REU Mentors and Projects 2018
(revised December 1, 2017)

UMBS forest ecosystem study

Chris Gough, Virginia Commonwealth University
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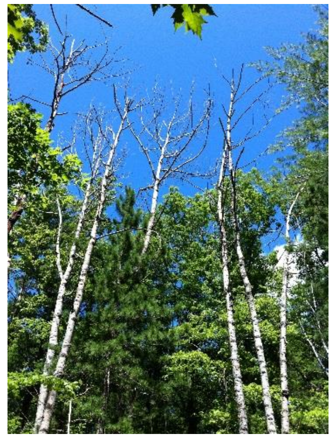
Forests of northern Michigan provide ecosystem services including the capture and sequestration of carbon, retention of nutrients, maintenance of organismal and ecosystem diversity, and protection of surface and ground water quality. Our collaborative team conducts research on the scientific underpinnings of these ecosystem services, with particular emphasis on landscape and community ecology, forest succession, carbon and nitrogen biogeochemistry, botany and mycology.



We conduct this research in a variety of settings, including a large-scale experimental treatment forest (stem girdling of >6700 trees in 2008) and a pair of long-term chronosequences (stands aging from 20 to >200 years old), utilizing proven methods to understand forest functioning at all stages of succession.

REU student collaborators on the UMBS Forest Ecosystem Study team have numerous research options. Some examples include: 1) how shifts in forest composition and structure alter forest carbon cycling; 2) mechanisms behind sustained high rates of carbon storage in a maturing forest; 3) fungal processes controlling decomposition and tree nutrient supply.

Effects of climate change on wetland biodiversity

Amy Schrank, Michigan Technological University

Climate change is predicted to result in significant losses in both the amount of and the biodiversity within Great Lakes coastal wetlands. Coastal wetlands provide important ecosystem services including nursery areas for the majority of Great Lakes fish species, important habitat for wildlife including rare and endangered species, a filter for pollutants and sediment, shoreline protection against wind and waves, and many others. Climate change is predicted to lower Great Lakes water levels overall and this is likely to promote colonization of wetlands by invasive plant species such as the aggressive invasive cattail (*Typha X glauca*). This invasive plant severely reduces native plant diversity in wetlands and changes the physical habitat structure as plant litter accumulates and habitat for small aquatic species (larval fish, macroinvertebrates, and larval amphibians) disappears. We are interested in how different methods of invasive cattail harvest have the potential to increase biodiversity in invaded coastal wetlands, with the goal of informing future restoration practices on how best to combat wetland loss in the face of climate change.

During the 2018 field season we will be sampling fishes, macroinvertebrates, and larval amphibians in cattail invaded wetland treatment plots to determine if different configurations of mechanical harvesting of invasive cattail species affect biodiversity. An REU student working on this project could ask a variety of questions on topics such as: 1) the effects of invasive cattail on biodiversity of aquatic species (fish, macroinvertebrate and/or amphibian larvae), 2) how changes in physical habitat structure (plant stem density, increasing plant species homogeneity) affect use of wetlands by aquatic species, 3) how patterns of habitat use might change as water levels decline in the future as a result of climate change, or 4) how increases in marsh edge as a result of wetland restoration activities affect biodiversity. A student working on this project will gain extensive field work experience and have the opportunity to collaborate with researchers working with a variety of wetland species.

How does wetland restoration alter greenhouse gas flux?

Beth Lawrence, University of Connecticut, Storrs
Shane Lishawa, Loyola University Chicago

Hybrid cattail (*Typha X glauca*) is an opportunistic wetland invader that reduces native biodiversity and alters ecosystem functioning. During the 2015 growing season, we initiated large scale (60x60m plots) restoration treatments (biomass harvest, mow, or control) in the *Typha*-dominated Cheboygan Marsh near UMBS. Our goals are to promote native marsh biodiversity recovery and create a source of renewable energy. However, little is known about how the different restoration treatments will influence greenhouse gas fluxes (CO_2, CH_4, and N_2O). Removal of *Typha* biomass may reduce the availability of labile organic matter and thus reduce greenhouse gas emissions, whereas mowing may increase carbon availability and result in greater flux rates.

An REU student working on this project could design an experiment to test how *Typha* restoration treatments alter field-based greenhouse gas fluxes, and will gain valuable field and laboratory experience.

Climate change effects on the threatened Pitcher's thistle on Lake Michigan dunes

Brian Scholtens, College of Charleston
Claudia Jolls, East Carolina University

The Laurentian Great Lakes basin houses the world's largest concentration of freshwater dunes, which in turn support more endemic species than any other part of the basin. Yet, this rich biodiversity is exposed to an unsettling and increasing variety of threats, including climate change and invasive plant and herbivore species. Since 1993, we have studied *Cirsium pitcheri*, Pitcher's thistle, a federally threatened plant endemic to the dunes and shorelines of the upper Great Lakes. Because Pitcher's thistle has no means of vegetative reproduction, successful seed set is critical for population persistence and survival of this iconic species. Unfortunately, seed predation by two invasive beetles, *Larinus planus* and *Rhinocyllus conicus*, can reduce Pitcher's thistle seed output by 50-95%.

Pitcher's thistle is one of several federally listed plant species predicted to be most impacted by climate change. Populations at the southern edge of the species range declined by 50% from 2005-2010. Modeling of the suitable climate envelope predicts contraction of range and a shift east, possibly away from the shores of Lake Michigan to Lake Ontario, where limited dune systems occur. The interactions among climate change, non-target biocontrol impacts, and invasive species are important new threats for Pitcher's thistle and the dune ecosystem.

Climate change will increase temperature under, at, and above the dune surface. An REU student working with us could ask, for instance, how seed germination will be affected by temperatures under and at the dune surface, or how seed predation by invasive beetles will be affected by temperatures at and above the dune surface. Other project addressing weevil distribution, phenology, and host specificity may also be possible.

Pollinator networks in a changing climate

[Israel Del Toro, Lawrence University]

The Pitcher's thistle is a federally threatened species with an extensive network of pollinators. In a changing climate, it is important for us to better understand the complex interactions between native pollinators and this species to better develop a successful conservation strategy. This project uses field observations, and statistical and spatial models to develop better predictions of how this plant-insect interaction will change in future climates. Possible student projects could explore whether the pollination mutualism between this threatened plant and native pollinators will be resilient to a changing climate or whether this mutualism may breakdown as the climate warms. Using spatial distribution models for the most abundant pollinators and comparing those to the thistle's distribution model can help us predict how differing range dynamics can lead to ecological mismatches. Students interested in pollination ecology, conservation biology, ecological modeling and biogeography are encouraged to apply

Effects of climate change on spatial behavior, disease transmission, movement, and reproduction of the forest mouse, *Peromyscus leucopus*.

[Ben Dantzer, University of Michigan]

Global climate change is predicted to increase the frequency and intensity of forest fires and forest pest outbreaks, both of which may alter spatial patterns of soil moisture and vegetation structure which, in turn, may affect the spatial behavior, disease transmission, movement, and reproduction of small forest mammals such as the white-footed mouse, *Peromyscus leucopus*. For instance, in response to increasingly patchy soil moisture, mice may decrease their home range sizes, which can increase the frequency of social contacts and, therefore, opportunities for disease transmission (white-footed mice are disease reservoirs).

UMBS has two large scale experiments that allow REU students to investigate the impacts of climate-induced forest disturbance on small mammals that are important components of forest ecosystems. The UMBS Burn Plots, a chronological series of 1-hectare burned forest plots, provide a natural opportunity to examine the effects of forest fires and time since the last fire. The nearby Forest Accelerated Succession Experiment (FASET), a 40-hectare area where all early successional trees (aspen and birch) were girdled several years ago and have since died, provide an opportunity to examine the effects of forest pest outbreaks.

To determine whether increasing forest fires are likely to alter mouse spatial behavior, parasite loads, and/or reproduction, an REU student could characterize soil moisture patterns, vegetation structure, and food availability in the UMBS Burn Plots, perform mark-recapture studies with mice, handle mice to characterize basic demographic and reproductive information, and measure the behavior (activity/exploration in standard behavioral assays, home range size) and disease loads of mice using blood and fecal samples and ectoparasite surveys. Students would develop expertise in fieldwork, behavioral observations, data collation, and statistical analyses.

To determine whether increasing tree mortality due to pest outbreaks is likely to affect mouse reproduction (*e.g.* when they breed and for how long) either directly (by reducing food availability) or indirectly (by favoring mice with specific behavioral characteristics) an REU student could collect data on tree seed availability and other sources of food within plots that experienced a range of disturbance levels, perform mark-recapture studies with mice to estimate population dynamics, handle mice to characterize basic reproductive information. Students could also measure the behavior and disease loads as described above.

Interaction of stream flow and benthic organisms

Paul Moore, Bowling Green State University
David Edwards, Bowling Green State University

Stream flow is the primary abiotic factor influencing stream ecosystem function. Physical forces associated with the flow can affect in-stream organisms such as crayfish and macroinvertebrates. However, natural systems have increasingly been under siege through flow alterations in the form of dams, land use, and extreme precipitation events (storms and droughts) due to global climate change. An understanding of the direct and indirect pervasive effects associated with the natural flow regime is crucial to identifying and predicting responses of organisms (and by extension ecosystem processes) to flow alterations. How organisms respond to flow can also enhance our interpretation of any evolutionary adaptations to flow. All of this is vastly important when we consider human influence to natural systems in the context of global climate change.

An REU student with this theme could conduct an in-depth examination of benthic organisms (e.g. caddisflies, mayflies, and stoneflies) above and below dam sites, or the response(s) of organisms such as crayfish to changes in a flow regime (velocity, magnitude or rate of change, drought, etc.). Students could also examine how flow physically allocates resources in different habitats, or some aspect of lake versus river invertebrate ecology.

Effects of climate change on hydrologic fluxes of carbon and mercury from forests to lakes

Luke Nave, University of Michigan
Kathryn Hofmeister, Cornell University

Mercury is a notoriously hazardous pollutant that accumulates in fish, posing health risks to humans who eat fish. From a peak in the 1980s, concentrations of mercury in fish in the Great Lakes region have declined – due to pollution controls – but are again on the rise. The rise, we hypothesize, is a result of changes in the coupled biogeochemical cycling of carbon and mercury. REU students have the opportunity to contribute to this project by collecting data from terrestrial and aquatic ecosystems to determine the role of greater export of dissolved organic carbon (DOC) from watersheds in mobilizing mercury to lakes. Additional project possibilities include studying relationships between geomorphology, hydrology, soil development and biogeochemistry, tracer studies to identify groundwater and surface water movement, and tree-soil-water interactions. REU students could use their results to predict how climate change, by altering hydrologic regimes and soil carbon, might affect transport of mercury to aquatic ecosystems.

Invertebrate mediated ecosystem services in a future climate

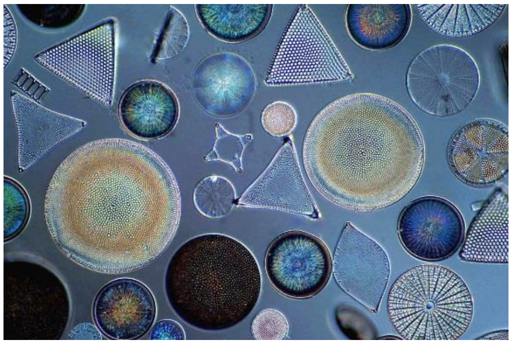
Relena Ribbons, Lawrence University and University of Copenhagen

Soil invertebrates, such as earthworms, ants, springtails, and mites, play major roles in ecosystems and nutrient cycling. Climate and species distribution models have suggested that soil invertebrate abundances are likely to increase as regional temperatures increase. An REU student could manipulate soil invertebrate communities and abundances to evaluate how these changes impact key ecosystem processes like decomposition, nitrogen cycling and soil respiration. Field experiments using a series of experimental plots, together with cutting edge laboratory techniques that evaluate microbial community composition, could reveal the effects of increased invertebrate abundances (*e.g.* earthworms) on key linkages between above and below ground ecosystem processes. For instance, an REU student could calculate how much CO_2 would be added to the atmosphere from increased decomposition and soil respiration. Students interested in invertebrate ecology, microbial ecology, soil biogeochemistry, and climate change are encouraged to apply.

Paleolimnological signals of climate change

Rex Lowe, Faculty Emeritus, Bowling Green State University
Pat Kociolek, University of Colorado

As the climate warms in northern Michigan concomitant changes occur in northern lakes. There are longer ice-free periods in winter and more intense thermal stratification during the summer. This potentially leads to changes in the quality and quantity of phytoplankton in lakes. The history of these changes can be investigated in lake sediments as microorganisms fall to the bottom of lakes. An REU student could examine the relationship between recent climate change and phytoplankton communities in Douglas Lake at UMBS by taking a core of the sediments, analyzing the diatom community and examining correlations with environmental parameters such as temperature and precipitation.



Climate change and wetland ecology

Robert Pillsbury, University of Wisconsin – Oshkosh

Virtually all wetlands are already affected by climate change, and will be more strongly affected in the future. Water temperatures will rise, water levels may fall (or rise), lake summer stratification periods will increase, and the chemical composition of freshwater may change. All of these changes may impact organisms that live in lakes, ponds, rivers, and streams, including algae, zooplankton, and mollusks. Effects will certainly differ among taxa, and may also differ among feeding guilds, and between native and invasive species.

An REU student working with me could choose among a variety of questions. For instance, a student might ask whether warming of lake water will favor certain species of algae, aquatic plants, and/or zooplankton over others. A student could also ask whether warming of lake water will have different effects on native mollusks, such as clams, than on invasive mollusks, such as zebra mussels.

Rising carbon dioxide and plant defense against insect herbivores

Dave Karowe, Western Michigan University

Rising atmospheric carbon dioxide, due primarily to the burning of fossil fuels, is causing plants to have higher levels of carbon but lower levels of nitrogen in their leaves. Today, most plants can respond to attack by herbivores by rapidly increasing their levels of chemical defenses (known as induction), but this is a nitrogen-intensive response because it requires rapid synthesis of RNA and enzymes. An REU student working with me could investigate whether, when grown under future elevated CO_2 levels, plants have higher pre-attack levels of carbon-based chemical defenses, due to higher carbon content of leaves but, due to lower nitrogen content of leaves, are less able to respond to herbivore attack by inducing chemical defenses. A student could also ask whether legumes such as soybean, because they have mutualistic nitrogen-fixing bacteria that provide more nitrogen under elevated CO_2, will still be able to induce chemical defenses in response to herbivore attack later this century. Additionally, a student could conduct feeding trials to determine whether an inability to induce defenses actually makes plants more vulnerable to herbivores.

Global atmospheric change and carnivorous plants

Dave Karowe, Western Michigan University

Carnivorous plants, such as pitcher plants and sundews, use their leaves to capture both carbon and nitrogen. However, they experience a trade-off between these two goals, since green tissue is best for photosynthesis but red tissue is best for prey attraction. An REU student could determine whether, in response to altered availability of atmospheric carbon and/or nitrogen, carnivorous plants are able to adjust their investment in carbon capture traits vs. nitrogen capture traits. For instance, an REU student could design a study to ask whether pitcher plants alter the red:green ratio of their tissues when exposed to future higher CO_2 levels and/or future higher amounts of atmospheric nitrogen deposition.

Effects of road salt contamination on dissolved organic matter in a northern Michigan wetland

Tim Veverica, University of Michigan

In response to increasingly variable winter weather in the Great Lakes Region stemming from global climate change, local municipalities apply road salt more frequently. More freeze-thaw cycles leads to icier roads, for which the prescribed treatment is generally an application of rock salt or brine. In systems which had very low Cl- before roads were paved, UV-reactive dissolved organic matter (DOM) would have degraded to end products such as humic acids that are an effectively recalcitrant pool of organic carbon. However, in the presence of Cl- from road salt, humic acids may degrade into volatile organic compounds, some of which could

deplete ozone or contribute to climate change in other ways. Since roads continue to encroach on wetlands, winter salt applications may have increasingly important effects on the carbon balance of Northern Michigan wetlands. This unexplored potential consequence of a common municipal practice in the Great Lakes Region may, in turn, affect future climate change.

In salt-rich environments, an estimated 90% of all trihalomethane (chloroform, trifluoromethane, etc.) emissions occur through chemical processing of humic DOM. Production of these compounds is influenced primarily by three factors: Availability of free Cl-, incident sunlight, and the UV reactivity of DOM. Using a variety of chemical methods (UV-Vis spectroscopy, ion chromatography, GC-MS), an REU student could ask questions such as 1) What are the effects of differing chloride concentrations on the degradation of wetland dissolved organic carbon? 2) How much chloroform, trifluoromethane, etc. are emitted as a consequence? and/or 3) Does dissolved organic carbon from different wetlands (e.g., marsh, swamp, fen, bog) behave differently?