

## REU Mentors and Projects 2018

(updated February 7, 2018)

### UMBS forest ecosystem study

[Chris Gough, Virginia Commonwealth University](#)

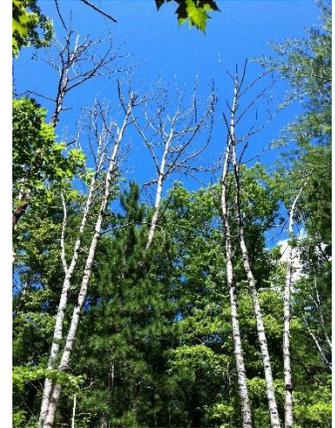
[Luke Nave, University of Michigan](#)

[Chris Vogel, University of Michigan](#)

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 plant and ecosystem ecology, disturbance ecology, ecological succession, carbon and nitrogen biogeochemistry, botany and mycology.

We conduct this research in a variety of settings, including a 20-year experimental forest with a long-running carbon "flux" tower, a landscape-scale experimental disturbance in which >6700 trees were stem girdled, a pair of long-term chronosequences with stands from 20 to >200 years old, and, beginning in 2018, a new experimental manipulation of disturbance severity in which tree mortality will range from 45 to 85 %.

REU student collaborators on the UMBS Forest Ecosystem Study team have numerous research options. Some examples include: 1) disturbance, climate, and forest age effects on carbon cycling; 2) mechanisms sustaining high rates of carbon storage in old forests; 3) remotely sensed ecosystem structure-carbon cycling relationships; and 4) fungal processes controlling decomposition and tree nutrient supply.



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

[Luke Nave, University of Michigan](#)

[Katy 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.

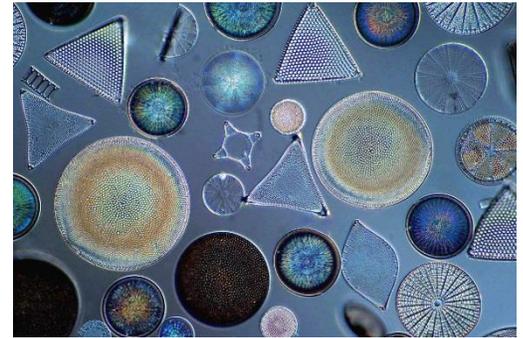


## Paleolimnological signals of climate change

[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 effects on the threatened Pitcher's thistle on Lake Michigan dunes

[Claudia Jolls, East Carolina University](#)

[Brian Scholtens, College of Charleston](#)

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: climate change, invasive plant and herbivore species, other human impacts. 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 beetles released for biocontrol of weedy thistles, *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. Interactions among climate change, non-target biocontrol impacts, and invasive species are new threats for Pitcher's thistle and the dune ecosystem. Pitcher's thistle also has 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 rare species to better develop a successful conservation strategy. We use field observations, greenhouse and growth chamber studies, and models to develop better predictions of how this plant and its interactions with insects will change in future climates. Climate change will increase temperature under, at, and above the dune surface, and change the timing and abundance of plants and insects. An REU student working with us might ask 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 projects addressing weevil distribution, phenology, and host specificity are possible. Student projects could explore whether the pollination mutualism between this threatened plant and native pollinators will be resilient or whether this mutualism may breakdown as the climate changes. Students interested in plant and pollination ecology and conservation biology are encouraged to apply

## Modeling future distributions of Northern Michigan songbirds in a changing climate and a shifting landscape

[J. Jordan Price, St. Mary's College of Maryland](#)

[Jason Tallant, University of Michigan Biological Station](#)

Golden-winged warblers (*Vermivora chrysoptera*) are listed as a species of high conservation concern across their entire range, especially within the Great Lakes Region. Populations in this region are estimated to have decreased by 40 percent since 1970, primarily due to habitat loss and species hybridization. Habitat loss in the regions of concern have been influenced by a confluence of climate change, changes in land management and use, and disturbance caused by invasive species. Golden-winged warblers have specific breeding habitat requirements, and it is unclear how future climate scenarios, land management practices, and interactions with other species will shape the landscapes needed by these warblers to thrive. This project will leverage historical collections, breeding bird surveys (BBS), and eBird citizen science data in conjunction with high resolution remote-sensing data of current land cover and future climate to model the potential future distribution of golden-winged warblers in the Great Lakes Region. Students interested in gaining experience conducting field surveys, creating remotely-sensed high resolution vegetation maps, and employing species distribution models 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](#)

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.

### **Climate-induced forest disturbance and biogenic volatile organic compounds**

[Steve Bertman, Western Michigan University](#)

The forests of northern Michigan have undergone much change in the last 100 years. Currently regrowing from widespread clearcutting, they are strongly affected by the changing climate. Future species distribution will depend on how temperature and soil moisture change in the next several decades, and emissions of biogenic volatile organic compounds (BVOC) into the atmosphere will depend on species distribution. BVOC drive the atmospheric chemistry that determines the composition of the atmosphere near the earth's surface. For example, production of tropospheric ozone, the third most abundant greenhouse gas, is strongly affected by the amount and the mixture of BVOC emitted into the atmosphere. Surveys of white pine saplings in two UMBS forests have determined that intermediate forest disturbance influences the physiological response of BVOC production. The limited range of disturbance currently available hampers the strength of conclusions that can be drawn, so a new large-scale experiment will start this summer. We will look at BVOC composition in paired plots with a prescribed level of disturbance. An REU student would collect samples from different species in all the plots and measure the concentrations using GC-MS.



## Climate change, wetland ecology, and invasive freshwater species

[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 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, or whether it will affect the phenology of emergent insects.

We are also beginning to see signs that climate change is affecting the flora of the Great Lakes and its waterways. Recently the invasive alga *Didymosphenia* has negatively impacted this region and many other pristine areas worldwide. It is suspected that these blooms are being triggered by climate change, although the exact mechanism has not yet been identified. An REU student working on this system could set up experiments along the St Mary's River to answer questions like: What is promoting these blooms in this very oligotrophic water (temperature, shifts in nutrient ratio, current, light)? Do we find corresponding changes in the bacterial community? How do higher trophic levels respond to these changes?



## 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<sub>2</sub> 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<sub>2</sub>, 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<sub>2</sub> levels and/or future higher amounts of atmospheric nitrogen deposition.



## Mercury bioaccumulation in terrestrial carnivores

[Jill Witt, University of Michigan, Flint](#)

Coal-fired electric power generator plants are one of the main anthropogenic sources of atmospheric mercury worldwide. Inorganic mercury, once deposited, can become biologically available as methylmercury and transfer into both aquatic and terrestrial food webs. Toxicity can occur when mercury is transferred up the food chain, biomagnifying as it moves from primary producer, to prey, to predator, and high tissue concentrations can result in detrimental physiological and behavioral effects on top consumers. Mercury deposition in terrestrial ecosystems, and the potential for conversion to a biologically available methylmercury, can vary regionally and by forest cover, potentially leading to differing risks in bioaccumulation and toxicity for wildlife.

An REU student could assess terrestrial ecosystem mercury contamination in tissues of American marten (*Martes americana*), a predator species found in mature forests from across northern Michigan and the Upper Peninsula. A students working on this project would quantify mercury concentrations in marten tissue and hair samples, which have already been collected, and determine if mercury bioaccumulation is concentrated at higher trophic levels in these terrestrial ecosystems. A student would have the opportunity to explore his/her own questions of how future climate scenarios, which differ in the extent of switching from coal to clean energy sources, could influence atmospheric mercury deposition and therefore impact bioaccumulation of mercury in terrestrial food chains. An REU students would gain experience in laboratory chemical analyses and GIS spatial analyses.

