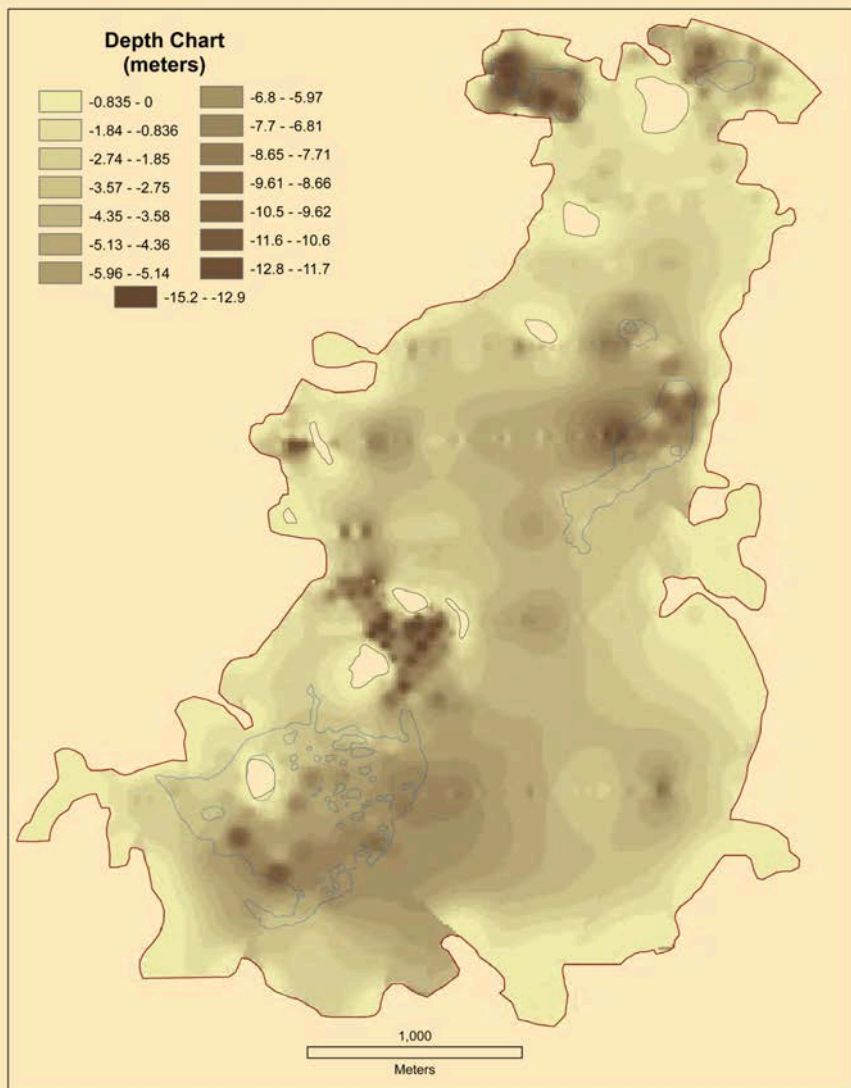


# 2013

# FIELD STATION ANNUAL REPORT



**Bathymetric Map of the Cedarburg Bog**

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***On the Cover:*** Depth soundings throughout the Cedarburg Bog are compiled into this bathymetric map (see Reinartz abstract)

Director:	James A. Reinartz
Manager/Staff Biologist:	Gretchen A. Meyer
Maintenance:	Lou A. Nelson
Administrative Assistant:	Cynthia K. Boettcher
Field Station Committee:	Peter Dunn, Timothy Ehlinger, Glen Fredlund, Tim Grundl, Gerlinde Höbel, Jeffrey Karron (Chairman), Stefan Schnitzer, Thomas Schuck, Erica Young

# About Us

## 2013 Highlights

- We joined a global phenological monitoring network by installing a PhenoCam - a fixed camera that records images of the phenology of a forest community. See abstract by Mark Schwartz.
- Our Farmhouse kitchen was remodeled and modernized with matching funds provided by the Friends of Cedarburg Bog.
- Our new Researcher House used for longer stays by individuals and groups was well-used by several groups of researchers in 2013.
- Extensive Friends of Cedarburg Bog projects to manage invasive glossy buckthorn in the Cedarburg Bog.
- Management of the Habitat Protection Area at UWM's new Innovation Campus in Wauwatosa made major progress on control of invasive species and establishment of native plant communities.
- Use of Downer Woods on campus for education and research remains strong, and control work on invasive common buckthorn and honeysuckle has made major progress. Garlic mustard is now in control down to a sustained management level. Downer Woods was named a UWM campus gem in 2013.
- A second consecutive spring controlled burn of the Benedict Prairie in Kenosha County made progress toward control of woody plant invasion.
- 38 research projects in 2013
- Almost 11,000 student hours of instruction and group use in 2013.

## The UWM Field Station

The UWM Field Station is used as an outdoor laboratory by researchers from various disciplines, including plant and animal ecology, evolutionary biology, ethology, taxonomy, geology, hydrology, and climatology. Located in the Town of Saukville, Wisconsin, about 30 miles (45 minutes) north of Milwaukee, the main Station facility has about 2000

acres including a wide variety of habitats available for research and teaching. The University of Wisconsin-Milwaukee owns approximately 320 acres, most of which were donated by The Nature Conservancy in 1964. Research at the Station has produced 329 scientific publications and 145 theses since 1970.

## Natural Areas at the Field Station

### The Cedarburg Bog State Natural Area

- One of the largest and the most biologically diverse of the wetlands in southern Wisconsin, is accessible to researchers and classes by the Field Station's boardwalk. Shallow and deep lakes, marshes, shrub communities, sedge meadow, hardwood swamp, conifer swamp, and the southernmost string bog in North America are just some of the vegetation types of the Cedarburg Bog. Populations of at least 35 species of higher plants and 19 birds are at or near the southern edge of their range in the Bog. The Bog is part of the national system of Experimental Ecological Reserves established by the National Science Foundation and The Institute of Ecology. A "Guide to the Natural History of the Cedarburg Bog," which serves as a ready introduction and reference source for researchers and educators using the Bog, is available from the Field Station and on our website. Trees with confirmed infestations of Emerald Ash Borer were found at the north end of the Cedarburg Bog in 2013. Approximately 12% of the trees in the Cedarburg Bog are black ash, accounting for 10% of total tree basal area, and 2% are green ash, 4% of basal area; we expect to lose all of these ash over the next few years.

### The Cedarburg Beech Woods State

**Natural Area** – 80 acres of one of the finest mature beech-maple forests in southern Wisconsin. The scale insect associated with beech bark disease has been found in the Cedarburg Beech Woods, although the disease is not known to occur here yet. Adult

Emerald Ash Borer beetles were captured in traps at the Station in 2012 and 2013, although signs of damaged ash trees in the upland forest have not yet been observed. The Cedarburg Beech Woods SNA is likely to experience major changes within the next few years. The beech-maple forest and the Cedarburg Bog are each State Natural Areas, and are classified as National Natural Landmarks by the Department of Interior.

#### **The Sapa Spruce Bog State Natural**

**Area** – 12 acres of highly acidic black spruce/tamarack bog and 11 acres of swamp hardwoods. The southernmost black spruce bog in Wisconsin, the small, acidic, Sapa Spruce Bog provides an ecological contrast to the large, neutral-pH, Cedarburg Bog, with which it shares most of its flora.

**Old Agricultural Fields** – Over 100 acres in various stages of succession are available for experimental research. A history of the use and management of the fields over the past 40 years is maintained. Six separate areas in the old fields have been planted with prairie species native to Wisconsin. A new experimental prairie area planted in the “North Hay Field” in the fall of 2005 is now very well established and serves as the location for Dr. Karron’s greenhouse. Two of the four controlled burn units in this prairie were burned in the spring of 2013.

**Management** – The primary management that Field Station natural areas receive is maintenance of trails and control of invasive exotic plants. Glossy buckthorn (*Rhamnus frangula*), common buckthorn (*Rhamnus cathartica*), Tartarian honeysuckle (*Lonicera tatarica*), autumn olive (*Elaeagnus umbellata*), multiflora rose (*Rosa multiflora*), meadow parsnip (*Pastinaca sativa*), purple loosestrife (*Lythrum salicaria*), sweet clover (*Mellilotus* spp.), motherwort (*Leonurus cardiaca*), Oriental bittersweet (*Celastrus orbiculata*) and garlic mustard (*Alliaria petiolata*) are all present, and being controlled in the Field Station natural areas. Purple loosestrife biological control beetles were released in Mud Lake in both 2012 and 2013. Friends of Cedarburg Bog volunteers help Field Station staff with trail maintenance

and our efforts to control invasives.

Only glossy buckthorn in the Cedarburg Bog and Oriental bittersweet on private properties south of the Station are currently so widespread and abundant that their control seems intractable with the hand and mechanical methods we are using elsewhere. Friends of Cedarburg Bog, with grant funding from the Knowles-Nelson Stewardship Fund and the We Energies Foundation through the Natural Resources Foundation of Wisconsin, has been conducting major projects to control glossy buckthorn in parts of the Cedarburg Bog. The WDNR State Natural Areas crew has also been actively controlling buckthorn in the Bog. Planning for buckthorn control work was formalized with the Wisconsin DNR in 2012 and fruiting-sized buckthorn was cut and treated with herbicide in 126 acres of the Bog in 2013.



## **Research and Teaching Facilities**

### **General Facilities**

- Office/classroom building with meeting rooms, teaching lab, and computer lab.
- A Research Lab constructed in 2004
- Service building – machine & wood shop
- The Farm House for researcher & student housing – The kitchen was remodeled and modernized in 2013
- The Researcher House for longer stays by individuals and groups
- Natural areas marked with a permanent

- grid – Accurately GPS-located in 2005
- Boardwalk to the center of the Cedarburg Bog – Reconstruction completed in 2009
- 14 aquatic mesocosms (200 gallon tanks)
- Several small boats, canoes, and trailers
- Global Positioning System equipment
- Extensive map and aerial photo collection
- Geographic Information System (GIS) for the Field Station area

### **Hydrology, Meteorology & Phenology**

- Extensive array of environmental sensors recorded by a digital data logger
- Phenological observation garden & native plant observations maintained
- Lysimeter pit in the old-growth forest
- Transect of piezometers from upland to Bog – UWM Geology added new piezometers in 2013

### **Animal Ecology & Behavior**

- Sound room facility for studies of frog communication and vocalizations
- Large outdoor experimental aviary
- Live traps & animal holding facilities
- Extensive arrays of bird nest boxes
- Insect collection, small mammal & bird study skins

### **Experimental Garden**

- 9 fenced research gardens
- 1 acre Experimental Garden with water & electricity
- A 30' x 60' screen house for studies of pollination biology
- A screen house for studies of plant-insect interactions
- Greenhouse & garden building
- High capacity irrigation well
- Farm & cultivating machinery

### **Plant Ecology**

- Herbarium & Plant lists

- Plant identification lab
- Vegetation sampling & surveying equipment
- Fenced deer exclusion plots in various plant communities and habitats

## **Outlying Natural Areas**

### **Neda Mine Bat Hibernaculum State Natural Area**

- An abandoned iron mine, located on the Niagara Escarpment near Mayville and Horicon, Wisconsin, is among the largest bat hibernacula in the Midwest. Up to 150,000 bats of four species (Little brown bats, Big brown bats, Eastern pipistrelles, and Northern long-eared bats) use the hibernaculum. The hibernaculum has the infrastructure and instrumentation to be a productive facility for research on the behavioral ecology of bats at a major hibernaculum. An infrared beam system provides continuous counts of bat flights through the entrances to the mine and we have monitored bat activity continuously since 2000. In 2011 the infrared beam system in one of the four entrances was replaced with a new generation of detectors that will provide more reliable detection with lower maintenance. The mine is also of geological interest; its cliffs provide an excellent exposure of the Niagara Dolomite and the only accessible exposure of the Neda Iron formation.

### **Neda Beechwoods State Natural Area**

- Lies on the Niagara Escarpment, just north of Neda Mine and is a well developed stand of American beech (*Fagus grandifolia*) at the western boundary of its range.

**Benedict Prairie** - Near Kenosha, is a 6-acre tract of virgin prairie along a railroad right of way that has a remarkably diverse flora. A vascular plant species list for Benedict Prairie has been published in the Field Station Bulletin. Woody plants were cut from the prairie and controlled burns were conducted in spring of both 2012 and 2013.

**Downer Woods Natural Area** - An 11.1 acre fenced woodlot, is an island of forested natural area in an intensely urbanized setting

on the UWM campus. The Field Station assumed management of Downer Woods in 1998. Since that time we have been working very hard to control the garlic mustard, buckthorn, and honeysuckle with funding provided by the University.

**UWM Innovation Campus – Habitat Protection Area** – In the northwestern part of UWM's new Innovation Campus on the old Milwaukee County grounds in Wauwatosa is an area that has been set aside and dedicated as wildlife habitat. The special target for conservation of this site is a butterfly habitat since it has historically



been an important roosting area for Monarch butterflies during their fall migration. The Field Station has been assigned the initial management and restoration of that habitat area and has been working with the UWM Foundation and a local volunteer group, Friends of the Monarch Trail, to control invasive plants and begin restoring native vegetation on that site. Marek Landscaping, Inc. was contracted in 2013 for management work on the property, and made excellent progress on invasive control.

## Field Station Programs

- 38 active research projects conducted at the Field Station in 2013.
- Including: 3 M.S. thesis, 3 Ph.D. and 11 studies by researchers from outside of the University.
- 8 papers published during 2013. Several others are in press.

## Database Development

The collection of a variety of long-term data is an important part of the Field Station's research program. Examples of our databases include:

- Vascular plant flora of the Field Station area (including approximately 720 taxa) & excellent herbarium.
- A complete stem map and diameter measurements of all trees in 5.5 acres (2.25 hectares) of the beech-maple woods first censused in 1987.
- Repeated surveys of the entire beech-maple forest at the permanent grid locations.
- A complete, quantitative, survey of the vegetation of the Cedarburg Bog, first conducted in 1991 and repeated in 2006.
- Phenological observations on leaf-out and flowering of standard genotypes of 6 species in a phenological garden, and 26 naturally occurring species at the Station since 2001.
- Long-term weather records from a standard US Weather Service weather station and a Bowen-Ratio energy flux monitoring system.
- Continuous monitoring of bat activity levels at the Neda Mine Bat Hibernaculum since 2000 and of temperatures in the mine since 1997.
- The Charles Weise 30-year study of Dark-eyed Juncos.
- The Charles Weise 27-year intensive study of the Black-capped Chickadee.
- The Charles Weise 26-year breeding bird survey of the Cedarburg Bog & upland woods from 1971 to 1996, repeated in 2006, 2007, 2008, and 2011.
- The Charles Weise 30-year bird-netting and banding program conducted in fall.
- The Field Station is a major site for long-term studies of avian vocalizations, including their organization and function.
- GIS developed for the Field Station area.

## Educational Programs

- Almost 11,000 student hours of instruction and group use in 2013.

- Ten workshops on topics in natural history.
- One undergraduate student project.
- Twenty Friends of Cedarburg Bog programs for the general public on a variety of topics.
- The guidebook to the Bog is available to teachers using the boardwalk for instruction.
- Several field ecology exercises developed for the Field Station are available to instructors.

## Friends of Cedarburg Bog

The mission of the Friends of Cedarburg Bog is to help preserve and study the Cedarburg Bog and to make the public more aware of its uniqueness. Specifically, their objectives are:

- To support research, including long-term monitoring.
- To assist in land preservation, management and stewardship.
- To develop formal and informal opportunities for public education.

- To generate volunteer labor for natural area management, education, public events, monitoring and research, and facility development and maintenance.

- To raise funds to support the activities of the group as defined above.

In 2013 the Friends sponsored 20 educational events for the general public. Volunteers from the Friends contributed many person-days of labor, including natural area and trail management, publishing a newsletter, raising funds, and sponsoring and providing staff for events. In 2013 the Friends also completed a study that identified the surrounding areas that contribute groundwater supply to the Cedarburg Bog (see abstract by J. Kline). The Friends also continued large grant-funded invasive control projects in 2013 (see notes under Management above). If you are interested in the Field Station's programs and activities, or you wish to support the preservation of the Cedarburg Bog State Natural Area, please consider joining the Friends group. Contact the Field Station for more information, or visit the FOCB website, [www.bogfriends.org](http://www.bogfriends.org).



Friends of Cedarburg Bog event at the UWM Field Station

# Abstracts of Research

## Genus-wide Microsatellite Primers for the Goldenrods (*Solidago*; Asteraceae)

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Microsatellite primers were developed for studies of polyploid evolution, ecological genetics, conservation genetics, and species delimitation in the genus *Solidago*. Illumina sequencing of an enriched library from *Solidago gigantea* identified ca. 1900 putative single-copy loci. Fourteen loci were subsequently shown to be amplifiable, single-copy, and variable in a broad range of *Solidago* species. The utility of these mark-

ers both across the genus and in herbarium specimens of a wide age range will facilitate numerous inter- and intra-specific studies in the ca. 119 *Solidago* species. This work was supported by a University of Wisconsin-Milwaukee Research Growth Initiative Grant, the Wichita State University Department of Biological Sciences, and by an Undergraduate Student Research Grant awarded by the WSU Honor's Program.

## Wildlife Monitoring in Ozaukee and Washington Counties, Wisconsin

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The Ozaukee Washington Land Trust (OWLT) began wildlife monitoring in 2004, as a means of assessing the success of habitat restorations, and identifying impor-

tant wildlife resources for OWLT habitat management and acquisition and protection planning. In 2013 we continued herp and bird monitoring.

## Wisconsin Herp Atlas

Gary S. Casper

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The Wisconsin Herp Atlas is a distribution database of amphibians and reptiles in Wisconsin. The Atlas was initiated in 1986 at the Milwaukee Public Museum, with the cooperative support of the Natural Heritage Inventory Program (WDNR) and The Nature Conservancy (Wisconsin Chapter). The Atlas collects and verifies records obtained from museum collections, field surveys, the literature, and field notes provided by volunteer observers throughout the state. Over 450 new county records have

been confirmed by the project. The data collected helps to map species distributions, document rare species occurrences, analyze distribution trends, examine habitat requirements, and plan conservation priorities. In 2006 the Atlas was abandoned by the financially troubled Milwaukee Public Museum, and in 2007 it was re-established through the UWM Field Station, where it now resides, and currently houses 51,592 occurrence records for Wisconsin. Record collection and vetting continued in 2013.

## Wildlife Ecopassage Monitoring

Gary S. Casper  
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Wildlife ecopassages are designed to afford safe passage for wildlife across roadways, thereby reducing road mortality and improving traffic safety. Ecopassages allow wildlife to pass underneath the highway lanes, and maintain habitat and population connectivity on the landscape. This can be especially important in maintaining genetic interchange across highways for more sedentary wildlife such as amphibians and reptiles. Little data are available for evaluating the conservation effectiveness of these structures. This project installed wildlife cameras and is conducting surveys of 6 ecopassages in Waukesha

and Racine counties, Wisconsin, to collect data on patterns of wildlife use. Species documented to date include: raccoon, opossum, eastern cottontail, house cat, mink, woodchuck, gray squirrel, weasel (probably long tailed), white footed or deer mice, white tailed deer, American robin, house sparrow, song sparrow, dark eyed junco, barn swallow, eastern milksnake, snakes, painted turtle and American toad. We continued data collection in 2013. Funded by C.D. Besadny Conservation Grant, Natural Resources Foundation of WI, and Wisconsin Department of Transportation.

## Reproduction in Cedar Lake Blanding's Turtles

Gary S. Casper  
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This radio telemetry study is monitoring female Blanding's turtles to determine nesting sites and collect data on reproductive success in Washington County, WI. Study objectives are to build upon past data defining critical habitat needs for this population, and specifically identify nesting areas and collect data on nesting success. Prior studies in

this area have documented activity ranges, unsuccessful nesting, and important foraging and over-wintering sites. In 2013 two adult females were tracked throughout the season and into hibernation. No nests were found. Funded by Cedar Lakes Property Owners Association, and Cedar Lakes Conservation Foundation.

## Amphibian Monitoring for the National Park Service Great Lakes Network

Gary S. Casper  
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The goal of this project is to finalize and implement amphibian monitoring protocols for the Western Great Lakes Park Network. A protocol utilizing automated recording systems and supplemental visual surveys was

completed in 2012, and we began implementing the program in three parks in 2013. Funded by the National Park Service.

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## **Enhancing Ecological Productivity of Milwaukee Estuary Area of Concern Watersheds**

Gary S. Casper  
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The goal of this project is to assess and map wildlife habitat in the Milwaukee River Basin for ranking habitat restoration sites for best

value. Work continued in 2013. Funded by an EPA Great Lakes Restoration Initiative award to Ozaukee County.

## **Wildlife Population Target Refinement for the Milwaukee Estuary Area of Concern**

Gary S. Casper  
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The goal of this project is to research the status of wildlife species in the Milwaukee County portion of the Milwaukee River Area of Concern, develop comprehensive species checklists, select focal species for habitat restoration projects, and develop survey

methods and target species. Work will include historical data collection, research, and reporting. We began the project in 2013. Funded by the Wisconsin DNR and the U.S. Environmental Protection Agency.

## **Food Abundance, Timing of Breeding, and Reproductive Success in Tree Swallows**

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Tree swallows are a widespread aerial insectivore, whose timing of egg-laying has shifted earlier by nine days since the 1950s. This adjustment in the timing of breeding may be a response to warmer spring temperatures and an earlier emergence of aerial insects, the primary food source for breeding tree swallows. The Mismatch Hypothesis predicts that reproductive success is maximized when animals synchronize their reproduction with the food supply, such that nestlings are raised during the peak in food abundance. In 2013 we continued a long term study of tree swallows at the UWM Field Station to examine whether tree swal-

lows adjust the timing of egg-laying so that offspring are raised during the peak of food abundance as predicted by the Mismatch Hypothesis. We measured daily temperatures, food supply, as well as egg-laying and chick-rearing dates of breeding swallows. Understanding the mechanisms influencing the timing of reproduction has taken on new urgency as climate change is altering environmental conditions during reproduction, and there is concern that species will not be able to synchronize their reproduction with changing food supplies.

## Patterns of Fisherian Covariance Differ Between Species in the *Enchenopa binotata* Complex of Treehoppers (Hemiptera: Membracidae)

Kasey D. Fowler-Finn, Joseph T. Kilmer, Allysa C. Hallett and Rafael L. Rodríguez  
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Mate choice is a key source of selection influencing patterns of diversification, and often leaves an apparent signature of its action in the form of correspondence between mating displays and preferences among closely-related species. One expected mechanism responsible for creating signal-preference correspondence is Fisherian selection. The Fisherian process is not always detectable because Fisherian covariance (i.e. genetic covariance between signals and preferences) should arise for only brief periods. Here, we test for Fisherian covariance using a full-sibling, split-family rearing design and two members of the *Enchenopa binotata* complex of treehoppers expected to vary in the level of signal-preference correspondence. In one species, population-level

male signals and female preferences do not match, suggesting directional selection that may have exhausted genetic variation in male signals. In this species, we found weak support for Fisherian covariance. In the second species, population-level male signals and female preferences match, and genetic variation in males signals is present. In this species, we found stronger support for Fisherian covariance. Finally, we compare the range of variation in family values for signals and preferences within species to the range across the *E. binotata* complex to evaluate the likelihood for Fisherian selection to contribute to rapid diversification. Funded by the National Science Foundation and an undergraduate research award to ACH from the University of Wisconsin-Milwaukee.

## Male *Enchenopa* Treehoppers (Hemiptera: Membracidae) Vary Mate-searching Behavior but Not Signaling Behavior in Response to Spider Silk

Kasey D. Fowler-Finn, Mishal Al-Wathiqui, Nooria Al-Wathiqui, Dan Cruz, and Rafael L. Rodríguez  
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Finding and attracting mates can impose costs on males in terms of increased encounters with, and attraction of, predators. To decrease the likelihood of predation, males may modify mate acquisition efforts in two main ways: they may reduce mate searching efforts, or they may reduce mate attraction efforts. The specific behavior that males change in the presence of predator cues should depend upon the nature of risk imposed by the type of predator present in the environment. For example, sit-and-wait predators impose greater costs to males moving in search of mates. Here we test whether cues of the presence of a sit-and-wait predator lead to a reduction in mate searching but not mate acquisition behavior. We used a member of the *Enchenopa bino-*

*tata* complex of treehoppers – vibrationally-communicating insects in which males fly in search of mates and produce mate attraction signals when they land on plant stems. We tested for changes in mate searching and signaling behavior when silk from a web-building spider was present or absent. We found that males delayed flight when spider silk was present, but only if they were actively searching for mates. These results suggests that males have been selected to reduce predation risk by adjusting how they move about their environment according to the cues of sit-and-wait predators. Funded by the National Science Foundation and undergraduate research awards to to NA-W, DC, and MA-W from the University of Wisconsin-Milwaukee.

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## Characterization of Physicochemical Groundwater Flow Processes in the Peatland of the Cedarburg Bog

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The Cedarburg Bog has long been identified as a groundwater recharge zone for Ozaukee and Washington counties. The purpose of this study is to characterize the subsurface geology of the bog as well as the surrounding area, using existing hydrogeologic and geophysical datasets, estimate temporal and spatial-scale recharge, and characterize hydrogeological responses of Cedarburg Bog brought on by changes in temperature, precipitation, and other meteorological factors. The Wisconsin Initiative on Climate Change Impact have developed state specific projections of climate change and found results to be highly variable, and we have replicated a series of variations of

the future climate in the MODFLOW model. Integration of well data and geophysical survey data from electromagnetic and electrical resistivity tomography resulted in a 3-dimensional subsurface map for the development of a groundwater flow model in the bog area.

Additionally, 20-year trends of the potentiometric surface were analyzed to identify differences throughout previous years and determine hydraulic conductivity by conducting slug and infiltrometer tests at multiple locations. The 20-year dataset was used to calibrate the model to the heads within the monitoring wells and private drinking water wells outside the bog. Preliminary



results produced from the MODFLOW model indicate the bog is acting as a recharge zone under current recharge conditions, approximately 5 inches per year, but some piezometers have shown a reversal of gradient in the recent past. Finally, a series of long-term monitoring data of groundwater level, temperature, EC, pH, and dissolved oxygen at several piezometers were analyzed to reveal the role of this peatland on the local groundwater flow system. Knowledge acquired from this investigation can be used to better inform local agencies, as well as predict future changes within this groundwater system.

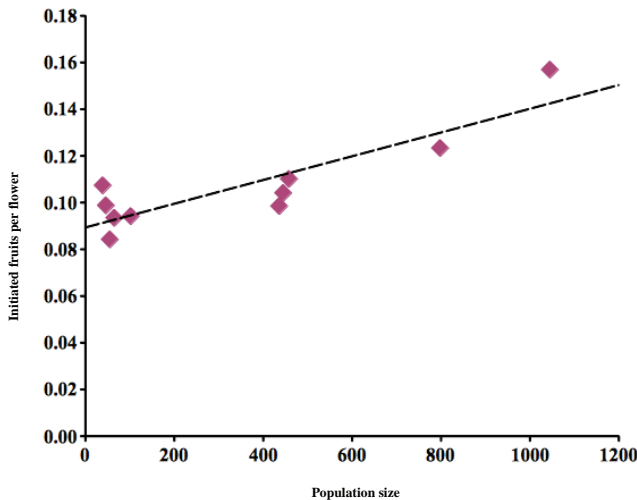


### Influence of Population Size on Reproductive Success of Whorled Milkweed (*Asclepias verticillata*)

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Evidence for a positive relationship between population size and individual fitness, otherwise known as the Allee Effect, has long been sought by conservation biologists due to its importance in understanding the biology of fragmented populations. Smaller populations may suffer from mate limitation,

increased risk of disease or herbivory, and sensitivity to damaging environmental or anthropogenic influences. Since most flowering plants are dependent upon pollinator visitation for reproductive success, small populations may be especially susceptible to the effects of insufficient pollinator



Initiated fruits per flower as a function of population size.

recruitment. Whorled milkweed (*Asclepias verticillata*) is pollinated by bumble bees, especially *Bombus griseocollis*, and by several species of wasps. We quantified reproductive success in *A. verticillata* populations ranging in size from 39 to 1,054 individuals. The number of developing fruits on individual plants increased strongly and significantly with population size. This finding

emphasizes the importance of protecting large populations, since they may have the lowest risk of reproductive failure. We will further quantify reproductive success by counting seed set, and the number of insertions and removals of pollinia, which are indicative of female and male pollination success, respectively. M.S. Thesis research, Dr. Jeffrey Karron, Major Advisor.



Wasp and bumble bee pollinators on *A. verticillata*

## Oxidative Stress and Male Ornamentation in the Common Yellowthroat

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This year we continued our study of the common yellowthroat (*Geothlypis trichas*) by performing an experiment to test the relationship between oxidative stress and a sexually-selected ornament (black facial mask) possessed by males of this species. The mask is used by females to assess potential mates, and males with larger masks sire a greater number of young. Mask size is also positively correlated with higher variation at the major histocompatibility complex (MHC), which are immune genes responsible for recognizing pathogens and activating the adaptive immune system. Higher variation at these important immune genes may

result in a more efficient immune response, which will reduce the amount of harmful free radicals produced. Free radicals are normally controlled by antioxidants but, when produced in excess, can cause damage to cellular proteins and DNA. This imbalance of antioxidants and free radicals is a process known as oxidative stress which is involved in the development of many diseases. It is hypothesized that males with higher immune gene variation will have lower oxidative stress and, ultimately, will be able to produce more attractive ornaments. We tested this hypothesis by experimentally activating the immune system of males. We are currently

analyzing the samples collected this summer to determine if males with larger masks have lower levels of oxidative stress before and after the immune challenge. This will allow us to understand how variation at immune genes may affect the physiology of these birds and how this impacts the production

of a male ornament. This research was supported by funds from the Animal Behavior Society, the American Ornithologists' Union, and the Wisconsin Society for Ornithology. Ph.D. research, Dr. Peter Dunn, Major Advisor.



# Multimodal Communication in Eastern Gray Treefrogs, *Hyla versicolor*

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Signal production and reception often encompass various modalities of communication. For example, a calling frog cannot but produce a visual component as it inflates and deflates its vocal sac to emit an acoustic signal. A frog calling in a pond also creates water surface waves, and calling on a branch he creates vibrational signals. Thus, a simple "acoustic signal" actually encompasses three modalities (acoustic, visual and surface wave / vibrational). An increasing number of studies show that multi-modal signals are common and that mate choice is often based on multiple signal modalities, yet

we know relatively little about the evolution of multimodal signaling. To better understand the evolution of multi-modal signals in frogs, we made detailed descriptions of visual (color, size) and vibrational portions of the signals of Gray treefrog males. We also conducted playback experiments with female gray treefrogs to evaluate whether they are attracted to visual (video of calling male) signal components, and started conducting preliminary trials testing whether females respond to vibrational signal components. Funded by the Research Growth Initiative.

## Can One Microbial Photosynthesizer Occupy Different Ecological Niches Within the Same Environment?

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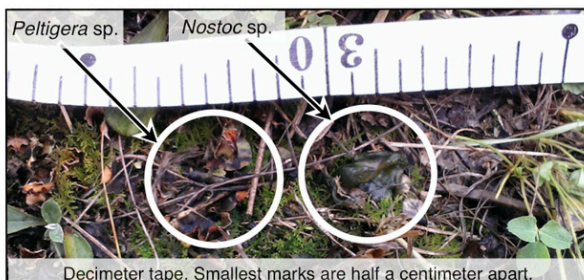
It is well known that terrestrial cyanobacteria and algae (microbial photosynthesizers) can occupy a variety of ecological niches including in free-living and symbiotic relationships. One symbiotic niche for terrestrial microbial photosynthesizers that is relevant to this study is the mutualistic relationship with lichen-forming fungi; microbial photosynthesizers form long-lived symbiotic relationships with fungi, and together they form the lichen body. It is far less understood, however, to what extent one microbial photosynthesizer can occupy different ecological niches within a given habitat. The UW-Milwaukee Field Station offers a unique opportunity to investigate this question as members of two different microbial photosynthetic genera (*Nostoc* and *Trentepohlia*) are known to occur both free-living and in lichen symbiosis on the property. We propose to answer the question "Can one microbial photosynthetic species

occur both free-living and symbiotically in the same habitat?" by sampling free-living and symbiotic states of *Nostoc* and *Trentepohlia* at the UWM Field Station. We will then sequence one genomic region from each sample of microbial photosynthesizer and reconstruct phylogenetic trees to determine if the same photosynthetic species inhabits different ecological niches.

An undergraduate student, Nick Bilicki, has begun working with me on the *Nostoc* portion of the study. We will sample two 1-meter plots per microbial photosynthesizer, and sample 5 - 10 samples of each. We were able to sample one plot of *Nostoc* in 2013 before the freezing weather set in, and we will sample the remainder in 2014. Together with my colleague Heath O'Brien, we will reconstruct phylogenetic trees. Funded by a Professional Development grant to Joneson.



*Peltigera* and *Nostoc* habitat. White line in middle is the decimeter tape.



Decimeter tape. Smallest marks are half a centimeter apart.



Copious *Nostoc* sp. in open pebbles, khaki green. Pen length = 135 mm.

## Use of Mark-Recapture Techniques to Estimate Milksnake (*Lampropeltis triangulum*) Populations in the Upper Midwest

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Published data on population characteristics of milksnakes (*Lampropeltis triangulum*) are rare, with most focused on estimates of density per area in populations from the western portions of its range. Information on Wisconsin populations does not exist, despite the importance of such baseline data for future conservation efforts. The UWM Field Station contains a rich herpetofauna that previous surveys have determined includes milksnakes. We attempted to study several population parameters of these snakes through the use of mark-recapture methods (e.g., Un-biased Lincoln-Petersen estimator). Surveys consisted of four periods, each lasting ca. 2 h, over two days in late May/

early June. Each survey involved checking cover objects and conducting random visual encounter surveys throughout 6.1 hectares of Field Station property. Surveys were either conducted by JMK and TJM, or in conjunction with a Field Herpetology course conducted at the Field Station in 2006, 2008, 2010, and 2012. To-date, seven annual sampling efforts have been completed (2006-2013). Upon capture, snakes were marked with Passive Integrated Transponder (PIT) microchips, a commonly employed technique to mark snakes for future identification. Throughout the duration of this study to-date, annual captures of novel individuals ranged from five to nine annually (annual

recaptures ranging from zero to seven individuals). This resulted in population estimates ranging from 4.5 to 12.4 individuals (density estimates of 0.73 to 2.03/ha). Small vertebrate populations are dynamic, and the variation in results obtained over time further support the notion that long-term datasets are critical when analyzing population parameters. Therefore, it will be important to continue this research for a number of years to determine if discernable trends have occurred.



## Identification of Contributing Areas for Groundwater Supply to Protect Critical Habitat at Cedarburg Bog

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Cedarburg Bog in Ozaukee County is a large wetland complex of many plant communities that supports a wide diversity of plants and animals. As at true bogs, direct precipitation is an important part of the Cedarburg Bog's water supply. The Cedarburg Bog however also receives calcareous groundwater. This groundwater contribution is what drives the uniqueness and diversity of the wetland community types and the species that depend on them. Species of particular interest are the Hine's emerald dragonfly (*Somatochlora hineana*) and eastern prairie fringed orchid (*Platanthera leucophaea*), both of which are rare and protected by State and Federal Endangered Species laws. Our study examined the hydrogeology of the Bog and groundwater flowpaths; and, using the results, expanded on previous habitat assessments for the Hine's emerald dragonfly to guide future monitoring for species recovery.

We applied several different techniques within a 42-square mile study area around the Bog. Surface water levels were monitored in lakes and streams as well as groundwater levels in study wells and over 1700 water supply wells. Geophysical methods, including electrical resistivity and electromagnetic induction, and well construction reports

helped construct local subsurface stratigraphy. Water chemistry and stable isotope analyses were used to determine how water composition changes with the seasons and as water moves through the Bog.

Results include identifying the Bog's groundwater contributing area and those parts of the Bog that are most dependent on groundwater flows. Since land use changes can affect these flows this information can inform protection strategies such as education, transportation and land use planning, zoning, conservation easements and land acquisition. The hydrogeologic picture combined with habitat assessment for the Hine's emerald dragonfly led to identifying the best potential habitat areas within the extensive bog mat, which will help to focus future monitoring of this rare species.

The project was funded by the Wisconsin Coastal Management Program through a grant to the Friends of the Cedarburg Bog with additional support from Wisconsin Geological and Natural History Survey, Wisconsin Department of Natural Resources, Ozaukee and Washington Counties, University of Wisconsin-Milwaukee, many students and volunteers.

## Atlas of North American Amphibians

Michael J. Lannoo<sup>1</sup>, David M. Green<sup>2</sup>, Gary S. Casper<sup>3</sup>, and Sarah Lourie<sup>2</sup>

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This is a book project with the University of California Press. The Atlas of North American Amphibians will present detailed distribution maps and brief species descriptions of each of the 298 currently recognized amphibian species in the United States and Canada. The intended audience will be professionals, including researchers, teachers, land and wildlife managers, natural resource

technicians and administrators, nature center staff, zoo staff, wildlife health staff, various federal and state agencies such as forest service, park service, environmental quality and agricultural departmental staff, and amateur naturalists. Currently in press for 2014 publication. Funded by Indiana University School of Medicine.

## Long-term Monitoring of Bat Activity and Temperature at the Neda Mine Bat Hibernaculum

Gretchen Meyer and James Reinartz

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The Neda Mine, an abandoned iron mine located near Iron Ridge in Dodge Co., supports about 150,000 bats each winter, making it among the largest hibernacula in the midwest. The mine is used primarily by little brown bats (*Myotis lucifugus*), with Northern Bats (*M. septentrionalis*), Eastern Pipistrelles (*Pipistrellus subflavus*), and Big Brown Bats (*Eptesicus fuscus*) found in smaller numbers. We have been monitoring bat activity at the mine since 2001 using an infra-red photo beam-break detection system that records bats entering and leaving the mine on a 5-minute interval 365 days per year. We have been collecting temperature data since 1996 using 18 battery-powered temperature

dataloggers spread within the mine and 2 dataloggers outside. We are also monitoring airflow in the mine. We are currently using these data to examine trends over time in winter temperatures in the mine, and the phenology of bat emergence in spring. We are currently collecting data on nocturnal aerial insect abundance at the Field Station to determine the relationship between night-time temperatures in spring and insect activity. These data will help us to interpret patterns of bat activity in the spring by providing information on how their aerial insect prey is affected by spring temperatures.

## Dimensions of Biodiversity Project

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We collected 24 *Trillium* samples at the Field Station and 24 samples each from 5 other locations from 4-50 km from there. We have isolated their DNA and will perform genotyping by sequencing in 2014 on these samples to assess population genetic measures of this species in that region. This is part of a

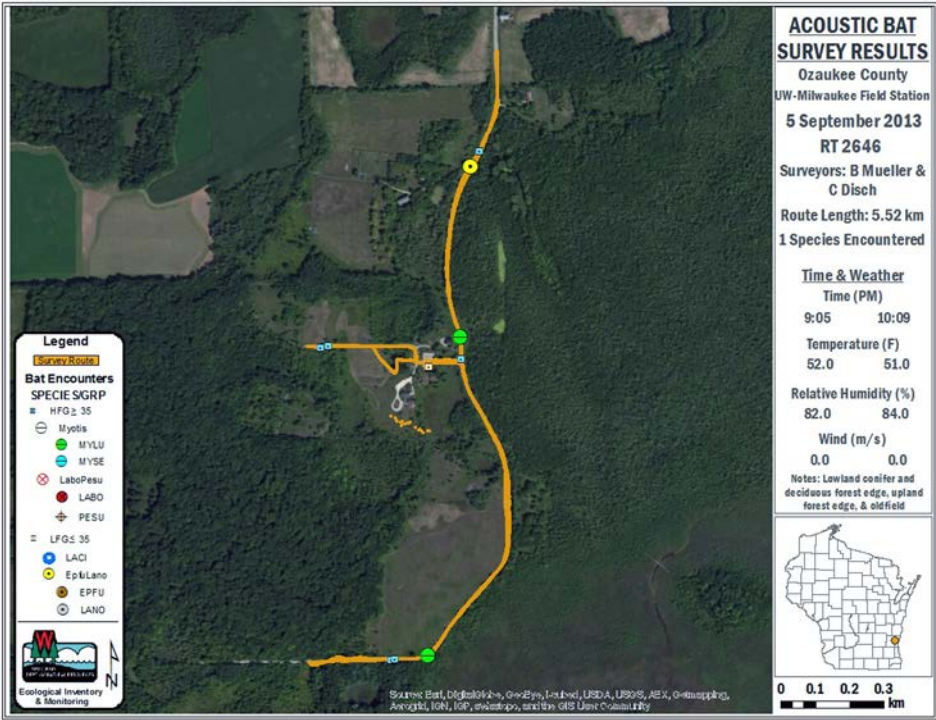
larger project to catalog nearly 40 species in this same manner across the state. As *Trillium* has by far the largest genome we are currently assessing smaller genomes for their efficacy in this process before attempting *Trillium* itself. Funded by the National Science Foundation.

# Bat Monitoring at the Cedarburg Bog – UW-Milwaukee Field Station

William Mueller, Western Great Lakes Bird Bat Observatory, wpmueller1947@gmail.com

The Wisconsin Bat Monitoring Program utilizes the help of volunteers to gather data on bats in a variety of Wisconsin locations. As part of this Monitoring Program, a demonstration “bat walk” for members of the Friends of Cedarburg Bog and other citizens monitored bats at the Field Station on September 5, 2013. The hand-held ANABAT device records bat echolocation/vocalizations while stamping the date and time of each bat encounter. Combined with a global positioning system (GPS), the detector records the position (latitude & longitude) of each bat passing the surveyor, mapping the route traveled during the survey. Attached

to the detector, a personal data assistant (PDA) then provides real-time tracking of the bat as it echolocates (as a change in frequency over time), and stores the data for later analysis by John Paul White at the Wisconsin Department of Natural Resources. Most encounters produce a record that can be identified to a species, but some are narrowed down only to a “species group”. During the survey conducted on September 5, we recorded the Little brown bat (*Myotis lucifugus*). We also detected one bat in a “species group” that was either a Big brown bat (*Eptesicus fuscus*) or a Silver-haired bat (*Lasionycteris noctivagans*).



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## Wood Duck Nest and Small Owl Nest/Roosting Box Project

John O'Donnell

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Beginning in 2012, 10 Wood Duck nest boxes and four nesting and/or roosting boxes for small owls (i.e., Eastern Screech and Northern Saw-whet owls) were constructed and then erected with accompanying predator guards in multiple locations around the Cedarburg Bog boundaries by board members of the Friends of the Cedarburg Bog and by an Eagle Scout under the supervision of the Friends of the Cedarburg Bog and the State DNR. Boxes have been placed both at the north and south ends of the Bog and near the UWM Field Station. The intent is to increase nesting populations of Wood Ducks and Eastern Screech Owls in and around the Cedarburg Bog and also to provide roosting sites for both Eastern Screech and Northern Saw-whet owls in the fall and winter seasons. All boxes will be monitored relative to possible nesting in the summer and/or before the next spring nesting cycle. Box monitoring will also record if any of the boxes (including Wood Duck boxes) were used by owls for roosting. Prey analysis will also occur should there be any evidence of prey remains, e.g., owl pellets, in or near a box used by roosting owls. The project hopes to add additional duck and owl boxes over the next several years and expand to include a limited number of American Kestrel nest boxes at the northeast end of the Cedarburg Bog complex. Estimates of box use and nesting success will be provided on an annual basis.



Friends of Cedarburg Bog Board member installing wood duck nest box

## Mud Lake Migration Point Counts

John O'Donnell<sup>1</sup> and Victoria D. Piaskowski<sup>2</sup>

Friends of the Cedarburg Bog, <sup>1</sup>[nodjod@wi.rr.com](mailto:nodjod@wi.rr.com), <sup>2</sup>[vickip1023@wi.rr.com](mailto:vickip1023@wi.rr.com)

Mud Lake is 245 acres in size and is the largest lake within the Cedarburg Bog. Point counts were conducted weekly in 2013 by canoe and/or kayak on Mud Lake during spring (April 23-June 7) and fall (August 31-October 31) migration to determine the

bird species using the lake and surrounding habitats. All bird species seen or heard were counted at six points around the lake. Birds observed while walking to and from the canoe landing and paddling between points were also counted. Playback for secretive

wetland species was used twice and the American and Least bittern responded. We documented 127 bird species that the lake and surrounding habitats during spring and fall migration.

The counts determined that both the American and Least bittern were probable breeders at Mud Lake. Spontaneous American bittern vocalizing (not elicited by recordings) was heard from the same areas of cattails on the outer lake edges in four consecutive weeks. In a different location, Least bittern responded to playback in two consecutive weeks. Willow flycatchers continued to nest on the islands. The fairly regular appearance of Northern harriers (both male and female) suggest that nesting may be occurring somewhere in the vicinity of the lake. As in 2011 and 2012, immature Bald eagles were sighted on a frequent basis in both spring and fall 2013, and this species may be confirmed as breeding near Mud Lake in the near future. Great Egrets were again observed at Mud Lake in the fall of 2013, suggesting that this species may be a "regular" fall visitor until the start of hunting season.

In 2013, a thick cover of ice persisted well into mid-April. When the lake was accessible, much of the spring waterfowl migration was over, resulting in lower numbers of waterfowl detected in the spring. The earlier opening of the fall hunting season seemed

to reduce the fall waterfowl counts. Interesting mammal sightings in 2013 included otter, mink, and beaver. Other mammals observed were coyote, red fox, white-tailed deer, muskrat, raccoon, opossum, and a number of squirrel, vole, and mice species.

The counts demonstrated that Mud Lake is an important spring and fall migration staging area for numerous bird species. The lake and surrounding habitats provided habitat during spring and fall migration for a number of bird species of conservation concern. Twenty-eight species of birds (22.0% of the total) are listed as being at risk in national or Wisconsin conservation plans. Of these, 16 are listed as being of conservation concern in national (U.S. / North American) Landbird, Shorebird, or Waterbird Conservation Plans. These species included Common loon, Pied-billed and Horned grebe, American and Least bittern, Virginia rail, Sora, Killdeer, Black-bellied plover, Greater and Lesser yellowlegs, Solitary sandpiper, Wilson's snipe, Forster's tern, Willow flycatcher and Wood thrush. Eighteen species are listed as Bird Species of Greatest Conservation Need in Wisconsin and six are listed in both state and national plans.

Michele Weiland and Brian Marquez also assisted with the migration counts in 2013.



## Phylogenetic Systematics of *Spiranthes* (Orchidaceae)

Matthew C. Pace

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*Spiranthes* (Orchidaceae), the ladies' tresses, is the only genus of orchids with its primary center of diversity in North America. This genus has long confused botanists and ecologists due to highly variable morphologies, putative hybridization, and documented cryptic speciation. Phylogenetic systematics offers a way to understand these challenges through a history-bound species concept. By including many samples of a single taxon, the morphological limits of species can be better understood. When combined with population genetic studies, the conservation needs of these plants can be better addressed. Leaf tissue from *Spiranthes* orchids was collected from the Cedarburg Bog for genetic analysis in 2013. Funded by the UW-Madison Dept. of Botany.



## Influence of Genetic Variation in the Biotic Environment on Phenotypic Variation in a Plant-feeding Insect

Darren Rebar

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While many species spend much of their lives in close association with other organisms, only recently have biologists started to explore the implications of the biotic nature of environments for their role as causes of variation in phenotypes. This means that the genotypes of individuals that constitute the biotic environment may influence the phenotypes of individuals that live in that environment. These are called indirect genetic effects (IGEs) when they occur between conspecifics, and interspecific indirect genetic effects (IIGEs) when they occur between heterospecifics. However, the impact of genetic variation in biotic environments remains largely unknown. I used a member of the *Enchenopa binotata* species complex of treehoppers (Hemiptera: Membracidae) to assess how male mating signals and female mate preferences are influenced by genetic variation in biotic environments. I used novel

implementations of classic quantitative genetics designs, with samples of full-sibling families of treehoppers (IGEs) and clone lines of a sample of host plant genotypes (IIGEs) constituting the background biotic environment.

To measure IGEs, I used full-sibling split-families as “treatment” social environments, and reared a random sample of focal females alongside each treatment family, describing the mate preferences of these focal females. With this I detected substantial genetic variation in social influence on mate preferences: the mate preferences of focal females varied according to the treatment families along with which they grew up.

To measure IIGEs, I reared a random sample of treehoppers on potted replicates of a sample of host plant clones, describing the male signals and female mate prefer-

ences of these individuals. I found that male signals and female mate preferences varied according to the clone line on which they developed, demonstrating that genetic variation in host plants has cross-trophic consequences on sexually-selected traits at the level of the insect.

I discuss the evolutionary implications of the presence of such genetic variation in biotic

environments on male signals and female mate preferences. I focus on how IGEs and IIGEs may influence the way in which selection may act within and across environments, including potential contributions to the maintenance of genetic variation and the promotion of evolutionary divergence. Ph.D. Dissertation research, Rafael Rodríguez, Major Professor.

## Cedarburg Bog Basin Topography





James A. Reinartz, Stephen Appel, Nick Nadelhoffer, Marc White, and Kevin Korth  
UWM Field Station, jimr@uwm.edu

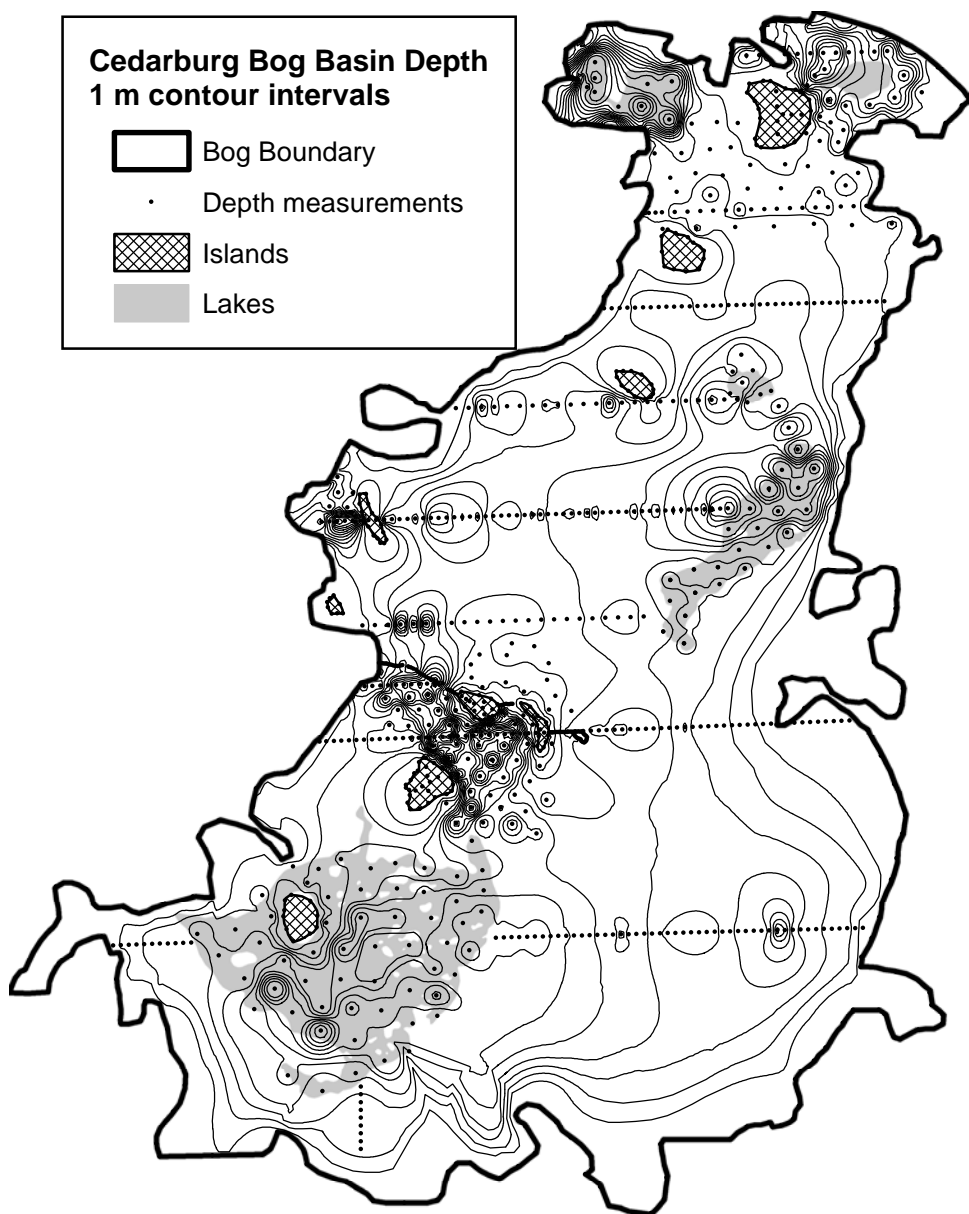
The 886 ha (2,190 acre) Cedarburg Bog basin has irregular contours that reflect its kettle moraine/end moraine glacial history and the time it spent as a glacial lake. There are nine glacial till islands in the bog and a maximum depth of peat and lake sediments of at least 15 m. Between these two extremes the basin depth varies

at a relatively fine scale. In the late 1960s Thomas Grittinger sampled the depth of the basin along six transects. Since that time we have added more basin depth soundings, taken by inserting a metal rod into the sediments until we reach refusal in either heavy clay or sand and gravel. We now have a sample of 620 measurements of basin depth. Because of the large size and the relief of the basin there are still parts of the Cedarburg Bog where we can only roughly estimate the basin contours. However, we have constructed the first working contour (or bathymetric) map for the Cedarburg Bog basin (see the figure in this report). The 620 depth measurements are shown as points, providing a sense of where we still need more detail. The deepest known part of the basin (15m) is just south of the islands over which the UWM boardwalk passes. The depressions under the lake in the northwest, at the western shore of Long Lake, and between Blue Goose Road and the island at the center-west part of the Bog are all about 13m deep. We will continue to collect measurements of the basin depth to improve the accuracy of the basin contour map. Map production was funded in part by the Friends of Cedarburg Bog.



## Cedarburg Bog Basin Depth 1 m contour intervals

-  Bog Boundary
-  Depth measurements
-  Islands
-  Lakes



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## The Evolution and Evolutionary Consequences of Social Plasticity in Mate Preferences

Rafael L. Rodríguez, Darren W. Rebar, and Kasey D. Fowler–Finn

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In many animals, experience modifies behaviour in a variety of ways and contexts. Here we focus on experience of social environments and phenotypic plasticity in mate preferences. We first review adaptive hypotheses about the evolution of social plasticity in mate preferences, finding support for all of them across different species. We suggest that future work should assess which patterns of variation in social environments select for which forms of plasticity in mate preferences. We then highlight that social plasticity in mate preferences creates feedback loops between the role of social environments as causes of variation in phe-

notypes and the role of social environments as causes of selection on phenotypes. Fully understanding the consequences of these feedbacks will involve assessing both how selection shapes the plastic response to variation in social environments and how individuals in social environments are selected to influence the mate preferences of others. This task is just beginning, but we review evidence of genetic variation in both of these aspects of social plasticity in mate preferences. Funded by the National Science Foundation, the Society for the Study of Evolution Rosemary Grant Award, and the University of Wisconsin-Milwaukee.

## Curves as Traits: Genetic and Environmental Variation in Mate Preference Functions

Rafael L. Rodríguez, Allysa C. Hallett, Joseph T. Kilmer & Kasey D. Fowler–Finn

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Study of the genetic and developmental architecture of mate preferences lags behind the study of sexual ornaments. This is in part because of the challenges involved in describing mate preferences, which are expressed as a function of variation in ornaments. We used the function-valued approach to test for genetic and environmental components of variation in female mate preferences in *Enchenopa* treehoppers (Hemiptera: Membracidae). These insects communicate with plant-borne vibrational signals, and offer a case study of speciation involving sexual selection and environmental change. We focused on female preferences for male signal frequency, the most divergent signal trait in *Enchenopa*. Obtaining complete, individual-level descriptions of

mate preferences in a full-sib, split-family rearing experiment, we document substantial genetic variation in mate preference functions. Focusing on traits describing variation in the shape of the preference functions, we further document considerable broad-sense heritability and evidence of weak genotype  $\times$  environment interaction in most traits. Against the background of recent and rapid divergence in *Enchenopa*, these results indicate potent mechanisms that maintain variation and sustain the involvement of mate preferences in sexual selection. Funded by the National Science Foundation and an undergraduate research award to ACH from the University of Wisconsin-Milwaukee.

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## **Bridging Spatial Scales Using Phenological Measurements to Improve Understanding of Autumn Atmosphere-Biosphere Interactions**

Mark D. Schwartz  
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Enhancing the accuracy of energy/carbon flux estimates at all scales is a critical part of improving understanding of the interactions between land surface biospheric processes and global climate change. Current approaches that scale between regional estimates with data from remote sensing, eddy covariance flux, and intensive plant- and stand-level flux measurements assume estimates from these extremely small areas are representative of larger regions. The timing of leaf senescence (coloring and subsequent fall; i.e., phenology) during autumn has large impacts on lower atmospheric energy-mass exchange through differential carbon assimilation and transpiration totals across the landscape, which are equal to or greater than those of spring phenology. However, spatial variations in autumn phenological timing at the community level have not been systematically measured and analyzed, and underlying environmental drivers are not well understood. If large, autumn leaf senescence variations may reflect gradients in plant growth that could foster systematic errors in seasonal fluxes of equal or greater magnitude than those during earlier portions of the growing season. Thus, autumn phenological data collected in a spatially explicit

manner offer considerable opportunities for gauging landscape-level spatial variations crucial for accurate scaling-up of flux measurements to larger areas or downscaling regional-scale atmospheric circulation models. In this project, spatial variability of autumn phenological data will be measured and analyzed at the community level, compared to microclimatic and remote sensing measurements, and used as the basis for regional-scale multi-species phenological models, which could contribute to increased accuracy of energy/carbon flux estimates across large areas.

As part of this project, 108 evenly distributed trees have been marked in Downer Woods (on the UW-Milwaukee campus) and are being phenologically observed in autumn (since 2007). In addition, automatic air and soil temperature measurements are being collected at several locations to support analyses of these phenological measurements. These measurements will also be compared to data being collected on at least one similar species (*Tilia americana*, Basswood) at both the UW-Milwaukee Field Station and at the primary study site of this project near Park Falls, WI. Funded by the National Science Foundation.

## **PhenoCam Monitoring of Seasonal Plant Development and Senescence at Downer Woods and the UW-Milwaukee Field Station**

Mark D. Schwartz  
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An exciting new development in phenological science is the use of fixed cameras to provide continuous near-surface remote sensing observations of seasonal development and senescence within small patches of vegetation. The PhenoCam Network is a global project (P.I. Andrew Richardson, Harvard University, sites primarily in North

America) that is designed to coordinate this type of data collection. The PhenoCam website is: <http://phenocam.sr.unh.edu/webcam/>

UW-Milwaukee added two nodes to the PhenoCam network with cameras installed in March 2013 on the Sandburg East Tower

(viewing north toward Downer Woods, see <http://phenocam.sr.unh.edu/webcam/sites/downerwoods/>) and at the UW-Milwaukee Field Station (viewing a small grove of trees north of the main buildings, <http://phenocam.sr.unh.edu/webcam/sites/uwmfieldsta/>).

The cameras record an image once every half-hour during daylight hours in both the visible and near-infrared. These data will be

added to the traditional ground-based visual phenology observations and climate data collected at both sites to continue efforts to better understand phenological changes, as well as bridge the spatial and methodological gaps between visual phenology and remote sensing-derived measurements.

## **Insect Herbivore and Pollinator Floral Trait Selection of Sawtooth Sunflower (*Helianthus grosseserratus*)**

Jason S. Servi and Gretchen A. Meyer

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Two significant insect-driven selective pressures on prairie flowers are herbivory and pollination. The strength of such selection by insects depends upon how attractive a wide variety of floral traits are to pollinators and/or herbivores. Which of these particular traits are most responsible for attracting the detrimental herbivore and favorable pollinating insect to any one flower, however, is a topic that is scarcely studied. In the fall of 2013, I began research into this topic at the Kettle Moraine Low Prairie State Natural Area, the largest mesic prairie east of the Mississippi River. Sawtooth sunflower (*Helianthus grosseserratus*) is a composite flower which is common in this habitat, and was chosen as the focus species. Various traits, including ray dimensions, disc size, and ultraviolet patterns were documented for each head. Through insect observation, seed counts, and floral damage, the attractiveness of each head to insects can be measured and correlated with floral trait values. Results from this study will provide key insight into the complex interaction between prairie flowers, pollinators, and herbivorous insects. Due to the increasing rarity of the prairie habitat, it is even more important to gain knowledge of this ecological system. Data is currently being analyzed from the first field season. M.S. Thesis research, Dr. Gretchen Meyer, Major Advisor.



Images of ultraviolet patterns of sunflower heads.



Visible light images of the same sunflower heads.

## An Urban Cooper's Hawk Nesting Study in the Metropolitan Milwaukee Area

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The objectives of this study are to gather baseline data on the reproductive success of Cooper's Hawks (*Accipiter cooperii*) in the urban metropolitan Milwaukee area, to describe urban nesting habitat, and to compare these data with other Cooper's Hawk studies in Wisconsin. Long-term objectives are to determine Cooper's Hawk nest site fidelity, breeding population mortality and recruitment, population growth trends, immigration and emigration patterns, and natal dispersal patterns for the same urban population. The nest at Downer Woods (UW-Milwaukee) produced five young, one male and four females. The adult male for this breeding area

was an ASY (after second year) bird, but an exact identification by colored leg bands was not possible. The adult female was partially identified as "green ?3/A" (?3 over A); thus, she was a different female than in previous years (black colored leg band). There are three possible nest sites that this female could have dispersed from. The most likely (i.e., closest, hypothesized based on other known adult female dispersals) is from a nest near Veteran's Park approximately 4 km south-southwest of Downer Woods. This project was supported, in part, through the Wisconsin Society for Ornithology (WSO) Small Grants Program.

## Perch Choice in Chorusing Gray Treefrogs

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Effective communication requires signalers to be easily detected by mates, yet camouflaged from predators. Animals can increase/decrease conspicuousness by displaying in front of backgrounds that maximize contrast towards mates, and/or minimize contrast to predators. A previous study based on calculations of vision models had shown that gray treefrogs should be most conspicuous

towards mates when displaying in front of brown reed grass, and best camouflaged against nocturnal mammalian predators when displaying in front of green reed grass (Novak, Reichert & Höbel, unpubl.). We investigated which perches males choose in nature, by sampling the color of available and chosen call perches at Byers pond. We found that male gray treefrogs do not choose

perches based on perch color, but that they use perches in the proportion at which they are available in nature. Thus, males do not appear to try to maximize either conspicu-

ousness or camouflage when selecting their calling perches. Undergraduate research project, Gerlinde Höbel, advisor.

## Effects of Different Bumble Bee Species on Reproductive Success and Mating Patterns in *Mimulus ringens*

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Over the last decade there have been dramatic changes in the relative abundance and diversity of bumble bee populations, including significant decline of many species both in North America and Europe. Often several species co-occur sympatrically and it is not known if these species provide equivalent pollination services for native flowering plants. To address this question we quantified seed set of *Mimulus ringens* flowers following individual visits by *Bombus vagans* and *Bombus impatiens*. These two species coexist in native populations and vary markedly in both body size and foraging behavior.

The mean seed set following single visits

by *B. vagans* was  $3131 \pm 261$ . This level of seed set was significantly higher than seed set resulting from visits by *B. impatiens* ( $2423 \pm 227$ ), suggesting that different bumble bee species may not have the same contributions to native plant reproduction. Therefore even without a decline in the total number of bumble bees, local plants may still be affected by reduced pollinator diversity or changes in the relative abundance of pollinator species. Future work will explore how visits by these two species influence pollen receipt, self-pollination rate, mate diversity and gene dispersal. M.S. Thesis research, Dr. Jeffrey Karron, Major Advisor.

## Bat Activity Surveillance Monitoring at Neda Mine Hibernaculum

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White-nose syndrome (WNS) is a devastating cave-bat disease caused by the fungal pathogen *Pseudogymnoascus* (= *Geomyces*) *destructans*. The disease has spread to 23 states and five Canadian provinces since its discovery in 2006 in New York, and has killed 90 to 100 percent of the bats in infected hibernacula. The U.S. Fish & Wildlife Service estimates that 5.7 million to 6.7 million bats have already died from the disease. Monitoring bat populations is crucial in states like Wisconsin that are currently considered unaffected, both for early identification of the

disease and to develop pre-WNS baselines in this region. The bat populations of Neda Mine have been inspected for WNS annually for the past three hibernation seasons and continue to be inspected at least annually.

Baseline data on population densities, movement patterns and health is necessary for ongoing research on WNS. To this end, the Wisconsin Department of Natural Resources (WDNR) will continue to monitor Neda's bat population using two surveillance techniques: 1) thermal infrared surveillance on a hibernating bat population and 2) pre/post

hibernation trapping of bats. Both techniques will allow the WDNR to conduct disease assessment during all phases of hibernation, which is when bats are most vulnerable. This information is also essential for accurately

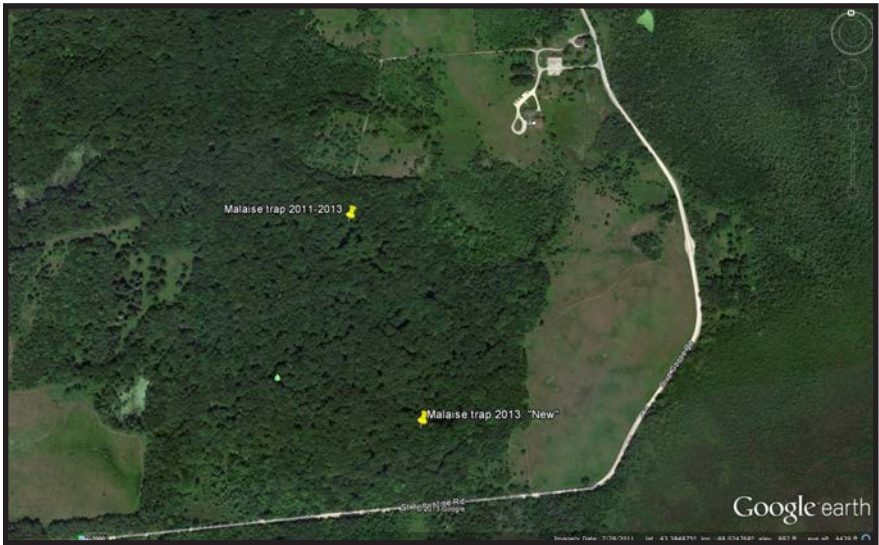
understanding the effects of the disease when it arrives and for planning the recovery of the bat population.

## A General Survey of Wisconsin's Beetle Diversity (Insecta: Coleoptera)

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During the 21 week period of 04 June to 24 October 2013, two Malaise traps were run, with samples collected weekly. One Malaise trap was located just inside the old growth beech-maple forest west-southwest of the Station (43.38567°N/-88.02638°W) in the same site as the previous year (2012 sampling). A second Malaise trap was set in the southeastern section of the forest (43.38295°N/-88.02534°W). The 2013 survey continued a sampling study begun in 2011. Material from 2013 is still in the queue

for processing (sorting, mounting, labeling) so I have no new records to add at this reporting. However, the annotated species list has now been published in *The Field Station Bulletin* (2013, Vol. 33: 1-19). Once again, traps were installed much later in the season than I had hoped. A major goal for 2014 will be to establish traps much earlier so as to better sample the early season species. The current plan is to focus, once again during the 2014 field season, in the old growth beech-maple forest.



Malaise trap locations for 2013 sampling.



Example of deployed "Townes style" Malaise trap.

## Examining Spring and Autumn Phenology in a Temperate Deciduous Urban Woodlot

Rong Yu

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This dissertation is an intensive phenological study in a temperate deciduous urban woodlot (Downer Woods) over six consecutive years (2007-2012). It explores three important topics related to spring and autumn phenology, as well as ground and remote sensing phenology. First, it examines key climatic factors influencing spring and autumn phenology by conducting phenological observations four days a week and recording daily microclimate measurements. Second, it investigates the differences in phenological responses between an urban woodlot and a rural forest by employing comparative basswood phenological data. Finally, it bridges ground visual phenology and remote sensing derived phenological changes by using the Normalized Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI) derived from the Moderate Resolution Imaging Spectro-radiometer (MODIS).

The primary outcomes are as follows: 1) empirical spatial regression models for two

dominant tree species - basswood and white ash - have been built and analyzed to detect spatial patterns and possible causes of phenological change; the results show that local urban settings significantly affect phenology; 2) empirical phenological progression models have been built for each species and the community as a whole to examine how phenology develops in spring and autumn; the results indicate that the critical factor influencing spring phenology is AGDD (accumulated growing degree-days) and for autumn phenology, ACDD (accumulated chilling degree-days); and 3) satellite derived phenological changes have been compared with ground visual community phenology in both spring and autumn seasons, and the results confirm that both NDVI and EVI depict vegetation dynamics well and therefore have corresponding phenological meanings. Ph.D. Dissertation research, Mark Schwartz, Major Professor.

# Recent Publications and Theses

## — Recent Publications Resulting from Field Station Projects —

**Flanagan, R. J., R. J. Mitchell, D. Knutowski, and J. D. Karron.** 2009. Interspecific pollinator movements reduce pollen deposition and seed production in *Mimulus ringens* (Phrymaceae). *American Journal of Botany* 96: 809–815.

**Hull-Sanders, H. M., R. H. Johnson, H. A. Owen, and G. A. Meyer.** 2009. Effects of polyploidy on secondary chemistry, physiology, and performance of native and invasive genotypes of *Solidago gigantea* (Asteraceae). *American Journal of Botany* 96: 762–770.

**Hull-Sanders, H.M., R.H. Johnson, H.A. Owen, and G. A. Meyer.** 2009. Influence of polyploidy on insect herbivores of native and invasive genotypes of *Solidago gigantea* (Asteraceae). *Plant Signaling & Behavior* 4: 893–895.

**Kapfer, J. M., W. P. Mueller, M. M. Porzky, and G.S. Casper.** 2009. Geographic distribution: *Regina septemvittata*, Wisconsin, Rock County. *Herpetological Review* 40:116.

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**Wilder, T. T., M. Heeter, L. Breitenbach, G. S. Casper, and J. M. Kapfer.** 2009. Geographic distribution: *Diadophis punctatus edwardsii*, Wisconsin, Monroe County. *Herpetological Review* 40(1): 113–114.

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**Wolkovich, E. M., B. I. Cook, J. M. Allen, T. M. Crimmins, S. Travers, S. Pau, J. Regetz, T. J. Davies, J. L. Betancourt, N. J. B. Kraft, T. R. Ault, K. Bolmgren, S. J. Mazer, G. J. McCabe, B. J. McGill, C. Parmesan, N. Salamin, M. D. Schwartz, and E. E. Cleland.** 2012. Warming experiments underpredict plant phenological responses to climate change. *Nature* 485: 494-497.

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**Betancourt, K. Bolmgren, E. E. Cleland, B. I. Cook, T. M. Crimmins, S. J. Mazer, G. J. McCabe, P. Pau, J. Regetz, M. D. Schwartz, and S. Travers.** 2013. Phylogenetic conservatism in plant phenology. *Journal of Ecology* 101: 1520-1530.

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## Recent Theses

**Vasquez, Eric C.** 2008. The effects of enemy exclusion and enemy damage on exotic and native plant species: a test of the enemy release hypothesis. M.S. Thesis

**Flanagan, Rebecca J.** 2009. Exploring the effects of competitors for pollination on the reproductive success of *Mimulus ringens*. Ph.D. dissertation.

**Goldsberry, Jessica K.** 2010. Riparian plant communities of the fifth order Milwaukee River floodplain and islands. M.S. Thesis.

**Hileman, Eric T.** 2010. Abundance and survivorship of Butler's gartersnake (*Thamnophis butleri*) in Wisconsin. M.S. Thesis.

**Ambardar, Medhavi.** 2011. Effects of habitat and predation on reproductive success in eastern bluebirds (*Sialia sialis*). M.S. Thesis

**Berg, Jason.** 2011. Susceptibility of five wetland community types to invasion by glossy

buckthorn (*Frangula alnus*, Mill.). M.S. thesis.

**Kilkenny, Francis F.** 2012. Gene flow and adaptation in *Lonicera japonica*. Department of Biology, University of Virginia, Charlottesville. Ph.D. dissertation.

**Reis, Anne.** 2012. Conservation of the southeastern Wisconsin tamarack swamp: Loss, persistence, and restoration. M.S. Thesis.

**Kim, Son Young.** 2012. Real-time adjustment of satellite behavior to local competition in gray treefrogs. M.S. Thesis.

**Rebar, Darren.** 2013. Influence of genetic variation in the biotic environment on phenotypic variation in a plant-feeding insect. Ph.D. dissertation.

**Yu, Rong.** 2013. Examining spring and autumn phenology in a temperate deciduous urban woodlot. Ph.D. dissertation

# Cooperation with Other Groups and Agencies

Service to the local community, and to the state-wide community of individuals, groups, and organizations engaged in natural area study and preservation is a major part of the Field Station's mission. To the extent that our staff has time available, we provide natural area consulting services to the community. The demand for these services exceeds our capacity to help, but we feel that these cooperative efforts are a very important part of our mission.

**1. Friends of the Cedarburg Bog.** The Field Station cooperates with and helps to support this non-profit organization that has a mission to initiate and support activities that will enhance the natural history, public appreciation, and scientific study of Cedarburg Bog in cooperation with the Wisconsin DNR and UWM.

**2. Department of Natural Resources.** The Station continued its wide range of planning and management activities in conjunction with the DNR. These activities include the day-to-day surveillance of the Cedarburg Bog performed by Station staff and some assistance with maintenance activities such as snowplowing.

**3. Natural Areas Preservation Council.** The Station participates in the State Natural Areas program, since the Station owns and manages five properties that have State Natural Areas status.

**4. Ozaukee Washington Land Trust.** The Land Trust is a non-profit, land conservancy for Ozaukee and Washington Counties. The Field Station helps to support the organization's activities in various ways. Jim Reinartz served on the Conservation and Stewardship Committees and on the management committee for their Fairy Chasm property.

**5. Invasive Plants Association of Wisconsin.** This non-profit organization works to stop the spread of invasive plants in Wisconsin. Reinartz served on the Board of Directors and was editor of the IPAW newsletter, "Plants out of Place".

**6. Riveredge Nature Center.** The Field Station cooperates with RNC on a wide range of programs.

**7. Regional School Systems.** Advanced biology classes from several high schools in the region (Milwaukee, Ozaukee, and Washington counties) use the Field Station for ecology field classes.

**8. National Oceanic and Atmospheric Administration – Milwaukee Office.**

Weather records are provided monthly and frost and snow depth data are collected in winter.

**9. Organization of Biological Field Stations.** The Station is an active member of this national organization and cooperates in the exchange of information on programs.

**10. Wisconsin Department of Transportation.** The Station raises beetles for biological control of purple loosestrife for WDOT.

**11. Urban Ecology Center—Milwaukee.**

G. Meyer serves on the Citizen Science Advisory Council.

**12. U.S. Fish and Wildlife Service.** G. Meyer provides support for monitoring of the federally-endangered Hine's emerald dragonfly (*Somatochlora hineana*).

**13. Wisconsin Task Force on Invasive Species.** Reinartz serves on the task force and chairs the Science and Research Subcommittee of the task force.

**14. Southeastern Wisconsin Invasive Species Consortium (SEWISC).** Reinartz serves on the Board of Directors and as Treasurer for the organization.

**15. Ozaukee Treasures Network.** The Field Station is cooperating with this consortium of over 30 environmental organizations to promote conservation in Ozaukee County.

**16. Wisconsin Phenological Society.** G. Meyer serves on the Board of Directors.

**17. National Science Foundation.** G. Meyer served on a review panel to evaluate submitted proposals.

# 2013 Natural History Workshops

This is a series of intensive workshops on specialized topics which provide a continuing education opportunity and a meeting place for biologists. Eleven workshop topics were offered in 2013. Most of these workshops were filled to the capacity of 20 people.

Workshop	Instructor	Date
Ecology and Physiology of Plants in Winter: Surviving the Big Chill	James Reinartz	January 4 & 5
Creative Writing About the Natural World	Mary Linton	April 12 & 13
Wildlife Inventory and Monitoring	Gary Casper	May 31 & June 1
Breeding Birds of Wisconsin	William Mueller, Owen Boyle and Jennifer Callaghan	June 1 - 8
Vegetation of Wisconsin	James Reinartz	June 17 - 22
Aquatic Invertebrates	Gretchen Meyer and Robert Clare	June 28 & 29
Ecological Geology	Roger Kuhns	July 8 - 12
Grasses: Identification and Ecology	Robert Freckmann	July 26 & 27
Common Algae of the North Kettle Moraine	Paul Engevoild	August 16 & 17
Lichens: Charismatic Cryptograms	Suzanne Joneson	September 6 & 7



Breeding Birds of Wisconsin workshop in June, 2013

# Class and Group Use

## Winter - Spring 2013

## Number of Student Hours

Ecology and Physiology of Plants in Winter Workshop . . . . .	360
Creative Writing Workshop . . . . .	320
Wildlife Inventory & Monitoring Workshop . . . . .	340
Winter Ecology Hike and Friends Chili Dinner . . . . .	540
Friends of Cedarburg Bog – Owl-prowl hike . . . . .	60
Friends of Cedarburg Bog – Winter survival . . . . .	60
Friends of Cedarburg Bog – Woodcocks and frogs . . . . .	80
Friends of Cedarburg Bog – Woodcocks, Frogs & a full moon . . . . .	75
Friends of Cedarburg Bog – The Bog in Spring . . . . .	60
Friends of Cedarburg Bog – Ecology of the Bog – North . . . . .	85
Friends of Cedarburg Bog – Marsh marigold walk . . . . .	45
Friends of Cedarburg Bog – Bog tour . . . . .	60
Friends of Cedarburg Bog – Meetings . . . . .	90
Field Station Garlic Mustard Search/Pull. . . . .	30
UWM Innovation Campus – Monarch trail tour . . . . .	80
Riveredge Nature Center Master Naturalists Training. . . . .	65
Urban Ecology Center / UW-Madison Arboretum bog tour . . . . .	75
Natural Resources Foundation – Bird-a-thon Big Day . . . . .	90
Northern Ozaukee High School – Ecology Club . . . . .	35
Benedict Prairie – Prairie volunteer day . . . . .	20
Wisconsin Phenology Society – Phenology program tour. . . . .	45
Milwaukee Institute of Art & Design – Ecology . . . . .	55
UW Arboretum Friends – Bog tour . . . . .	150
UW Oshkosh – Environmental class field trip . . . . .	380
UWM – Geophysics – Neda Mine exploration. . . . .	120
<b>TOTAL . . . . .</b>	<b>3,320</b>

## Summer 2013

Breeding Birds Workshop . . . . .	720
Vegetation of Wisconsin Workshop . . . . .	1,240
Aquatic Invertebrates Workshop . . . . .	215
Ecological Geology Workshop . . . . .	600
Grasses: Identification and Ecology Workshop. . . . .	380
Algae: Identification and Ecology Workshop. . . . .	290
Friends of Cedarburg Bog – Stargazing . . . . .	120
Friends of Cedarburg Bog – Summer Solstice Walk. . . . .	60
Friends of Cedarburg Bog – Wild foods workshop . . . . .	160
Friends of Cedarburg Bog – Spring Birds walk . . . . .	55
Friends of Cedarburg Bog – Photography Workshop . . . . .	35
Friends of Cedarburg Bog – Bat Monitoring . . . . .	25
Friends of Cedarburg Bog – Dragonflies of the Bog . . . . .	60
Friends of Cedarburg Bog – meetings . . . . .	70
Wild Ones – Bog Tour . . . . .	45
Treasures of Oz / FOCB – Bog Tour & Open House. . . . .	320
Riveredge Nature Center – Teacher Naturalist class . . . . .	55

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## Summer 2013

## Number of Student Hours

4H – Bog Tour . . . . .	25
Urban Ecology Center – Intern field trip . . . . .	45
Urban Ecology Center – Lichens class . . . . .	30
Urban Ecology Center – Bird walk . . . . .	55
Upward Bound tour . . . . .	35
American Indian HS – Science Scholars tour . . . . .	45
UW Whitewater – Ecology class . . . . .	120
UWM School of Freshwater Sciences – Bog tour . . . . .	65
<b>TOTAL . . . . .</b>	<b>4,870</b>

## Fall 2013

Lichens: Charismatic Cryptogams Workshop . . . . .	360
Friends of Cedarburg Bog – Annual Meeting & potluck . . . . .	140
Friends of Cedarburg Bog – Forest Ecology walk . . . . .	90
Friends of Cedarburg Bog – Fundraising Event . . . . .	50
Friends of Cedarburg Bog – Fall migrant bird hike . . . . .	80
Friends of Cedarburg Bog – Owl Prowl . . . . .	70
Friends of Cedarburg Bog – Buckthorn control work day . . . . .	75
Friends of Cedarburg Bog – meetings . . . . .	80
Kettle Moraine Lutheran High School – Ecology Club . . . . .	60
Kettle Moraine Lutheran HS – AP Environmental Science . . . . .	45
Greendale High School – Ecology . . . . .	75
Riveredge Nature Center – Plants in Winter class . . . . .	75
Riveredge Nature Center – Christmas Bird Count . . . . .	60
Society for Ecological Restoration field trip . . . . .	120
Wisconsin Bird & Bat Observatory meeting . . . . .	15
Alverno College – Wetland Ecology . . . . .	65
University of Illinois-Chicago– Ecology field trip . . . . .	625
UW – Whitewater – Ecology class . . . . .	40
UWM – Geology Club – Neda Mine . . . . .	60
UWM – Conservation and Environmental Science class . . . . .	15
UWM – Foreign Exchange Students – Bog Tour . . . . .	60
UWM – Geography – Soils . . . . .	180
UWM – Geology – Hydrogeology . . . . .	280
<b>TOTAL . . . . .</b>	<b>2,720</b>

**TOTAL 2013 Class & Group Use Hour . . . . .10,910**

# Meteorological Data for 2013

This yearly summary is modeled, where possible, after the summaries provided by the National Oceanic and Atmospheric Administration (NOAA). Some differences between the two reports reflect differences in available equipment. Records for the Field Station are reported in degrees Celsius and in other metric measures. In addition, growing degree-days at 5° and 10°C, (see below for description) were substituted for the heating and cooling degree-days used by NOAA. The variables reported in the summaries are defined as follows:

## Temperature

**Average Daily Maximum:** Monthly mean of the 30-min period in each day with the highest mean temperature.

**Average Daily Minimum:** Monthly mean of the 30-min period in each day with the lowest mean temperature.

**Daily Average:** Monthly mean of all 30-min means. (NOAA uses the midpoint between the daily minimum and maximum for this measure.)

**Highest(Date):** Highest 30-min mean temperature. (Day of month with highest temperature.)

**Lowest(Date):** Lowest 30-min mean temperature. (Day of month with lowest temperature.)

## Degree Days

**Sum at 5°:** Sum of the number of degrees by which the daily average temperatures exceeded 5° C.

**Sum at 10°:** Sum of the number of degrees by which the daily average temperature exceeded 10° C.

## Radiation (kW/m<sup>2</sup>)

**Mean:** Mean of all 30-min means in the month.

**Maximum:** Maximum 30-min mean during the month.

## Relative Humidity

Monthly mean of the 30-min means for each quarter of the day.

## Number of Days

**Precipitation** of 0.25 mm or more

### Temperature-Maximum

**32° and above:** Number of days with a maximum 30-min mean temperature of 32° C or above.

**0° and below:** Number of days with a maximum 30-min mean temperature of 0° C or below.

### Temperature-Minimum

**0° and below:** Number of days with a minimum 30-min mean temperature of 0° C or below.

**-18° and below:** Number of days with a minimum 30-min mean temperature of -18° C or below.

## Mean Pressure (mbars)

Mean of all 30-min means in the month.

## Precipitation (mm)

**Total:** Sum of all precipitation during the month.

**Greatest (24 hrs) (Date):** Total precipitation on the day with the most precipitation and the date on which it occurred.

## Wind

**Mean Speed (m/s):** Monthly mean of all 30-min means.

**Maximum Speed (m/s):** Highest mean wind speed during a 30-min period.

The Field Station can provide weather data in electronic format; datasets go back to 1989. Please contact us if you would like to receive the weather data.

# Meteorological Data for 2013

## Temperature (C°)

Average Daily Maximum	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	OCT	NOV	DEC
Average Daily Minimum	-1.1	-1.7	1.4	9.7	19.4	23.2	25.6	25.9	22.1	14.6	5.7	-2.9
Daily Average	-10.5	-10.8	-6.9	1.0	7.7	12.2	14.8	13.7	10.1	4.4	-2.5	-12.2
Highest (Date)	-5.3	-5.7	-2.3	5.3	13.6	17.7	20.5	20.0	16.0	9.7	1.7	-7.2
Lowest (Date)	14.4 (29)	8.0 (18)	12.3 (30)	30.0 (30)	29.2 (30)	30.5 (23)	33.2 (17)	34.1 (27)	33.6 (10)	26.5 (1)	16.9 (17)	10.7 (4)
	-22.0 (22)	-19.4 (1)	-18.7 (4)	-6.0 (3)	-1.7 (13)	4.4 (3)	9.6 (12)	6.8 (14)	3.2 (23)	-2.1 (23)	-14.9 (29)	-23.6 (30)

## Degree Days

Sum at 5°	2.3	0.0	1.0	65.5	265.2	380.7	481.7	464.4	331.5	155.3	27.7	0.6
Sum at 10°	0.0	0.0	0.0	24.6	139.6	230.7	326.7	309.4	182.8	60.4	1.7	0.0

## Radiation (kW/m<sup>2</sup>)

Mean	0.08	0.09	0.16	0.17	0.23	0.25	0.25	0.24	0.19	0.11	0.07	0.06
Maximum	0.55	0.69	0.86	0.98	1.05	1.07	1.04	0.98	0.86	0.71	0.54	0.43

## Relative Humidity (%)

Hour 00-06 mean	81.8	88.1	82.2	83.4	86.0	93.2	93.9	94.6	95.7	90.5	82.2	88.4
Hour 06-12 mean	79.1	83.4	74.1	72.2	67.9	75.5	71.7	72.3	78.4	78.7	78.6	85.4
Hour 12-18 mean	71.4	75.3	66.9	64.2	59.6	63.0	65.6	61.2	67.4	69.3	68.4	77.1
Hour 18-24 mean	79.9	84.7	78.6	76.6	76.8	85.6	86.7	89.1	92.7	86.0	76.8	83.7

## Number of Days

Precip. 0.25mm or more	11	10	9	14	15	14	9	9	13	12	12	13
Max Temp 32° and above	0	0	0	0	0	0	3	2	1	0	0	0
Max Temp 0° and below	17	15	12	0	0	0	0	0	0	0	8	21
Min Temp 0° and below	29	28	30	11	1	0	0	0	0	6	19	29
Min Temp -18° and below	2	4	1	0	0	0	0	0	0	0	0	8

## Pressure (mbars)

Mean	1017.07	1014.18	1016.91	1015.02	1015.45	1014.00	1017.38	1017.78	1017.01	1015.11	1019.31	1017.30
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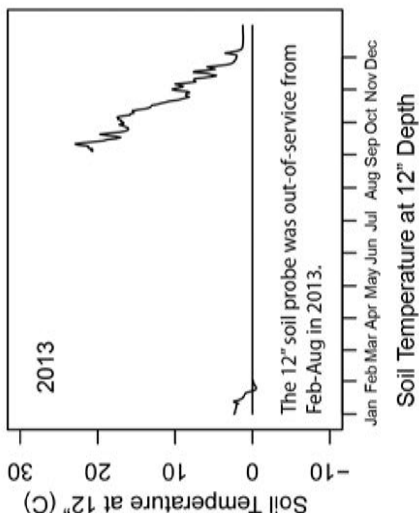
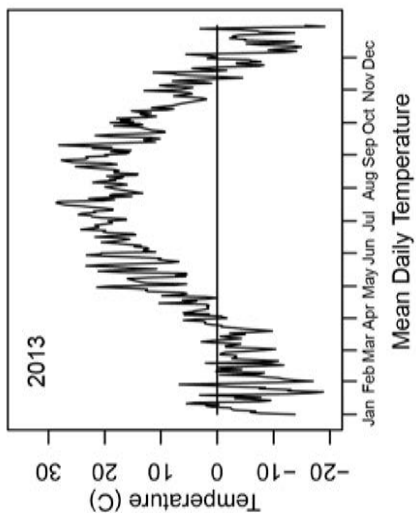
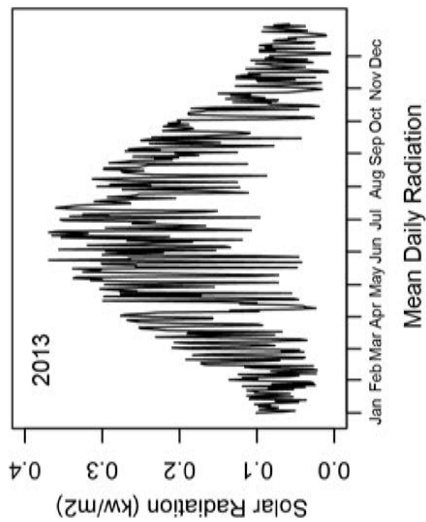
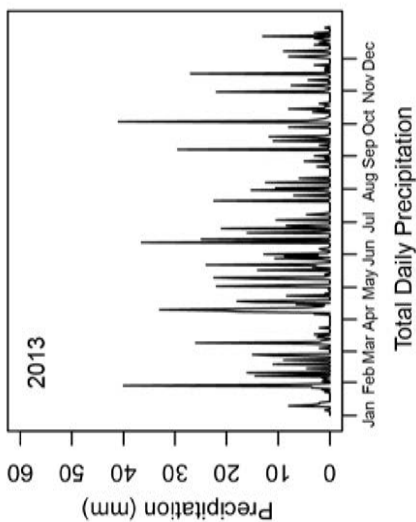
## Precipitation (mm)

Total	74.0	85.0	45.0	146.1	143.5	132.5	62.9	38.3	70.8	87.7	48.3	50.0
Greatest (24 hrs) (Date)	40.0 (29)	16.0 (10)	26.0 (10)	33.0 (10)	24.0 (22)	36.5 (12)	22.5 (21)	12.5 (7)	29.5 (7)	41.0 (3)	27.0 (17)	13.0 (22)

## Wind

Mean Speed (m/s)	2.2	NA <sup>1</sup>	2.1	2.4	1.8	1.3	1.1	1.0	1.1	1.3	1.9	1.8
Maximum Speed (m/s)	8.4	NA	5.4	6.1	5.3	4.9	4.2	3.5	4.1	4.3	6.4	4.6

1- NA, not available. The anemometer was not recording Jan. 30 - Feb. 5.





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