2023 LRES Student Research Colloquium

April 13, 2023

Abstracts

Oral Presentation Abstracts

Abstracts are listed alphabetically by last name.

Biodigesters: Managing Organic Waste

Elizabeth Reiva

Sustainable waste management is a complex problem with many factors. One important aspect is how specifically organic waste can be managed. This presentation gives a brief overview of the mechanics behind biodigesters and their potential use in managing organic wastes at the small-farm and household level, which can provide more flexibility to waste management.

Local knowledge of drought impacts and indicators across water use sectors in Montana

Sale Rhodes

Increasing demand for water resources amidst decreasing water supply in the arid Mountain West has led to more frequent and more severe drought events. Changing climates, precipitation patterns, and temperature trends will further exacerbate this imbalance. Accurate anticipation of drought using conventional indicators, such as meteoric data, is an ongoing challenge. Local and traditional knowledge (LTK) based on longevity and lived experience on a landscape may offer insight for improving drought planning and management. The theoretical background for this research is sense of place theory, considering place attachment as a way that local knowledges are formed. Different water use sectors are used to consider the variability in local knowledge that exist within and between communities in Montana. Analysis of two sets of qualitative data consider how water use sector can inform local knowledge about indicators and impacts. Results include the frequency that different drought impacts and indicators are drought referenced across sectors (quantitative) as well as the similarities and differences of drought impacts and indicators reported by each sector (qualitative). Preliminary results show the widespread use of hydrologic drought indicators as well as examples of local knowledge of place-based drought indicators. Additionally, drought impacts vary by water use sector, confirming the idea that relationship to place, understood in this project through water use sector, informs concern about water resources. The results of this analysis point to novel indicators and priority impacts that managers can consider in drought planning and mitigation efforts. The value of local drought knowledge is apparent in these results, demonstrating opportunities for incorporating local knowledge into future drought decision making in Montana.

Harvest Weed Seed Control: A Potential Non-Chemical Weed Management Tool for Cereal and Corn/Soybean Rotations in SE Montana

Samir Desai

With the evolution of multiple herbicide resistance in agroecosystems has increased, there is an increased need to develop late-season non-chemical weed management practices

[e.g., harvest weed seed control (HWSC)]. At crop harvest, HWSC disrupts the dispersion of weed seeds from the combine and minimizes the weed seedbank replenishment. However, understanding weed seed retention at crop harvest is an initial attribute to study for identifying potential weed species for HWSC. Field experiments were conducted to evaluate seed retention and seed-shattering phenology of wild oats (Avena fatua L.) in spring wheat, feral rye (Secale cereale L.) and downy brome (Bromus tectorum L.) in winter wheat, and kochia [Bassia scoparia (L.) A. J. Scott], common lambsquarters (Chenopodium album L.), redroot pigweed (Amaranthus retroflexus L.), and green foxtail [Setaria viridis (L.) Beauv.] in soybean and corn. Avena fatua retained 70-100% seeds at spring wheat physiological maturity. Secale cereale and B. tectorum retained 85-95% and >75% seeds in winter wheat, respectively. In corn and soybean, all tested weed species retained 85-90% seeds at crop physiological maturity, except C. album which retained 75-80% seeds. High seed retention (70-100%) of all tested weed species at winter wheat, spring wheat, corn, and soybean physiological maturity makes them suitable candidates for HWSC. Our results will aid in future research, which aims to evaluate different HWSC systems such chaff-lining, narrow windrow burning, and impact mill.

Does CO2 modify the critical period of weed control?

Kevin Sheridan

Despite increased biological and ecological knowledge, as well as technological advances, agricultural weeds continue to be a leading management concern in both conventional and organic systems. Competition between weeds and crops for nutrients, water, and sunlight can affect overall yield and quality, reducing farm revenues and increasing production costs. In organic systems, weed management is especially challenging given the inability to rely on synthetic inputs such as herbicides. In these systems, farmers integrate biological, cultural, and mechanical tactics to manage weeds, usually leading to high demand for labor. Given the difficulty and cost of recruiting farm labor, optimizing the time invested in weed management is an essential aspect of enhancing the sustainability of organic farms. Determining the critical period of weed control, i.e., the period in which weed removal is necessary to avoid yield and economic losses, can help farmers maximize crop yield and quality while minimizing labor needs. Previous research has been done to assess this period for different crops but to my knowledge, there has been no research into how this critical period of weed control may be modified from climate change. Elevated levels of CO2 in the atmosphere have been shown to impact crop-weed competitive interaction and have the potential to modify the length of the critical period of weed control, yet no study has compared the length of the critical period of weed control between ambient and predicted levels of CO2. The data generated from this project will be critical for both organic and conventional vegetable producers to adapt to the changing climate.

Assessing the Importance of Smooth Brome and Parasitoids in Limiting Damage Caused by the Wheat Stem Sawfly

Jackson Strand

Wheat stem sawfly, Cephus cinctus Norton (WSS), causes significant damage in cereal crops throughout the northern Great Plains of North America. WSS parasitoids (Bracon cephi and Bracon lissogaster) are an important factor in managing WSS outbreaks and damage. Previous research has shown smooth brome (Bromus inermis) grass to be an effective WSS sink, and potential parasitoid source, when grown in areas surrounding wheat fields in Montana. However, the degree to which the parasitoids can utilize smooth brome as a temporally stable local refuge is unknown. Our objective was to identify and quantify the organic volatile compounds produced by WSS infested and uninfested smooth brome and winter wheat. By using electroantennogram and bioassay techniques, our goal is to then understand the response of WSS parasitoids smooth brome volatiles and contrast with the parasitoid response to winter wheat. We found increased levels of b-ocimene, nonanal, and Z-(3)-hexenyl acetate within smooth brome compared to winter wheat, and overall elevated quantities of volatile compounds within the infested plants. Our results suggest that smooth brome emits elevated but similar quantities of organic volatiles compared to winter wheat, allowing WSS parasitoids to locate WSS larva infested stems.

Impact of native vegetation on cheatgrass fitness: A neighborhood competition study

Erin Teichroew

Plant community composition and spatial arrangement must affect the fitness of a target plant, but they are rarely assessed in competition studies. Neighborhood studies allow for the effect of individual plant responses and include spatial proximity factors influencing the target plant. We evaluated competitive interactions between cheatgrass (downy brome, Bromus tectorum) and species in the surrounding community (neighborhood). We characterized neighborhoods centered around a randomly selected target cheatgrass individual, at two semi-arid grassland sites in Montana. We measured the percent cover and density of all neighboring species, and categorized them by life-forms (grasses, forbs, or cheatgrass) in four neighborhoods (5, 10, 15, 20 cm radius) surrounding the target plant. We used linear models to analyze the impacts of the neighbors' covers and densities on the cover of the target. AIC model comparison suggested that increasing neighborhood size increased model performance. We also evaluated the impact of the most common species in the 20 cm neighborhoods and found that Sandberg bluegrass (Poa secunda) cover was associated with a decrease in target cheatgrass cover at the more ecologically intact site, while western wheatgrass (Pascopyrum smithii) and neighboring cheatgrass covers were associated with an increase in target cheatgrass cover at the more disturbed site. This suggests that site differences may have a larger impact on cheatgrass fitness than life-forms or individual neighboring species.

Proximal and Remotely Sensed Spectral Data Facilitates Wheat Stem Sawfly Infestation Estimates in Spring Wheat

Lochlin Ermatinger

The wheat stem sawfly (Cephus cinctus Norton) was first documented as a significant pest to the production of small grains within the Northern Great Plains (NGP) of North America around the beginning of the 20th century. It is estimated that the wheat stem sawfly (WSS) is responsible for up to $350 million annually in economic losses across the NGP. Management tactics include no-till, crop rotation, and choosing solid-stemmed cultivars. The success of these tactics is seldom documented and adoption is not widespread. The lack of uniform WSS management strategies may be partially explained by the difficulty in monitoring WSS infestation. Due to the cryptic nature of this stem boring insect, the only accurate method of estimating WSS infestation is dissecting large quantities of stems. This is a resource intensive practice that is mostly confined to the research domain. Remote sensing (RS) presents an opportunity to improve WSS infestation monitoring practices. RS is commonly referred to as the study of objects and surfaces through analysis of their spectral behavior. Building off the work of Nansen et al. (2009) we are conducting a multiscale study of the reflectance of wheat in the presence of WSS infestation to identify reflectance behavior consistent with WSS injury. To accomplish this, we grew wheat plants in a controlled environment and monitored their reflectance with a hyperspectral spectroradiometer (350-2500nm) at the leaf and plant level on weekly basis. This study presents novel proximal remote sensing methods for detection of WSS infestation in growing wheat plants.

Poster Presentation Abstracts

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Crop rotation and residue effects on soil function

Zane Ashford

In semi-arid agricultural systems typical of the northern Great Plains, crop residue is the most readily available and sustainable source of organic matter input for building soil health. We conducted on-farm research at Cavin Steiger's farm in Forsyth, Montana, to compare post-harvest residue effects on soil function, following crop rotations with cereals, legumes, oilseeds, and sugar beets. Specifically, we measured biological indicators of nutrient cycling capacity because of their sensitivity to changes in land management practices. The geometric mean of extracellular enzyme activity, a measure of average nutrient cycling capacity, was highest in soil previously cropped in sugar beet ($p=0.0004$). Potentially mineralizable nitrogen, a proxy of nitrogen availability, was higher in sugar beet soils compared to those cropped with sunflower, but not significantly different than those cropped in fava bean or wheat ($p=0.04$). Soil health indicators did not correlate with biomass of residue inputs that persisted from the previous growing season ($p=0.3$).

Impact of seeding rate, nitrogen availability, and disease pressure in cheatgrass and winter wheat interactions

Laura Berrios-Ortiz

The concentration of winter wheat in the Northern Great Plains results in a specialized pest complex threatening its economic and environmental sustainability. Weeds like cheatgrass (Bromus tectorum) and pests like Fusarium crown rot form a multi-trophic pest complex, but management recommendations do not address them jointly. Understanding how crop management affects these two pests is essential to provide producers with ecologically based recommendations that reduce the reliance on off-farm inputs. To do this, we asked: (1) How do disease pressure and management decisions affect the competitive interactions between cheatgrass and winter wheat? (2) How does winter wheat competition affect the population dynamics of cheatgrass? (3) How does F. pseudograminearum vary according to seeding rate and nitrogen levels? and (4) What are the pest management tradeoffs? Three test sites were established in 2021 and 2022 in Montana using a split-plot design for 16 treatment combinations of two seeding rates, two levels of nitrogen, with and without cheatgrass, and with and without fungicide. Data included winter wheat yield, cheatgrass biomass, nitrogen availability, and pathogen isolations. Results indicate an interaction (ANOVA II $\chi 2$ $p=0.05$) between cheatgrass biomass and seeding rate on crop yield and solid evidence (ANOVA II $\chi 2$ $p=0.006$) of the interaction between available nitrogen and disease pressure on crop yield. Understanding how pests and crops interact under different management scenarios will allow farmers to make informed decisions based on the ecological context of their production. Thus, we will develop and deliver easy-to-adopt, economically viable, and environmentally appropriate recommendations for the joint management of grassy weeds and pathogens in winter wheat.

Evaluation of fall-applied residual herbicides for weed management in Chickpeas

Akamjot Brar

Weed management at earlier crop stages is crucial for successful establishment of chickpeas. Early emerging weeds out compete the crop for water, light and nutrients. Fall application of residual herbicides can reduce weed abundance of these early emerging weeds in spring planted chickpeas. The crop safety and weed control of 13 combinations of soil active herbicides applied in fall and followed by single application of post-emergent herbicide after spring planted chickpeas, was evaluated in field experiments at two sites in Montana (Huntley and Corvallis), in the year 2021-22. The herbicides combinations, ethalfluralin + triallate and pyroxasulfone + flumioxazin, provided 70-80%% suppression of Bassia scoparia and Amaranthus retroflexus at Huntley and Chenopodium album at Corvallis before POST. Post-emergence application of clethodim and bentazon increased control from 90 to 100% by eliminating late emerged weeds. None of the herbicides showed any damage to the chickpea crop.

Managing Invasive Annual Grasses using an Integrated Indigenous Perspective

Ian I. McRhew

Invasive annual grasses threaten the remnant Palouse prairie grasslands in northwestern Montana, which include ecosystem services of pollinator refuge, forage for wildlife and livestock, and habitat for culturally important species for the local Séliš, Ksanka, and Qĺispé Tribes. This project tested tolerance of culturally significant species to herbicides commonly used to control annual grasses, with a goal to increase abundance of native grasses, forbs, and shrubs. Six herbicides and nine plant species were individually tested. Treatment combinations were arranged in a strip-plot design and replicated three times at two sites on the Flathead Reservation. The majority of herbicide treatments were applied October 2021; however, the glyphosate treatment was applied March 2022, and indaziflam was applied August 2022, thus the efficacy of indaziflam will be assessed summer 2023. Canopy cover of annual grasses were sampled summer 2022, and the non-treated control ranged from 20% to 57% across both sites. At both sites, rimsulfuron and sulfosulfuron had the greatest effect on annual grass cover, reducing cover to 2.8% and 3.1%, at the Plant Lane site, and 0.5% and 15.2%, respectively, at the North Valley Creek site. Propoxycarbazone, imazapic, and glyphosate had much less control on both sites; however, annual grass cover was still less than the non-treated control. The seeding treatment occurred March 2022 and density of seeded species was recorded by measuring frequency of plants/m2 in the summer 2022. With the exception of Rocky Mountain Bee plant (Cleome serrulate), seeded species were not evident the first growing season. Annual grass cover will be sampled again in 2023 along with pollinator visitation to seeded species, and density of seeded species. These strategies for restoring native pollinator communities impacted by invasive annual grasses will inform local land managers of ecosystem services that are vital to the future of Tribal food sovereignty systems.

Determining the Critical Weed Period of Organically Grown Carrots

Emma Kubinski

An essential aspect of adopting an integrated weed management plan is understanding the critical period of weed control. This information is of special importance in carrot (Daucus carota) production given the crop's high potential for yield decrease due to weed pressure. This challenge is further compounded in organic agriculture where synthetic chemical control cannot be relied upon, often limiting weed management to labor-intensive methods. Determining the critical period of weed control will help to minimize labor needs while optimizing yields, crop quality, and economic returns. To determine the critical period of weed control, the maximum amount of time early-season weed competition (i.e. the critical timing of weed removal), and the minimum weed-free period required to prevent unacceptable yield reductions (i.e. the critical weed-free period). To evaluate this, a field study was conducted in Bozeman, MT during the 2021 and 2022 growing seasons. The experiment followed a randomized block design with six weed removal treatments applied based on the carrot leaf stage, plus a season-long weed-free and a season-long treatment. In addition to yields, marketability and sugar content were also evaluated. Preliminary findings suggest that the critical period of weed control ranges between weed-

free to the 2-leaf stage and weedy to the 4-leaf stage. To generalize our results, the carrot leaf stage will be correlated to growing-degree days. A four-parameter log-logistic regression analysis will be used to assess the length of the critical period of weed control and to graphically represent the impact of the length of crop-weed competition on yield, sugar content, and marketability. Results from this study define the critical period of weed control and enable organic carrot growers to have a more efficient and affordable integrated weed management program.

Testing Biofertilizer Application from a Prototype Montana Biodigester Unit on Cabbage and Spinach Crops

Tyler Kulak

In an era with a increasing demand for sustainable fuel and fertilizer sources, biodigesters may be able to address this growing need as a biodigester breakdown food waste into methane biofuel and nutrient rich biofertilizer. In cold climates, like Montana, questions to the efficacy of a biodigester and research into how to improve it's design in a colder environment is required. To evaluate the unit's efficacy, we're testing biofertilizer produced by biodigesters in the Gallatin Valley, on cabbage and spinach in a greenhouse study. Treatments consisted of a control (no biofertilizer), low, and high application doses. This study will quantify the effectiveness of biofertilizer applications by looking at plant heights and dry weights in order to aid future research into how to optimize biodigesters in colder climates.

Wetland Mitigations Bank Credits: Functional Capacity Units ensure a no-net-loss of wetland function. But, can Service Capacity Units ensure a no-net-loss of wetland value?

Alexandra Lin

Since the 2008 Wetland Compensatory Mitigation Rules, wetland mitigation banks (MB) have become the most popular, and federally encouraged means of compensatory mitigation. MB are designed to compensate for unavoidable impacts to wetland area, functions, and values, yet are heavily skewed toward compensating for loss to wetland functions. Yet there is a lack of literature and programmatic approaches to compensate for the economic and social values caused by the loss of wetland ecosystem services (ES) from unavoidable wetland impacts. For instance, how does an MB compensate for the loss of Flood Attenuation to a local population? The geographic relevancy of the wetland ES of Flood Attenuation makes it an ideal measure of the spatial disparities caused by MB. Further, because MBs are often located in rural regions, analyzing the ES of Flood Attenuation provided by wetlands is vital in understanding the effects of redistributing wetlands to these MBs. The Hydrogeomorphic Approach (HGM) and Montana Wetland Assessment Method (MWAM) provide means to create a Functional Capacity Index (FCI) for dynamic surface water storage and, by including spatial attributes, a measurement of the Service Capacity Index (SCI) for Flood Attenuation. Functional Capacity Units account for MB credit purchases and ensure a no-net-loss of wetland function. However, can Service Capacity Units be used for MB credit purchases, and will they ensure a no-net-loss

of wetland value? Here we use MBs located in the Upper Missouri and Middle Yellowstone regions of Montana as case studies for this comparison.

Hydrologic and Geomorphic Effects of Steep-Hillslope Tethered-Logging of Beetle-Kill Forest on Monarch Pass, Colorado

Madeline Roberts

The goal of our project is to evaluate the viability of steep-hillslope cut-to-length logging as a forest management strategy to mitigate wildfire potential of stands that had high tree mortality from mountain spruce beetle. This research evaluates the hydrologic and geomorphic effects on the hillslope with a focus on quantifying the relationship between erosion, ground cover type, and precipitation intensity.

Data Driven Irrigation Scheduling for Water and Nitrogen Use Efficiency

Meghan Robinson

Water is the primary limiting resource for crop production in semi-arid climates, and water management will be critical for the future of sustainable agriculture. Nitrogen can be an important limiting resource for crop production as well, and due to its mobility, it is susceptible to leaching below the rootzone with deep percolation. Soil moisture management is an important mechanism for controlling water and nitrogen use efficiency, which is particularly relevant in irrigated systems where the quantity and timing of supplemental water applications are decided by producers. Increasing soil moisture with irrigation can result in higher crop yields, but also increases the risk of runoff, deep percolation, and associated nitrogen loss. We expect that implementing data-driven irrigation scheduling can reduce water and soluble nutrient losses by allowing management decisions based on soil moisture conditions relative to soil water holding capacity. In this research, we will work with producers growing potatoes in the Gallatin Valley and barley on the Fairfield Bench near Great Falls to explore interactions among soil water holding capacity, weather, and irrigation management to understand how irrigation scheduling can maximize water and nitrogen use efficiency. We will install soil moisture sensors and suction cup lysimeters to capture nitrate in the fields of cooperating producers under both their standard practices and data-driven irrigation scheduling methods. We will use field measured soil moisture data to calibrate Hydrus water flux models, and then use models to predict deep percolation under actual irrigation management and hypothetical scenarios. Using lysimeter nitrate concentrations and predicted deep percolation, we will estimate nitrate leaching rates over the course of a growing season. Preliminary modeling results suggest that under similar quantities of total irrigation, soil moisture-based irrigation scheduling produces less deep percolation than fixed date irrigation, representing the potential for improved water use efficiency and downstream water quality.

Does Remotely Sensed Forest Management Help Predict Wildfire Severity?

Rich Schonenberg

Wildfires in the western United States have increased in frequency, severity, and total burned area over the past 50 years, and have become more destructive over the past decade. Forest management, through the alteration fuels composition, alteration of local energy budgets, and biogeochemical shifts, influence fire behavior and severity. Regional scale forest management is a poorly understood factor for the occurrence and severity of wildfire. In this research we Intend to answer the questions, "Does Remotely Sensed Forest Management Help Predict Wildfire Severity"? and if so, "Which Forest Management type is the best Predictor of High Severity Wildfire?

Improving agronomic traits of Camelina sativa with combined rhizobacterial inoculants.

Henry Stowell

Camelina sativa is a potential oilseed feedstock. Various strategies are being explored to improve the sustainable of its production such as the implementation of plant growth promoting rhizobacteria (PGPR), beneficial microbes that form plant associations through the rhizosphere. PGPR can aid plants in nutrient-uptake, nutrient solubilization, and disease suppression, and can bolster plant growth through the production of phytohormones. Plant growth responses vary greatly between plant species with the same bacterial species, and between potential PGPRs. We examined the response of agronomic traits in C. sativa to inoculations of three PGPR candidates, both with individual candidate inoculations and combinations thereof. Preliminary results suggest that combined inoculations of Bacillus thuringiensis (ATCC 33679) and Pseudomonas putida (ATCC 12633) significantly increased the mean plant height and significantly decreased the mean time to flowering of C. sativa grown in greenhouse conditions. Additionally, combined inoculations of B. thuringiensis and Pseudomonas brassicacearum (Strain 36D4 closest match) significantly decreased the mean time to flowering. Trait measurements such as seed yield and total dry biomass are in progress and will provide further insight into the effects of these candidates.