow presence/absence across a range of elevations and drainage areas. Streamflow presence or absence observations from the citizen and sensor networks are then compared to satellite imagery to improve flow detection algorithms using remotely sensed data from Landsat. This presentation will highlight how crowd sourcing can be used to expand baseline data of streamflow presence and absence in the Cache la Poudre River basin and beyond.

Filling in the Gaps: Mapping the Missing Agroforestry Features of the United States
Nycole Echeverria

Currently agroforestry features are not included in the EPA's annual Greenhouse Gas Inventory, meaning potential carbon mitigation is not being taken into account. This includes trees associated with non-urban settlements as well as roadside woodlots and field windbreaks. Given estimated sequestration rates at 2-6 Mg/ha/year, it is important to discover how many agroforestry features there are in the United States and add them to the inventory.
However there are challenges that have prevented other people from studying this issue. There is currently no one national dataset, there is a potential to double-count features with forest lands, and there is a need for time series data to assess feature and land use changes over time.
To address these needs and challenges, myself, Mark Easter, and Amy Swan began creating our own agroforestry inventory in the winter of 2015. By using NAIP imagery to digitize each agroforestry feature within a four mile square (with twenty squares in each state), we were able to estimate the area of features, the number of features, and the biomass carbon within a state. We then repeated this process using images from past years to provide an idea of changes over time. This work was time extremely intensive and detail heavy. While the method that we used may not be feasible on a national level, it is useful in helping to develop programs to do the same thing and in providing estimates on just how much data we are missing from the Greenhouse Gas inventory.

Crop domestication and breeding impacts on microbially-mediated plant health
Megan Machmuller, Amélie Gaudin and Matthew Wallenstein

Over the next few decades, we must simultaneously increase global crop production and decrease the environmental impacts of agriculture. While plant breeding and biotechnology have dramatically increased crop production, these approaches have been 'top-down', selecting for cultivars with high yield potentials but also high nutrient requirements and low nutrient use efficiency. Consequently, root traits that support microbially-mediated nutrient acquisition may have been lost through breeding selection under high nutrient inputs. My research aims to characterize the influence of maize domestication and breeding on rhizosphere microbiome structure and function. I am examining plant genotype-microbial interactions in maize varieties that span 9,000 years of selection and breeding- from the closest living wild relative (teosinte) to modern cultivars. The development of high-yielding crops that also take advantage of a beneficial microbiome can provide many cascading effects on crop health, reduce the need for fossil-fuel based fertilizer inputs, and contribute to more sustainable agriculture systems.