2nd Annual NRAGS Graduate Research Symposium

Accepted Abstracts for Oral and Poster Presentations

April 22, 2014
9:00 am
Cargill Building
University of Minnesota
9:00 am  Welcome

9:15 am  Michael R. Barnes, NRSM  
Commute choice: The influence of socio-demographic, psychological, & situational factors on driving behavior

9:30 am  Baishali Bakshi, NRSM  
Obesity and climate change: Improved health as an adaptation strategy for climate change

9:45 am  Kyle Gill, NRSM  
Dynamics in tension: Quantifying structure, stand dynamics, and climate-growth relationships of non-serotinous jack pine

10:00 am  Christopher Looney, NRSM  
Patters of competition and biomass production efficiency in northern Minnesota black ash (Fraxinus nigra) wetland forests

10:15 am Coffee Break

10:45 am  Jane Cowles, Ecology, Evolution & Behavior  
The roots of global change: How biodiversity and warming affect belowground productivity in perennial grassland communities

11:00 am  John L. Berini, Conservation Biology  
Temperature-induced changes to the production of plant secondary metabolites and spatial variation in the diet composition of moose

11:15 am  Jason Papenfuss, Conservation Biology  
Managing water levels in the Namakan Reservoir: Effects on walleye spawning habitat

11:30 pm  Eva Lewandowski, Conservation Biology  
Citizen science: A tool for conservation education and engagement

11:45 am  Alice Maserati, Food Science & Nutrition  
Desiccation response, iron homeostasis and virulence in Salmonella typhimurium: Importance of sseD and sopD

12:00 pm  Lunch & Poster Session

1:00 pm  Eric Nooker, Land & Atmospheric Science  
Processing & fresh market sweet corn under ridge & chisel plow tillage in Minnesota, USA

1:15 pm  Vanessa Perry, NRSM  
It’s complicated: Why relationships matter in conservation, some findings and possible implications

1:30 pm  Majory K. Silisyene, NRSM  
Access to environmental information and implications on natural resources management: A case of northern Tanzania

1:45 pm  Andrew M. Larson, Applied Economics  
Land market integration, structural change, and smallholder farming in Zambia

2:00 pm Coffee Break

2:30 pm  Grace Wilson, Land & Atmospheric Science  
Estimating water quality effects of conservation practices and grazing land-use scenarios

2:45 pm  Marta Roser, Land & Atmospheric Science  
Removal of nitrate and phosphate from agricultural drainage water using bioreactors

3:00 pm  Mikhail Titov, Bioproducts & Biosys. Eng.  
Identification of potential drainage ditch side inlet locations

3:15 pm  Kevin M. Dorn, Plant Biology  
Genomics-enabled domestication of the winter biofuel crop field pennycress (Thlaspi arvense L.)

3:30 pm  Awards Ceremony

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Oral Presentation Abstracts
Commute Choice: The influence of socio-demographic, psychological, and situational factors on driving behavior

Michael R. Barnes
Ph. D Student
Natural Resources Science & Management

Abstract
Commute mode and transportation choices in a Midwestern metropolitan area of the United States were investigated using the Theory of Planned Behavior. Extensive socio-demographic factors were included in the analysis to predict commute mode choices among participants. The study hypothesized links between both TPB and socio-demographic factors with commute mode choices and attempted to find intervention points for behavior change around transportation choices. General findings included an overwhelming prevalence for driving compared to alternative forms of transportation. Furthermore, Attitude, Social Norms and PBC, all were significant in predicting intention to drive. Socio-demographic items such as education, gender, and years of homeownership were also significant predictors independent of TPB factors. Residential relocation (proxy of years of homeownership) was found to be a significant intervention point where participants were more likely to choose forms of transportation other than driving. This study also extended numerous TPB researchers’ work in identifying significant socio-demographic factors that play a role in an individual’s commute mode choice. Additionally it backed up work by Bamberg (2006), among others, in identifying residential relocation as a potential intervention point in commute mode choices.
Obesity and climate change are two of the most important problems of this century having serious implications on global health, environment and food security. This paper examines if these two problems are related, the direction of such a relation, and its implications on society through review of relevant literature and an empirical analyses of 87 countries using health and emissions data from WHO, World Bank and CIA handbook. We find that obesity leads to climate change both directly and indirectly so that measures to mitigate obesity in terms of improved health could be a reasonable adaptation strategy for climate change. Our recommended strategies to reduce global obesity inform a more cost-effective solution to climate change than mitigation measures for climate change alone.
“Dynamics in Tension: Quantifying structure, stand dynamics, and climate-growth relationships of non-serotinuous jack pine.”

Kyle Gill
Natural Resources Science and Management M.S. candidate
Department of Forest Resources
Advisors: Anthony D’Amato and Shawn Fraver

Abstract:
Ecotones, transition zones from one biome to another, exist where groups of biota meet their climatic and abiotic limits. Small changes in these limiting factors can generate significant impacts on ecosystem structure and function in relatively short time periods. Species in these tension zones often display behaviors and dynamics that differ from the non-marginal portions of their range posing challenges for their conservation and management. Jack pine (Pinus banksiana) meets the southwestern edge of its native range in the prairie-forest ecotone in north central Minnesota. Much of the science concerning the dynamics and management of this species, which often grows in nearly monospecific stands, is based upon research performed in portions of this species’ range where large, lethal fires and serotinous cones predominate creating even-aged populations. However, management guidelines based upon this research have had limited success along this species’ range margin, where non-serotinous cones are documented. This has raised questions as to whether the forest dynamics (establishment patterns, age structures, disturbance regimes) and climate responses (positive and negative relationships between growth and climatic factors) of these populations deviate from patterns observed elsewhere. Correspondingly, this project aims to quantify forest dynamics and climate responses for these range-margin populations using dendrochronological techniques. Preliminary results indicate a range of age structures and positive relationships between diameter-growth and warm temperatures. These indicate adaptation to a range of dynamic patterns, which may include low-intensity surface fires, canopy gaps created by drought-induced local mortality, or pioneer-afforestation during favorable climate and habitat conditions.
Patterns of competition and biomass production efficiency in Northern Minnesota black ash (*Fraxinus nigra*) wetland forests

As forest stands age, inter-tree competition typically becomes a pivotal factor in determining future development. At the same time, stand biomass production has been traditionally assumed to peak fairly early in stand development. However most studies to date have investigated young, even-aged plantations. Whether patterns of competition and stand production documented in upland forests apply to wetlands is also little-researched. I examined whether competition was an important influence, and how production efficiency varied by tree size, in old-growth black ash forests in northern Minnesota. Five 0.5 ha plots were established in different old-growth stands, with every live tree assessed for diameter, age, and Cartesian coordinates. Inter-tree competition was investigated using a variety of distance-dependent and independent competition indices. I examined the relationship between annual biomass increment with total tree biomass to determine the relative contribution of different-sized trees to stand productivity. Preliminary results suggest the importance of competition varies greatly between sites, and can interact strongly with tree size. Consistent with predictions for old-growth upland forests, trees peaked in biomass production efficiency at intermediate sizes. These results will both extend theories of forest stand development to wetland systems, as well as inform land managers about natural stand dynamics within a forest type imminently threatened by emerald ash borer.
Ecosystems worldwide are increasingly impacted by multiple anthropogenic drivers of environmental change. Global temperature is projected to increase 2-4.5°C above pre-industrial levels by 2100. Simultaneously, human activities are leading to species losses via habitat fragmentation, simplification, and nutrient eutrophication, and to shifts in community composition and species dominance. Warming and compositional shifts can have a variety of direct and indirect effects on ecosystem processes that can in turn affect the provisioning of ecosystem services (the benefits that humanity derives from ecosystems). While aboveground effects of these changes are readily apparent, belowground responses to shifting composition, diversity and warming temperatures are harder to document but likely increasingly important--plant belowground biomass is intimately connected to the belowground carbon storage capacity of an ecological or agricultural system. In a long-term grassland experiment, I examined how biodiversity and warming independently and interactively affected root growth through the soil profile. Total root biomass at all depths was increased by both warming and diversity. Further, rooting depth analyses suggest that the allocation of fine roots, responsible for nutrient and water uptake, shifted deeper in the soil with warming and diversity, and this shift was likely linked to dry surface soil and increased nitrogen supply at depth under these treatments. Larger, deeper rooting systems may drive the positive effect of biodiversity and warming found on aboveground productivity and may also lead to more stable provisioning of ecosystem services in the future, as the variability and strength of climate change impacts are buffered by the surface soil.
Temperature-induced changes to the production of plant secondary metabolites and spatial variation in the diet composition of moose

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In Minnesota, moose (Alces alces) were recently listed as a “species of special concern” by the Minnesota Department of Natural Resources due in part to the ongoing threat of climate change. While the relationship between increasing temperatures and the decline of moose in Minnesota is well documented, the mechanism is not well understood. Plant secondary metabolites (PSMs) play an important role in defense against herbivory and can impact herbivore survival and reproduction. While several studies suggest that plants increase production of PSMs due to heat stress, this has not been tested in a controlled setting. Here we investigated the effects of increasing temperatures on the production of PSMs in balsam fir (Abies balsamea) and paper birch (Betula papyrifera) and assessed if temperature-induced changes to phytochemistry are correlated with diet composition. Specifically, we analyzed PSM concentrations in plants reared under three different temperature regimes: ambient, ambient + 2°C, and ambient + 4°C. To examine how moose diets changed across a similar temperature range, we used stable isotopes of carbon and nitrogen from forage and hair to reconstruct the diets of moose from areas that span a 6°C summer temperature gradient. Preliminary results suggest that PSM production in paper birch increases in response to warmer temperatures; however, moose from warmer regions ingested proportionally more paper birch compared to moose from colder regions. I discuss how this pattern could be driven by a combination of forage availability and forage selection.
Title: Managing water levels in the Namakan Reservoir: Effects on walleye spawning habitat
Author: Jason Papenfuss
Department: Fisheries, Wildlife, and Conservation Biology

Abstract: The most recent water level management policy (rule-curve) in the Namakan Reservoir was established in 2000 by the International Joint Commission and was intended to strike a balance between benefits to plants and animals in the reservoir and human water needs (e.g., hydroelectric power generation, recreation, and navigation). Walleye (Sander vitreus) are prevalent in the reservoir, sensitive to water levels, and ecologically, culturally, and economically important, making them an excellent species for studying the effects of rule-curves. To compare the effects of two rule-curves (1970-2000 and 2000-present), I used spatial modeling to estimate water depth and therefore seasonal habitat availability at various sites within the reservoir. The overall objective of the study was to determine if the most recent rule-curve has improved spawning habitat availability for walleye.
Eva Lewandowski

Conservation Biology Graduate Program

Citizen science: A tool for conservation education and engagement

**Presentation Abstract:**
Citizen science is an increasingly common and important tool in conservation biology, with public volunteers serving a key role in collecting biological monitoring data worldwide. However, by supplying their volunteers with conservation knowledge, action strategies, and a social support structure, citizen science projects also have the potential to invoke conservation actions in their volunteers outside of their participation in the project. In the United States, the public’s participation in butterfly-related citizen science and conservation is widespread. I examined the current state of butterfly-related citizen science projects to determine what information and tools projects were providing to their volunteers to promote butterfly conservation. The majority of projects actively encourage conservation, and they provide their participants with information on important conservation threats and action strategies. Citizen science projects also provide a social support structure for their volunteers by promoting group work, providing ways for volunteers to meet and contact one another, and emphasizing a sense of belonging to the project. Volunteers, in turn, engage in a variety of butterfly-related conservation activities outside of their citizen science participation, such as planting nectar and host plants, decreasing pesticide use, and giving educational talks about butterfly conservation. By exploring the link between citizen science projects and the resulting conservation actions of their volunteers, I am working to identify project attributes that influence a volunteer’s engagement in conservation.
Desiccation Response, Iron Homeostasis and Virulence in *Salmonella Typhimurium*: Importance of *sseD* and *sopD*.

Alice Maserati*, Jamie Stiernagle, Susan Ledgister, Francisco Diez-Gonzalez, and Ryan C. Fink
*Presenting Author: Food Science PhD Program - Dept. Food Science and Nutrition - CFANS

**Introduction:** Several studies have demonstrated *Salmonella* ability to survive desiccation. However, the molecular mechanisms and physiological pathways behind this adaptation are not clear yet. Objective of our study was to explore the transcriptional profile changes during desiccation and the role of virulence-related genes in the *Salmonella* adaptation to desiccation.

**Methods:** To determine changes in the transcriptional activity induced by desiccation, *Salmonella enterica* Typhimurium was inoculated on cellulose filters, dried overnight and equilibrated to a $a_w$ 0.11 and 1.0. After 4 days, cells were collected from filters and total RNA sequenced. Mutants in two virulence-related genes were generated using homologous recombination. To test mutants ability to survive desiccation and the iron homeostasis impact, Dipyridyl or EDTA were added as chelating agents. Following growth in presence or absence of chelators, cells were re-suspended in 96-well plates and dried at 42°C for 4 days and equilibrate to $a_w$ 0.11 for additional 4 days.

**Results:** Transcriptome analysis identified 2 virulence-related genes up-regulated after desiccation: *sseD* and *sopD*. Mutation in both genes affected the survival rate after desiccation and equilibration compared to the WT in the control medium (>1.2 Log). The addition of chelators affected WT survival and showed an additional effect on the mutants after desiccation and equilibration.

**Conclusions:** *sseD* and *sopD* play a role in the desiccation response by *Salmonella* Typhimurium. The stronger decrease in cell count observed when chelators were added also suggest that iron homeostasis is crucial for the efficacy of the cellular response.
Eric Nooker

Land and Atmosphere Sciences Department

Sweet corn grown under ridge and conventional tillage in Minnesota, USA

Minnesota is among the top states in the U.S. in terms of sweet corn production. Soil tillage is a significant part of corn production and affects environmental quality as well. Most literature focuses on tillage practices used for field corn production, so this research tested for differences in yield and quality of three sweet corn varieties grown under both ridge tillage and conventional tillage. The research was conducted the summers of 2012 and 2013 at the University of Minnesota Outreach, Research and Education Park in Rosemount, Minnesota. It was found that during 2013 ridge till played a role in greater yield and ear marketability than conventional tilled plots. This data parallels some results found on field corn research; with careful ridge till management, yield and quality of sweet corn production can be enhanced when compared to conventional tillage.
It’s Complicated: Why Relationships Matter in Conservation, Some Findings and Possible Implications.

Vanessa Perry
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ABSTRACT

Using a study of farmer decision-making in the Red River Basin (RRB), Minnesota as a backdrop, this presentation explores the importance of relationships, community, peer pressure, and social norms in conservation. Using participatory, social science research methods, researchers from the University of Minnesota collaborated with local partners to investigate farmers’ values, beliefs and decision-making processes associated with water resource conservation. Twenty-four key informant interviews with farmers and two agency personnel focus groups were conducted December 2012 through July 2013. Interview questions focused on water quality and quality BMPs, but also explored conservation attitudes, beliefs and behaviors broadly. Data were analyzed for predominating themes and relationships between themes using an open coding process, building from currently accepted theories of attitude formation and behavioral motivations. The study results will be finalized summer 2014, however findings to date suggest that a more complete understanding of the determinants of conservation behavior could complement existing programs and inform future interventions and policy direction in the RRB. Specifically, managers may consider developing conservation interventions and programs which maximize perceived agency by participants and minimize financial and social capital risk.
Population increase is one of the main factors contributing to challenges in natural resources management. As population increases, forest clearance increases. This trend is particularly common in Sub-Saharan Africa; Tanzania being among them. Loliondo II Forest Catchment Reserve located in Northern Tanzania is among forests at risk of being depleted. The likeliness that this forest may continue to be destroyed not only reduces the chances of survival of people in the area, but also the chances of existence of irreplaceable ecosystems, including the Serengeti Ecosystem. This study analyzes information access and sharing from surveys and interviews with the goal of understanding how people learn about the status of their forest, as well as about relevant environmental issues. Findings show that both men and women heavily rely on village meetings and word of mouth, and that the environmental information they access rarely focus on natural resource management strategies.
Land Market Integration, Structural Change, 
and Smallholder Farming in Zambia 
March 4, 2014

Andrew M. Larson  
Ph.D. Candidate, Department of Applied Economics  
University of Minnesota

Abstract  
The bifurcation of Zambia's agricultural land markets prevents smallholder farmers from participating in modern food marketing channels. High transaction costs in terms of time and financial resources make conversion of customary land into commercial land title prohibitively expensive for smallholder farmers. The simulated conversion of land title, without changing ownership, instigates a reallocation of capital and labor resources in the modeled economy that benefits smallholders in their roles as producers and household owners of factors of production. With the increase in commercial land area, labor becomes scarce and farm production becomes more capital intensive, thus increasing labor productivity and smallholder household income. This analysis highlights the importance of integrating land markets and giving smallholders an effective increase in the range of their resource allocation decisions.
Presentation Title: Estimating water quality effects of conservation practices and grazing land-use scenarios

Presenting Author: Grace Wilson

Department: Dept. of Soil, Water, and Climate

Graduate Program: Land and Atmospheric Science

Abstract: Conservation management practices (CMPs) such as reduced tillage, fertilizer management, and buffer strips, are well-established means by which to control erosion and nutrient losses from fields planted in annual row crops. However, agricultural systems which include perennial plant cover, such as the perennial forages found in grazing systems, may represent an alternative way to reduce these losses. In this study, management intensive rotational grazing (MIRG) was tested as a way to improve water quality on highly vulnerable row crop land, compared to more traditional conservation management schemes in the South Branch of the Root River watershed (a karst-influenced watershed in Southeastern Minnesota). The effects of both sets of alternative scenarios were evaluated with a watershed-based modeling approach using the Soil and Water Assessment Tool (SWAT). Both the conservation management practices and land-use changes were targeted to reduce contributions of sediment and phosphorus loads from cropped upland areas. Watershed-wide implementation of all conservation management practices resulted in the greatest reductions in sediment (52%) and total phosphorus (28%) loads from upland crop areas, but had the largest land area requirements. Changing land-use from row crop production to pasture for grazing was most effective at reducing total sediment and phosphorus loads on a per-acre changed basis, reducing sediment and phosphorus by greater than 85% on targeted areas. Simulation results indicate that utilizing CMPs or MIRG, when targeted to areas of steeper slope (greater than 4%), could appreciably reduce sediment and phosphorus loads in this watershed, with limited reductions in row crop agriculture acreage.
Removal of nitrate and phosphate from agricultural drainage water using bioreactors
Marta Roser, Masters student, Land and Atmospheric Science

Decreasing nitrate and phosphate release from agricultural land into surface and ground water is essential for environmental and health reasons. Discharge into waterways lead to eutrophication and hypoxia in water bodies and contamination of drinking water. While many in-field measures can be taken to diminish nutrient runoff, such as slow release fertilizer and cover crops, there are also edge-of-field practices that can be utilized such as bioreactors. A bioreactor contains material that serves as a carrier for biofilms of denitrifying bacteria such as *Pseudomonas* that reduce nitrate to atmospheric nitrogen. Denitrifying bioreactors are already being utilized by farmers in the Midwest, but there is the potential to add a section to a bioreactor that would contain materials that sorb phosphorus. We will be testing materials such as steel slag, crushed concrete, and limestone in a column study and report on their ability to sorb phosphorus. Additional materials for denitrification, such as coconut fibers, will be tested as well.
**Title:** Identification of potential drainage ditch side inlet locations

**Author:** Mikhail Titov, Department of Bioproducts and Biosystems Engineering

**Abstract**

Water drainage is an important factor in achieving high crop yields. Agricultural drainage alters flow pathways thus providing shortcuts for water, sediment, and pollutants it might carry. Sediment and debris deposition after storm events diminishes ditch system capacity to divert water over time. Therefore maintenance is necessary to keep drainage system clean so it can function properly. Side inlets are human made features within drainage ditch system that funnel water from agricultural fields thus reducing ditch bank erosion and reducing maintenance costs. Quite often inlets are equipped with debris filter and are surrounded by a buffer strip to reduce pollutants load. Several parties are interested in determination of optimal inlet locations. This includes farmers who are interested in reducing crop inundation time while not spending extra money when not necessary, hydrologists who run models, and various governmental bodies interested in assessment and inventory. Existing approaches to determine inlet locations, aside from on-site assessment, are primarily based on simple topographic indices like flow accumulation and/or its derivatives like stream power index (SPI). When faced with flow accumulation calculation, researchers have to decide on whether to remove sinks from digital elevation model (DEM). Either choice leads to unacceptable results in low-relief landscape due to incorrectly predicted flow paths in side inlet proximity. An alternative robust approach to detect potential side inlet locations using unaltered DEM is proposed.
Genomics-enabled domestication of the Winter Biofuel Crop Field Pennycress (Thlaspi arvense L.)

Kevin M. Dorn¹, Donald L. Wyse², M. David Marks¹

¹ Department of Plant Biology, University of Minnesota
² Department of Agronomy and Plant Genetics, University of Minnesota

Throughout the Midwest, large portions of the landscape lack a living cover from the time of harvest in the fall until establishment of the next crop in June. This lack of plant cover leaves the soil vulnerable to soil erosion and to the loss of nutrients through surface flow and leaching into surface waters. The use of winter cover crops has been shown as an effective method for limiting spring weed growth and protecting soil and water health. Field pennycress is being developed as a fall planted cover crop, which also produces a harvestable oilseed in the spring suitable as a biodiesel feedstock. While there has been limited breeding to improve agronomic qualities in pennycress, we are applying modern genomic technologies to rapidly improve pennycress. Pennycress is closely related to the model plant species Arabidopsis thaliana, and the translation of basic knowledge should stimulate rapid improvements in pennycress. To this end, we are utilizing the power of next-generation sequencing (NGS) to develop the initial genomic resources to jumpstart a modern genomics-based breeding program. While short read NGS datasets have traditionally been computationally difficult to assemble, we have configured and built a desktop computer able to perform de novo assembly and annotation of the pennycress transcriptome and genome. From this work, we have identified candidate genes responsible for controlling key traits like seed dormancy and flowering time, which will guide future improvement efforts. The generation of these genomic resources will provide an unprecedented tool for beginning the domestication of field pennycress.
Poster Presentation Abstracts
Poster session 12pm – 1pm
Brian Krohn, NRSM

Abstract

The EPA’s Renewable Fuel Standards sets an ambitious goal of producing 16 billion gallons of cellulosic biofuel by 2022. Perennial grasses have been proposed as a possible feedstock for bioenergy production, as they have the capacity to meet up to half of this goal. Perennial grasses can also improve the current agricultural landscape by providing environmental benefits such as improved water quality, reduced soil erosion and increased habitat. However, meeting the EPA’s bold initiative will necessitate considerable changes to the current agricultural and natural landscape of the US. It is possible that these changes to land use will have substantial positive and negative impacts on the environment. The overarching goal of my research is to understand if and how perennial grasses can deliver their proposed environmental benefits while simultaneously meeting their estimated bioenergy potential. To do this I will first focus on understanding and modeling realistic perennial grass yields across the landscape using climate, soil, terrain, and management parameters. Then, I will develop high-resolution spatial scenarios of various perennial grass bioenergy systems in the Central US that will represent potential development pathways for the nascent perennial grass bioenergy industry under varying market and policy conditions. Finally, I will assess if the market-mediated placement of perennial grasses on the landscape that meets bioenergy goals provides the desired environmental benefits, namely benefits related to soil loss.
Buckthorn breaks bud earlier in the spring and holds leaves later in the fall compared to co-occurring native understory species and the forest canopy. This phenology may allow buckthorn to take advantage of high light levels prior to canopy closure in spring and after leaf drop in fall. We hypothesize that this unique phenology is one mechanism that facilitates invasion of the forest interior by buckthorn. To test our hypothesis, we experimentally shaded buckthorn seedlings, reducing high light levels in the spring and fall to simulate intact canopy conditions. Forty individuals at two sites in central MN, USA were randomly assigned to four treatments: spring shading, fall shading, both spring and fall shading and no shading. We measured spring and fall leafing phenology, light availability and seedling survival and growth. After a year and half of shading little mortality was observed but individuals receiving shading treatments had significantly decreased growth. Supporting our hypothesis that access to phenology induced high light levels in the spring and autumn is one mechanism for buckthorns success in closed canopy forests.
B4WarmED forest warming experiment: Increased temperature effects on herbaceous plant phenology

Karen Rice1, Rebecca A. Montgomery1, Roy Rich1, Nicholas Fischelli2, Marie-Hélène Jacques3, Artur Stefanski1 and Peter B. Reich1, (1)Forest Resources, University of Minnesota, Saint Paul, MN, (2)Climate Change Response Program, National Park Service, Fort Collins, CO, (3)Département de Biologie, Université Laval, Québec City, QC, Canada

Climate change may alter forest biodiversity and function including herbaceous plant dynamics such as phenology. Climate change may alter the timing of events such as leaf emergence, flowering and fruiting, which are crucial to plants’ overall success. We hypothesize that warming will increase the growing season length of herbaceous plants by causing earlier leaf out and delayed senescence. To test for this we monitored phenology of numerous individuals of two herbaceous plant species in the Boreal Forest Warming at an Ecotone in Danger (B4WarmED) experiment. The project has two forested sites in northern Minnesota with 96 7.1m2 plots established in open and closed canopy conditions. Treatments include simultaneous above (via infrared lamps) and below-ground (via buried cables) warming to elevate the temperature to three target levels (ambient, + 1.7 °C, + 3.4 °C). For each species, we recorded emergence and senescence weekly during the growing season from 2009 through 2011. Both the direction and magnitude of phenological responses differed between species and among treatments. Differences in response to warming may alter competitive interactions of co-occurring species. For instance, tall growing Eurybia macrophylla emerged earlier and senesced later when warmed. In contrast, its smaller neighbor, Maianthemum canadense, did not shift phenology with warming. A positive response to warming allows E. macrophylla to usurp limited resources then not available to species that emerge at the same time as under ambient conditions. Maianthemum canadense, which did not respond to warming and emerged later than E. macrophylla, may be harmed by increased shading from its competitor.
Community-Based Approaches to Addressing Agroecological Integrated Systems in the Brazilian Amazon Rainforest

Conventional and modern agriculture faces a number of problems including pollution, land degradation, and the depletion of groundwater. The causes of these environmental crises are rooted in prevalent socio-economic structures that do not account for complex interactions within an ecosystem. The current deforestation of the Brazilian Amazon rainforest is a reflection of these issues. Certain approaches towards social and agricultural development have decreased biodiversity and threatened the lives of indigenous people. Agroecology is an ecological approach to agriculture production that considers interactions between humans, resources and the environment. It serves as an alternative approach to conventional agriculture as a response to current environmental and social problems. The purpose of this study was to assess the effectiveness of current practices in agroecological research. We accomplished this by finding and evaluating sustainable, methodological approaches of these practices in the Brazilian Amazon rainforest. We examined processes of experimental design, the analysis of integrated systems, and the implementation of community education in conservation. Initial results from a literature review on sustainability in the Brazilian Amazon rainforest revealed lacking sustainable development and non-holistic analyses. Future work involves modeling of decision-makers and stakeholders modeling for sustainable development focusing on food security within the Brazilian Amazon rainforest.

Authors & Affiliations:

Jaime Thissen1, Kathryn Solorzano Lowell2, Lakiah Clark3, Vanessa Rivera Quiñones4

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Electrobiosynthesis for CO₂ Conversion
Ben Frigo-Vaz, Shunxiang Xia, Bo Tang, Xueyan Zhao and Ping Wang
Room 237, 1475 Gortner Avenue, St. Paul, MN 55108

Introduction
Due to climate change, extensive research worldwide has been made in developing better ways of sequestering carbon dioxide. Compared with normal photosynthesis pathway, In Vito enzyme or microbial based CO₂ fixing via electrosynthesis can provide many advantages:
- Greater potential efficiency
- Production of specific chemical products with minimize co-products
- Operation on a variety of energy sources
- Faster reaction rates than possible In Situ systems

Fixing of CO₂ through Formic Acid Synthetic Metabolic Pathways

![Diagram of CO₂ fixation through formic acid pathway]

- Carbonate with Carbon Nanotubes & Nanoscopic Catalysis
- CO₂ Input
- CO₂ + H₂ → HCO₂⁻ + H⁺ → H₂O + CO₂
- Biocatalyst Production
- Desired Product Output

In Vito Cofactor Regeneration and Enzyme Catalysis

![Diagram of In Vito cofactor regeneration]

- Chemical route of enzymatic synthesis of methanol from CO₂ with in situ regeneration of NADH. (Abbreviations of enzymes: FDH—formate dehydrogenase; FAldDH—formaldehyde dehydrogenase; ADR—alcohol dehydrogenase; GDH—glutamate dehydrogenase.)
- Notes: The FDH reaction could be supplied by electrosynthesis

![Diagram of enzyme attachment]

- Chemical route for the attachment of enzymes and cofactor onto polystyrene particles
- In order to attain high stability and reaction rate of multiple enzyme reaction, cofactor and different enzyme can be co-immobilized on nano-particles

CO₂ Reducing Carbon Nanotube Electrode

Our lab is developing a carbon fiber - carbon nanotube electrode for the reduction of CO₂ to formic acid. Nanotubes offer high surface area for electrochemical reactions such as reducing CO₂ to formic acid as well as sites for enzymes or other nanoscopic catalyst to increase specificity and reduce parasitic reactions.

![Image of carbonized fiber and CNT coated carbon fiber]

<table>
<thead>
<tr>
<th>Materials</th>
<th>Concentration (μM)</th>
<th>Concentration (nM)</th>
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</table>

![Image of carbonized fiber and CNT coated carbon fiber]

Tab 1. Performance of different electrodes in converting CO₂ to formate. (Conditions: 0.5 M K₂CO₃, 18 V bubbling CO₂, condens sample.)

Research Objectives
- The production of formic acid reducing electrodes and incorporation into bioreactors for electrosynthetic growth of organism for in situ production of chemical products
- Combination of formic acid electrosynthesis, co-factor regeneration with consortium of enzymes in multistep in vitro synthesis of high value chemical products

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GROWTH OF BACTERIA CONSORTIUM ON NANO-CARBON ELECTRODE FOR POWER GENERATION
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INTRODUCTION
-Carbon nanotubes (CNTs) supported carbon fiber electrode has outstanding electrochemical properties in fuel cell application
- Clostridium butyricum (C. b) can produce H2 by digesting glucose and Megasphaera eldi (M. e) has hydrogenase that can catalyse oxidation reaction of H2. Our project is to build a microbial fuel cell system (Figure 1).
- Immobilization of bacteria on carbon nanotubes can improve the efficiency of electron transfer
- This microbial fuel cell can be an inexpensive solution for domestic sewage by digesting the organic molecule and generating power.

Figure 1: The design of the microbial fuel cell. Clostridium butyricum and Megasphaera eldi were immobilized on the carbon nanotube anode electrodes.

METHODS
- Preparation of CNTs based carbon fiber
- Analysis of microbial system
  - The bio-gas was analyzed by using gas chromatography (GC)
  - The population of two bacteria strains was studied
  - The morphology of bacteria and CNTs based carbon fiber has been studied by using scanning electron microscope (SEM)

CONCLUSION
-Clostridium butyricum and Megasphaera eldi co-culture system provides a possible pathway to digest organic compounds.
- Both bacteria can attach onto the carbon nanotubes enriched electrode
- The co-culture system power density can reach to 500 mW/m² compared to the single strain culture
- Our latest optimized MFCs can run a small fan with the U’s logo

FUTURE PLAN
-To further discover the design of MFC to increase the maximum performance
-To determine whether hydrogenase will help hydrogen oxidation

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