2016 UROP PROJECT IDEA LIST

1. **Using atmospheric modeling and aircraft measurements to determine global sources of pollutants**

Research Description

This project will use a global model of the atmosphere (www.geos-chem.org) to simulate concentrations of key toxic air pollutants. We will use airborne and ground-based measurements to test the model and draw conclusions regarding the emission sources of these chemicals and how they affect human health globally. Students will work on machines at the Minnesota Supercomputing Institute (MSI), and should wish to gain experience with Unix and scientific programming. Programming experience would be helpful but is not required; students can learn on the job.

Contact Person

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2. **Investigating over 100 years of red pine forest dynamics at the Cloquet Forestry Center**

Research Description

Red pine is an important tree species across Minnesota's forested landscape in terms of its ecological and economic significance. Despite its importance, there are few long-term datasets available to assess the long-term growth dynamics of red pine. One such study is available at the Cloquet Forestry Center (CFC). This nearly 200-year old stand (2-acres in size) has seen a number of fires but has otherwise been managed very little, providing a unique dataset to understand the natural development of Minnesota's red pine forests. Forest inventory measurements occurring in 1912, 1917, 1922, 1927, 1932, 1962, 1973, and 2015 provide insights into long-term forest growth and mortality patterns in Minnesota's red pine forests. The objective

of this UROP is to summarize the forest inventory information collected over the past 103 years and conduct a forest health inventory at the CFC.

Contact Person

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3. **Biodiversity Research**

1. The study of plant specimens in the University of Minnesota herbarium Location: St Paul
2. DNA isolation, gene sequencing, DNA fingerprinting, and phylogenetic or population genetic analysis of plants, fungi, or insects in our laboratory Location: St Paul
3. Experiments with fig trees on display in a rainforest exhibit at the Bell Museum of Natural History Location: Minneapolis
4. Digital imaging and data basing to make biodiversity information available on-line Location: St Paul. Beyond tropical rainforest diversity, the latter opportunity could focus on Minnesota flora.

Description:

The island of New Guinea is one of the largest remaining tropical wilderness areas in the world and little is known about its plant, fungal, and insect diversity. We have collected plants, fungi, and insects in New Guinea over many years to describe species new to science and to study genetic diversity. These studies aim to document patterns of biodiversity and understand the ecological and evolutionary processes that lead to the formation of new species. We study the pollination of fig trees by specialized insects as a particular case of coevolution (http://geo.cbs.umn.edu).

Contact

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4. **Dairy Farming, Worker Safety and Agricultural Communication**

Research Description

Injury events due to animals are by far the most frequent - and costly - source of worker injury on Minnesota dairy farms. Effective animal handling techniques strengthen farm safety, cow health, and production. Raising awareness about low-stress animal handling techniques, also known as stockmanship, among dairy farmers in Minnesota is critical for the agricultural industry. We must identify the best communication strategies, channels, and content to reach dairy farmers and agricultural media organizations in order to effectively share training and educational materials.

Opportunities for undergraduate research would be to help conduct a content analysis of how the media - including mainstream news organizations, agricultural journalists, and bloggers - and other organizations cover stockmanship and related animal welfare and safety issues, paying particular attention to how they discuss the role of workers and training in their articles and materials. This is a strong first step in identifying the culture and support currently surrounding workers, as they take information back to their communities to implement. The student would also help identify how to build a communication plan and position education and training materials in ways that might resonate with bloggers and other media influencers.

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5. Studies of a Fungal Plant Pathogen: Loose Smut of Oat

Research Description:

Oat in Minnesota is an important crop with multiple commercial applications. While much of the oats produced in the region is used for animal feed or as a companion crop to establish alfalfa, there has been increased interest in recent years in boosting oat production for human consumption. Pathogenic fungi affect both the yield and quality of oat and thus adversely impact production.

A disease of oat that occurs almost everywhere the crop is grown is loose smut caused by the basidiomycete fungus *Ustilao avenea*. This fungus is seed-borne, surviving from season to season on the seed. As the seed germinates, the spore also germinates and infects the seedling. The fungus then grows within the plant until flowers start to form. At that time, the loose smut fungus replaces the seed with the black powdery spores characteristic of this disease. The disease is most conspicuous in organic production systems and elsewhere where seed treatments are not used. The small grains pathology (SGP) laboratory has conducted field screening for oat smut for many years but recently two challenges to screening for disease have emerged. The first challenge arose as we are proposing to screen a collection of oats, which includes a number of species of wild oat, for reaction to *U. avenea.* As the wild oats in the collection are considered to be noxious weeds they cannot be planted in our regular field nursery. The first is that our field screening nursery is frequently infected with significant levels of crown rust. We need a means to control crown rust (*Puccinia coronata*) while still allowing for the smut to develop fully in the oat plant. The project aims to conduct a series of greenhouse experiments to address these challenges.

UROP Project:

The UROP student will also undertake a number of preliminary tests to establish and effective greenhouse-based protocol for screening oat for reaction to *U. avenea*. The UROP student will also determine the impact of fungicides used in the summer field nursery on the survival of *U. avenea*. Spores of *U. avenea,* from treatments with and without a fungicide applied to control *Puccina coronata*, harvested from the 2015 field nursery will be examined for the impact of the fungicide on spore survival and efficacy. Research will be based both in the greenhouse and in the laboratory.

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6. Dwarf, potted gladiolus – R&D of a new product

Research Description.

The University of Minnesota Flower Breeding and Genetic program is breeding new traits into *Gladiolus* to winter hardy, perennials in USDA Zones 3-4 as well as greenhouse types that are short (dwarf) for use as flowering, potted plants. A new gladiolus phenotype recently discovered in a field trial of interspecific flowering seedlings is dwarf, upright plants with large flowers. The flowers are equivalent in size to standard cut or garden types. However, the plants range from 6" to 10" (15-24 cm) in height (soil line to inflorescence tip). Several seedlings with a range of different flower colors have this new dwarf trait. The height range of these dwarf selections, coupled with large flower size and short leaves make these well suited for a new use as flowering potted plants. We do not know how these gladiolus selections will perform as flowering potted plant crops. Such knowledge could help in moving this product type forward as a commercial crop.

UROP Project:

The opportunity for undergraduate UROP research would involve setting up an experiment to force dormant gladiolus corms of our dwarf selections and discover whether any accessions are adaptable to potted plant culture. The objective of this experiment would be to quantify morphological traits (the plant phenotype) that relate to potted plant production. Plants would be screened for their resulting plant morphology to characterize the range of plant growth among the dwarf selections. Important traits, which may influence adaptability and acceptability of gladiolus as flowering potted plants, include the number of leaves, flowering and inflorescences, as well as plant stature. Leaf data to be collected would include leaf unfolding rates (weekly), total number of leaves, leaf lengths, leaf widths (cm) to determine leaf length:width ratios, relative height of leaf tips in relation to inflorescence and flower position, occurrence of tip burn (salt damage) or other noticeable phenotypes (nutritional/disease susceptibility). This data would be used to generate a peer-reviewed publication and direct the gladiolus breeding program forward to finalize R&D of this potential new crop.

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7. Research Area: Plant Sexual Reproduction

Research Description

Plant sexual reproduction is essential for seed and fruit production and therefore key to food production. Sexual reproduction also allows for the mixing of genomes and selection of superior individuals for improving varieties. The process of pollination, where pollen (male gamete) adheres to the pistil (female reproductive organ), hydrates, germinates and grows a pollen tube to the ovule (female gamete) is a first step in seed and fruit development. These processes are also a point where pollen-pistil interactions occur, which regulate fertilization within and between species. Pollination has many fascinating processes, which facilitate or inhibit fertilization. For example, pollen tubes are a single cell with one of the highest known growth rates, exceeding 1 mm/hour. This research studies pollen-pistil interactions and how specific genes and process control pollen tube growth and fertilization.

UROP Project-1

Mate selection is a complex and important process, both for a species and for an individual. Unlike animals, a plant cannot move and has limited control over the pollen that is delivered to its pistils. This project tests the hypothesis that plants exhibit mating preferences by controlling the rate at which pollen hydrates, germinates and grows toward the ovules. The model plant *Nicotiana tabacum* will be used because of the ease in measuring pollen tube growth both *in vivo* and *in vitro*. The methods use controlled crosses among cultivars and a simple method that measures the rate of pollen tube growth to test whether pollen-pistil interactions do discriminate the pollen type or mate and therefore determines the mating preference among cultivars. Results will have important implications to seed and fruit production as well as the evolution of species.

UROP Project-2

Pistils provide nutrition that allow a pollen grain to produce a pollen tube that grows to and fertilize an ovule, producing seeds and fruits. Proteins are an important part of this nutrition and may also function to regulate pollen tube growth rates. This research tests the hypothesis that many of the proteins produced by the pistil are taken up by the pollen by a non-specific

endocytosis mechanism. The model plant *Nicotiana tabacum* will be used because of the ease in measuring pollen tube growth both *in vivo* and *in vitro*. The methods will measure the uptake of proteins into pollen during germination or pollen tube growth. Results will have important implications to seed and fruit production as well as the regulation of pollen tube growth by the pistil.

Research-2: Plant Propagation

An important type of asexual plant propagation is the formation of adventitious roots on shoots (without roots) removed from a plant. This type of clonal propagation is used extensively by the green industry to produce millions of identical propagules of a specific plant. Species and even different cultivars within a species differ greatly in their ability to form adventitious roots. To increase propagation efficiency, methods are optimized for a species or cultivar, allowing for the propagation of clones with identical characteristics, for sale to consumers.

UROP -Project

Several new selections of *Acer ginnala* (Amur maple; a popular landscape tree) were selected from a population of mutagenized individuals. In order to perform replicated tests of the selections in a variety of environments and begin propagation for possible sale, an efficient method of asexual propagation is required. This project will test several methods for rooting greenwood cuttings of *A. ginnala*. The methods will measure rooting in several different growth regulator applications and root development in different media. Rooting will be evaluated both by the number of root initials formed and the length of roots produced. This research will provide important information to the green industry for the propagation of Amur maples. Note, due to the use of greenwood cuttings from field-grown plants, this UROP will begin during Spring semester 2016 and continue into the summer.

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8. **Mineralogy of Deep Ocean Deposits**

Research Motivation:

Marine hydrothermal circulation is a fundamental process in which heat and chemical species are exchanged between seawater and the ocean crust; this process drives biogeochemical cycling of many elements, including iron, in deep marine settings. These circulation processes result in the venting of hydrothermal fluids at the seafloor and the formation of hydrologic features called plumes. Hydrothermal venting is globally widespread, and responsible for a dissolved iron flux to the ocean that is approximately equal to continental riverine runoff. However, much of the iron precipitates within plumes as mineral particles within about 100 km of the vent site. It has been observed that particles within plumes concentrate a variety of trace elements from seawater (rare earth elements and certain oxyanion species, such as phosphorus, arsenic, and vanadium). The primary geochemical mechanism driving the reactivity of plume particles with seawater elements is thought to be iron-bearing minerals. Therefore, our group studies the mineral structure and reactivity of particles that form in plumes.

The UROP Project:

The Toner Group has participated in oceanographic research cruises to a variety of deep-sea sites of hydrothermal venting over the past 7 years. During those cruises, plume particles were collected using submerged filtration pumps. For most of these studies, the mineralogy of the particles has been described through graduate student research activities. For this UROP project, we envision a motivated undergraduate scientist working with original, but as yet unanalyzed, data sets to identify the minerals present in the samples using the software program *JADE*. In addition, we would like the undergraduate researcher to develop a particle counting method based on scanning electron microscopy (SEM). Results will be published in peer reviewed geochemistry journals. The UROP student will be invited to participate in the Toner Group research meetings, and discuss research findings regularly with Professor Toner, Ph.D. students, and undergraduate students.

Successful UROPs:

The proposed research project will require a person with good computer skills, self-motivation, attention for detail, and drive to create new scientific approaches and knowledge. The researcher should also be willing to learn basic geochemistry and mineralogy in support of their method development.

Contact

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9. Project Title: The call of the wild: Exploiting wild cereal species for cultivated wheat and barley improvement.

Research Description:

Since the time of first domestication, genetic diversity in cereal crop species has been seriously eroded. This has resulted in genetic vulnerability to many pathogens and insect pests. The wild relatives of wheat and barley are a virtual treasure trove of diverse alleles that can be exploited for use in improving the cultivated species. We have large collections of various wheat and barley progenitor species from across their native habitats in the Near East, North Africa, and Central Asia. These collections are being phenotyped for many traits of economic importance (yield, disease resistance, agronomic traits, salt and drought tolerance, etc.) and genotyped with thousands of molecular markers to map genes underlying these traits through a technique called association genetics. This information will be valuable for transferring important genes into cultivated wheat and barley, thereby enhancing their productivity and adaptation.

UROP Project:

Two UROP positions are available. The first involves the wild wheat species *Aegilops sharonensis* and second the wild barley species *Hordeum vulgare* subsp. *spontaneum*. UROP students will characterize the respective species for traits of their interest (disease resistance, agronomic traits, abiotic stress tolerance etc.), analyze genetic diversity (see Olivera et al. Crop Science 2010. 50:636–648), and utilize geographic information system (GIS) to investigate the ecogeographic distribution of variation for target traits. Depending on individual interests, students will learn about plant pathology, phenotyping of plants for biotic and abiotic stresses, genetics, genome-wide association study, plant genetic resources, and bioclimatic effects on native populations of wild cereal species for various traits. Research may be based in the greenhouse, laboratory and/or field depending on the type of project developed.

Contact:

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10. UROP proposal: Bioproducts and Biosystems Department

Proposal 1: Midwest Floating Island Nutrient Treatment

I'm currently running tests on floating island treatment systems using microcosms located between the Sarita Wetland and fore bay. I would like an undergrad to assess:

Mycorrhizal fungi live on the roots of the plants and alter plant-inaccessible phosphorous into a plant-available form. However, most of the studies done on this were focused on environments with low phosphorous availability and how plants benefited from the fungi. It would be interesting to know how they reacted in a high phosphorous environment where P-sequestration is the goal.

Analyze the phosphorus removing organisms and how they change over a 7 days period and how that correlates with changes in phosphorus concentration. This could also be done with samples taken from the roots of the plants using DNA fingerprinting.

Proposal 2: Cover Crop Runoff Response

I have two studies that explore best management practices within small watersheds, I would like an undergrad to measure change in water infiltration using field tests on fields that have used multiple years of cover crop vs control sites with no cover crop activity.

Contact Person:

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11. Project Title: *In vitro* digestibility of nutrients of various microalgae products of possible use in diets for growing pigs

Research Description:

The objective of our research is to describe the nutritional value of microalgae and microalgae co-products for growing pigs. Microalgae are a growing technology in production of biofuels. Large amounts of microalgae

products can be available for animal feeding programs. However, little is known regarding their nutrient composition and utilization in diets for pigs.

UROP Project:

Specifically, the objective of this UROP project is to measure *in vitro* digestibility of nutrients of 4 microalgae products. These products were produced in collaboration with the laboratory of Dr. Roger Ruan and Chi Chen. The student will be expected to learn the steps to correctly measure *in vitro* digestibility of nutrients from our Post-Doctoral Research Associate. The student will be expected to present a summary of the data to the swine nutrition group.

Contact Person:

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12. UROP Research Project

My current research interests focus on the development of socially responsible leadership, college student leadership development, and faculty perspectives about the use of service-learning in the leadership classroom.

Students interested in research related to women's leadership in agriculture may contact me to explore research options.

Contact Person:

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13. Somalia agriculture and soils

Description

This project will assist in acquiring and interpreting agricultural data relative to soils, crops and livestock production systems in Somalia. Historical and current soils data from southern Somalia will be compiled and assessed relative to on-going research conducted by the Somali Agricultural Technical Group (SATG) (www.satg.org). The assessment will lead to the possible inclusion of a location near Afgoi, Somalia, as a "Sentinel Site" for the Bill and Melinda Gates Foundation funded Africa Soil Information Service (AfSIS) project (http://www.isric.org/projects/africa-soil-information-service-afsis). The sentinel site will be sampled and characterized using consistent sampling protocols referred to as the Land Degradation Surveillance framework (LDSF). Nic Jelinski of the Department of Soils, Water and Climate will help oversee this project.

This person will work with a larger on-going public-private-partnership involving the University of Minnesota, SATG, the Somali diaspora, UN agencies and NGOs involved in Somalia.

Contact Person:

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14. Sustainable & Organic Horticultural Food Production Systems

Project 1. Evaluating the performance of biostimulants on vegetable transplants in organic production systems

Overview: Biostimulants are production-enhancing products often formulated from beneficial microorganisms to confer a benefit (such as drought tolerance, disease resistance, improved vigor etc…) to crops. But do they really work? This project will evaluate a suite of commercially available biostimulants on a variety of vegetable crops in the greenhouse and compared to non-treated controls to measure efficacy.

Project 2. Evaluating the effects of organic fertilizers on insect herbivory of brassicas

Overview: Nutrient availability influences plant quality and host plant suitability of insect herbivores. This project will investigate the response of imported cabbageworm caterpillars to different types (organic vs. synthetic) and rates of fertilizers in brassicas (broccoli and/or other crop). This will be performed in the greenhouse, but may have the opportunity for field application in 2016.

Contact Person

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15. **Dispersal of human pathogens by migratory birds**

Description

In this project, students will explore the impact of migratory birds on water quality and food safety. Migratory birds such as Canada goose are known to harbor human pathogens such as *Salmonella* and *Campylobacter*. These birds can disperse pathogens to wide areas through their fecal droppings and contaminate water and soils. However, impact of migratory birds on water quality and food safety is not well understood. Students can use both culture-based method and state-of-art molecular biology tools to quantify and characterize pathogens in environmental samples.

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16. **Spatial and Depth Distribution of Lead in Urban Soils**

Description:

Lead in urban soils can be a contributing factor to the risk of elevated blood lead levels, especially in children. Although significant progress has been

made over the past 3 decades in raising awareness and reducing exposure to lead, elevated blood lead levels remain a public health concern in some urban areas. This project will assist in analyzing and collecting data on the distribution of lead in urban soils of the Twin Cities Metropolitan Area. Specifically, an undergraduate student participating in this work will 1) investigate the potential for handheld magnetic susceptibility meters to screen and map household and garden properties for soil lead, in conjunction with other techniques, 2) assist in the analysis of existing datasets to reveal patterns in the distribution of lead in urban soils and 3) participate in community engagement events which provide screening for lead in soil samples in underserved communities.

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