2016 Field Station Annual Report

UNIVERSITY of WISCONSIN
UWMILWAUKEE
Field Station

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On the Cover: Louise Marum, Matthew Heritsch, and Alyssa Tomlinson measure a silver maple during the Forest Communities workshop in 2016. The Field Station workshop program has been offering credit and continuing education classes in natural history topics for 35 years. These are intensive two-day and week-long courses taught by regional experts at the advanced undergraduate/graduate level on various topics in field biology, with over 25 course topics taught regularly as part of the program.

About Us

2016 Highlights

- The Field Station obtained a grant from the Southeastern Wisconsin Invasive Species Consortium to continue eradication of invasive shrubs and garlic mustard in Downer Woods. With completion of this project, the invasive control work in Downer Woods will enter a new maintenance phase requiring substantially less annual effort.
- The Friends of Cedarburg Bog continued their major project to control buckthorn in hundreds of acres of the Bog, funded with a $197,000 grant from the US EPA, and two other grants. A crew of four was hired to work on the project in 2016. The Field Station helps direct and manage the project.
- Two "lowlights" for 2016: The die-off of all three species of ash trees due to Emerald Ash Borer is nearly complete in both the upland forest and the Cedarburg Bog. The white-nose syndrome disease was confirmed in bats at the Field Station's Neda Mine Bat Hibernaculum.
- The Friends of Cedarburg Bog completed a rustic boardwalk to Mud Lake from Cedar Sauk Road to replace the treacherous informal path that provided the only previous access.
- The Field Station website was redesigned, and the Field Station Bulletin articles have been archived in UWM's Digital Commons where they are available for download.
- The exterior of the Farm House was painted and all of the trim was cladded with aluminum, greatly improving the appearance of the house.
- 44 research projects in 2016.
- Almost 13,000 person-hours of instruction and group use in 2016. Use of our Downer Woods on the main campus for instruction has grown now that the worst invasive plant problems are largely under control and the forest is recovering.

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 371 scientific publications and 149 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. In 2015, the DNR purchased 66 acres of land in the Cedarburg Bog from The Bog Golf Course, the first major addition of acreage to the State Natural Area in decades. As of 2016 Emerald Ash Borer has killed essentially all of the mature

ash trees in the Bog. Approximately 12% of the trees in the Bog were black ash, accounting for 10% of total tree basal area, and 2% were green ash, 4% of basal area.

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. We have known that Emerald Ash Borer beetles have been present in the woods since 2012 when adults were captured in traps at the Station. Essentially all of the white ash in the upland forest are now dead. White ash made up about 9% of the trees in the forest and 13% of the total basal area of trees. 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. We conducted controlled burns of three prairie/old-field areas (Burn units 2, 4, and 5) on 15 April 2016 with Field Station staff and volunteers.

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*), Japanese barberry (*Berberis thunbergii*) meadow parsnip (*Pastinaca sativa*), purple loosestrife (*Lythrum salicaria*), sweet clover (*Melilotus* spp.), motherwort (*Leonurus cardiaca*), Oriental bittersweet (*Celastrus orbiculatus*) 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. 2016 was the first year that we observed excellent control of purple loosestrife by the beetles; flowering was essentially eliminated in 2016 and the plants were very

A Wisconsin DNR crew worked with the Friends of the Cedarburg Bog Invasive Management crew to control buckthorn in the winter of 2016

badly damaged. 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 long-term control throughout the natural areas seems intractable with the hand and mechanical methods we are using elsewhere. Since 1991 fruiting-sized buckthorn has been cut and treated with herbicide in various selected control plots in the northern and central parts of the Bog by the Wisconsin DNR and the Friends of Cedarburg Bog. FOCB continues to work with a $197,000 Great Lakes Restoration Initiative grant from the US EPA, $9,300 from the Wisconsin Knowles-Nelson Stewardship Program, and $7,900 from the We Energies Foundation through the Natural Resources Foundation of Wisconsin for buckthorn control work in the Bog. With a total budget of almost $250,000 for the project, FOCB has a very ambitious goal to remove fruiting-sized buckthorn from hundreds of acres of the Bog.

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 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

Animal Ecology & Behavior

- Sound room facility for studies of frog communication and vocalizations
- Live traps & animal holding facilities
- A large array of snake cover-boards
- Extensive arrays of bird nest boxes
- Flying squirrel nest boxes
- Insect collection, small mammal & bird study skins

Experimental Garden

- 7 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. 2015 was the first year that the fungus that causes white-nose syndrome in bats was positively detected at the Neda Mine Hibernaculum. The disease was confirmed in the bat population in 2016, and we expect to see a large decline in the bat populations over the coming years. The bats emerged earlier than normal in spring 2016, and we received reports of dead and dying bats from the neighbors at Neda Mine (see the abstract by White, Feldkirchner and Boyle). 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. More extensive woody plant brush removal was conducted in 2014, and the prairie was burned in the spring of 2015 and again on 14 April 2016.

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. In 2016 the Field Station obtained a grant from the Southeastern Wisconsin Invasive Species Consortium to continue eradication of invasive shrubs and garlic mustard in Downer Woods. With completion of this project, the control work in Downer Woods will enter a new maintenance phase requiring substantially less annual effort.

UWM Innovation Campus – The UWM Monarch Conservancy – 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 conservation goal for this site is 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.

Field Station Programs

• 44 active research projects conducted at the Field Station in 2016.

• Including: 5 M.S. thesis, 4 Ph.D. and 12 studies by researchers from outside of the University.

• 14 papers published during 2016. 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.

• A working map of the Cedarburg Bog basin depth.

• Phenological observations on leaf-out and flowering of standard genotypes of 6 species in a phenological garden, and 25 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. Dr. Mark Schwartz' research relating climatic parameters to seasonal development of plants has contributed to this long-term database.

• Continuous monitoring of bat activity levels at the Neda Mine Bat Hibernaculum since 2000 and of temperatures in the mine since 1997.

• Drs. Peter Dunn and Linda Whittingham have conducted long-term studies on tree swallows and sexual selection.

• Records of long-term (30 year) research projects conducted by Dr. Charles Weise, on Black-capped Chickadees, Dark-eyed Juncos, breeding bird surveys of the Cedarburg Bog & upland woods, and a bird-netting and banding program conducted in fall.

• The Field Station was a major site for long-term studies of avian vocalizations, including their organization and function, by Dr. Millicent Ficken.

• Herpetological research has been a major research area at the Field Station for over a decade. Knowledge of our amphibian and reptile populations has been contributed by Dr. Gerlinde Hoebel, Dr. Gary Casper, and Dr. Joshua Kapfer.

• Dr. Jeffery Karron's research on pollination mechanisms has contributed to long-term information on the pollinators of the Field Station.

• GIS developed for the Field Station area.

Educational Programs

• Almost 13,000 person-hours of instruction and group use in 2016.

• Nine workshops on topics in natural history.

• Long-time volunteer naturalist at the Field Station, Kate Redmond a.k.a. The Bug Lady, writes "Bug of the Week", which are essays on local bugs. There are now over 400 of these excellent and entertaining essays posted on the Field Station website (http://uwm.edu/field-station/category/bug-of-the-week/). Bug of the Week has become by far the most visited feature of our website.

• 8 undergraduate student projects.

• 21 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

The Friends of the Cedarburg Bog – 2016

The Friends of the Cedarburg Bog (FOCB) was founded in 2005 and the organization's capacity has grown remarkably since then. The FOCB Board of Directors continues to follow their strategic Action Plan focusing their effort in five areas:

• Strengthen Community Support for the Bog – The Bog can be best protected through well-informed collaboration of its immediate and extended communities.

• Expand FOCB's Conservation Impact –

Volunteers and Field Station staff constructed and installed a boardwalk to Mud Lake

Stewardship efforts must grow faster than the encroaching dangers to the Bog's sensitive ecosystem.

• Extend the use of the Bog as a Natural History Classroom and Laboratory

• Be a Good Partner – Increase collaboration with like-minded organizations.

• Be a Healthy Organization – Strengthen FOCB's focus, finances and effectiveness.

Some of the main highlights and challenges for FOCB in 2016 include:

• FOCB obtained final approval from the Wisconsin DNR for construction of a safe, rustic boardwalk to Mud Lake from Cedar Sauk Road. Construction of the boardwalk was completed in the fall of 2016 with the help of many volunteers and donated funds for all of the materials.

• FOCB membership and donations continue to be strong, and the permanent endowment has shown continued growth.

• The Bog has many long-time supporters, who may live at some distance but have a real connection to the Bog. In 2016 FOCB continued their effort to engage and attract more of the Bog's geographic neighbors by holding an open house for neighbors event at the Field Station.

• The Friends continued its most ambitious stewardship project to date, working on a $197,000 grant from the EPA to mitigate buckthorn encroachment in the Bog. With additional grants from the Natural Resource Foundation of Wisconsin and the DNR, and considering volunteer labor, that project is valued at over a quarter of a million dollars.

• The Friends expanded their well-received educational programs, offering 21 events in 2016, the largest number of events for the general public ever held in a year at the Station.

• FOCB committed funding of $5,000 to support the Field Station's Natural History Workshops, and is now a sponsor of that program. Additionally, FOCB provided funding for a night-lighting system in the parking area.

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 information on how to become involved, or visit the FOCB website, www.bogfriends.org.

Abstracts of Research

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 important wildlife resources for OWLT habitat management and acquisition and protection planning. In 2016 we continued herptile, crayfish and bird monitoring at several OWLT properties.

Wisconsin Herp Atlas

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The Wisconsin Herp Atlas is a distribution database of amphibians and reptiles in Wisconsin. The author initiated the Atlas 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 600 new county records have been confirmed by the project. The data collected helps to map species distributions, document rare species occurrences, analyze distribution and habitat associations, and plan conservation priorities. In 2007 the Atlas was moved to the UWM Field Station, and currently houses over 73,000 occurrence records for Wisconsin. Record collection and vetting continued in 2016, and 5 new county distribution records were published.

Wildlife Ecopassage Monitoring

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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. Few data are available for evaluating the conservation effectiveness of these structures. This project will assess the effectiveness of ecopassages in Southeastern Wisconsin, and collect data on patterns of wildlife use. Funded by C.D. Besadny Conservation Grant, Natural Resources Foundation of WI, and Wisconsin Department of Transportation.

National Park Service Great Lakes Network Amphibian Monitoring Program

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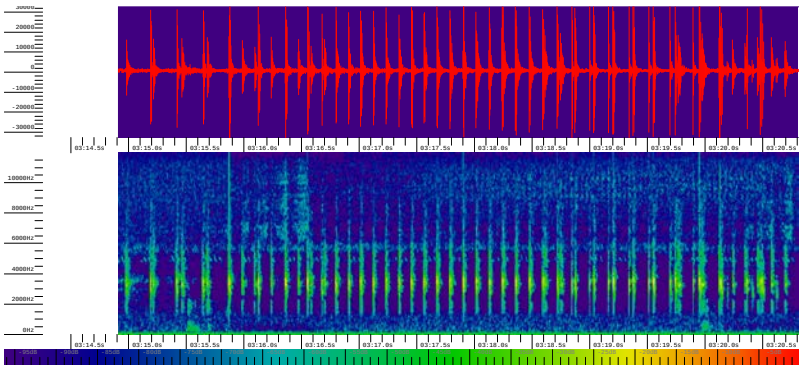
The goal of this project is to implement amphibian monitoring in seven National Parks in the Western Great Lakes region. A protocol utilizing automated recording systems and supplemental visual surveys was completed in 2012, and we began implementing the program in three parks in 2013. In 2016 we monitored seven parks and additional analysis and reporting was commissioned for 2017. Funded by the National Park Service.

Measuring a wood turtle, Ottawa National Forest (photo by Kristina Kroening)



Using acoustic analysis of spectrograms, Dr. Casper's team documented three new county records for Minnesota's most endangered frog, Blanchard's cricket frog, *Acris blanchardi,* in 2016 surveys along the Mississippi River for the National Park Service. The frogs are very well camouflaged.

Wildlife Population Assessment for the Milwaukee Estuary Area of Concern

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The goal of this 3-year project is to evaluate the status of selected wildlife populations in the Milwaukee County portion of the Milwaukee River Area of Concern, and make recommendations for addressing Beneficial Use Impairments through habitat restoration projects and monitoring. The project is coordinated with Milwaukee County Parks, participating under separate funding. Work includes historical data collection, wildlife surveys, landowner outreach, and reporting. Work was extended in 2016 through 2017 with new survey areas.. Funded by the Wisconsin DNR and the U.S. Environmental Protection Agency.

Effects of *Metriocnemus knabi* Predation on Bacterivorous Ciliates in *Sarracenia purpurea* Pitchers

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Decomposition of prey in the leaves of the carnivorous pitcher plant *Sarracenia purpurea* provides energy that supports an inquiline community consisting of bacteria, protozoans, rotifers, mites, and dipteran larvae. The natural history of this community is well described, and it is historically organized into a four trophic-level food web with bacteria as the basal level supporting protozoa, the bacterivorous bdelloid rotifer *Habrotrocha rosa* and filter-feeding larvae of the pitcher plant mosquito *Wyeomyia smithii*. Rotifers and protozoa are consumed by the mosquito larvae; rotifers are also consumed by the raptorial larvae of the flesh fly *Fletcherimyia fletcheri*. Larvae of the pitcher plant midge *Metriocnemus knabi* feed on drowned arthropods and, in a processing chain commensalism, promote bacterial growth and a subsequent increase in larval mosquito biomass. We recently reported that midge larvae also consume rotifers. In this study, we further tease apart the interactions among *W. smithii* and *M. knabi* larvae, *H. rosa* and two common bacterivorous pitcher ciliates. We reconstituted

food webs in a factorial design experiment in 50 mL plastic centrifuge tubes using wood ants as "prey." The experiment ran for two weeks; ants were added on days 1 and 7.

As expected, predation by both *W. smithii* and *M. knabi* caused significant decreases in rotifer numbers and drove them to near extinction by 14 days ($P < 0.001$). *W. smithii* also caused significant reductions in *Colpoda* and *Cyclidium* ($P < 0.01$). Unexpectedly, both ciliates were reduced to very low numbers by *M. knabi* larvae ($P < 0.01$). In each case, there were significant additive interactions between the two predators resulting in decreases in the two ciliates after one and two weeks ($P < 0.03$ for *Colpoda*; and $P < 0.0001$ for *Cyclidium*). There was a significant interaction between midges and mosquitoes for rotifers, but only after two weeks ($P < 0.0001$). In natural pitcher communities, it is not uncommon to find rotifers and ciliates in the presence of both dipteran consumers. We hypothesize that a spatial refugium exists within the pitcher based on the feeding behavior of the two consumers. By demonstrating that midges consume both rotifers and ciliates, we now have reason to redraw the pitcher plant inquilines food web. We suggest that both *W. smithii* and *M. knabi* together form a guild of keystone predators.

Wisconsin Iron through Geologic Time

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Wisconsin has many iron deposits that have produced ore for 130 years. They reflect secular changes in the deposition of iron minerals over the last 3 billion years. The Jackson County Iron Mine, worked from 1969 to 1986 is geologically the oldest, formed as an exhalative hydrothermal deposit on the deep sea floor over 2.7 billion years ago. It is highly metamorphosed, with magnetite as the main ore mineral. The Gogebic Iron Range in Iron County formed about 1.85 billion years ago. It was enriched by supergene processes forming well-crystallized minerals including hematite, manganite and barite. It was worked from 1882 to 1963, with renewed interest as recently as 2016. The Butternut-Conover District also in Iron County, was developed in Proterozoic deposits in a greenstone belt. These were worked between 1912 and 1915. Late Proterozoic Freedom formation in Sauk County in southern Wisconsin was extensively worked between 1903 to 1915. The Mayfield Iron ore at UWM's Neda mine was a hematitic oolitic sedimentary rock deposited during the Ordovician. It was originally a shallow water limestone ferruginized during leaching of overlying rocks. The ore was worked between 1850 and 1915. It is unusual in that it contains phosphate minerals such as variscite, and phosphosiderite. Goethite-rich iron ore was worked in the 1880's near Ironton in Sauk County. The ore was in a vein cutting Cambrian sandstones, probably a fringe deposit of the Upper Mississippi Valley zinc-lead district. The Gilman Mine in Pierce County worked goethite-rich bog iron ore developed on top of Ordovician dolostone, deposited during the Cretaceous in a temperate to tropic climate. Ore was produced from 1893 to 1907. Subeconomic, deposits of ironstone as crusts and concretions occurs in 1.8 million year glacial drifts in western Wisconsin. These were deposited in bogs on the surfaces of moraines in a tundra environment.

Effects of Food Abundance on the Timing of Breeding in Tree Swallows

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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. In 2016 we completed the 20th year of study of the reproductive ecology of tree swallows at the UWM Field Station. One of our main goals is to determine how environmental factors, particularly temperature and food abundance, influence the timing of breeding and reproductive success. A prominent hypothesis predicts that reproductive success is maximized when animals synchronize their reproduction with seasonal peaks in food supply. This mismatch hypothesis does not seem to be supported in tree swallows, and many other species. Instead, reproductive success appears to be more closely related to the absolute levels of food, rather than to the timing of food. We thank Gretchen Meyer and Lou Nelson for their assistance, particularly in collecting data. This research was supported by funds from the College of Letters and Science, UWM.

Genetic Monitoring and Conservation of the Eastern Prairie Fringed Orchid (*Platanthera leucophaea*)

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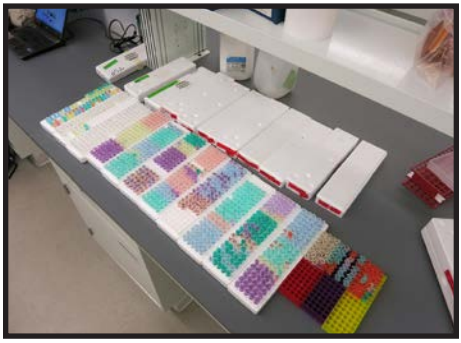
For species at risk of extinction, their last chance at continued survival depends on the successful execution of recovery plans that are based on proven restoration and management techniques. *Platanthera leucophaea* is a federally threatened species which has experienced major habitat loss and decline in both population size and number. Current management practices include hand pollination of flowers to increase fruit set and seed dispersal between neighboring populations to prevent inbreeding. In this study, we investigated range-wide genetic patterns and monitored genetic changes in populations that have experienced over twenty years of documented management. For the range-wide study we genotyped 40 populations across the range of the species to evaluate the extent of gene movement from long distance seed dispersal by wind and pollen dispersal by its pollinators (hawkmoths) and identify areas within the range of conservation priority. Range-wide low genetic structure (F_{st} = 0.06), slight isolation by distance, and weak trends in geographic location and diversity and inbreeding suggest that gene flow was historically high in the species, and that not enough time has elapsed since recent fragmentation and population loss occurred to detect its genetic effects. For the genetic monitoring we compared DNA samples col-

lected prior to the start of new management techniques (1998) and samples collected in 2015. These data were paired with measurements of fruit set and seed viability at specific populations to look for evidence of inbreeding depression. We found the combined treatment of hand pollination and seed addition lead to an increase in all measures of genetic variation. Populations with no management or only hand pollination had little to no change in genetic variation. Seed viability differed significantly among these populations, and preliminary results suggest hand pollination in combination with seed addition will likely lead to an increase seed viability over time. We observed no difference between treatment types when only considering the genetic status of populations in 2015. This work highlights the importance of genetic monitoring over time to accurately measure the impact of restoration work and offers the rare opportunity to assess a long history of well documented restoration and management that is widely applicable to other species facing reduced reproductive success in isolated habitats. M.S. thesis research, Northwestern University and the Chicago Botanic Garden.



Extracted DNA samples in lab

The Microbial Pathway to Nutrient Supply for Carnivorous Pitcher Plants: How Bacteria are Essential to the Detrital Food-web in *Sarracenia purpurea*

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Sarracenia purpurea, a species of pitcher plant, grows in nutrient-deficient wetlands like Cedarburg Bog and supplements mineral nutrition through carnivory. New pitchers are sealed and sterile, but open to fill with rainwater, acquire aquatic inhabitants, and capture prey, sustaining a detrital food-web. This food-web is responsible for prey digestion; well-characterized invertebrates tear prey apart while microbes produce hydrolytic enzymes, releasing nutrients from organic materials for plant absorption. These micro-ecosystems have been the target of food-web studies but microbes are a poorly-defined component, often represented as a “black box” in food-web models. Detailed analysis of pitcher bacteria and their functions are lacking. This research addressed two questions: How does bacterial community succession and hydrolytic enzyme activity develop in *Sarracenia purpurea* over the lifespan of pitchers, from opening to senescence? What metabolic functions and nutrient transformations are mediated by the bacterial taxa identified in pitchers? Pitcher plants in the Cedarburg Bog were sampled over 2013-2016, pitcher water measured for enzyme activities using biochemical assays, and DNA extracted for genetic analysis of 16S rRNA amplicons. Hydrolytic enzyme activity examined over the lifespan of individual pitcher’s fluid showed increases with microbe recruitment and prey capture, peaking at 1-2 weeks. A secondary increase of enzyme activity occurred after a winter dormancy period, but did not match peak activity from the first season. Using previously identified bacterial

taxa in pitcher fluid from 16S rRNA sequencing; PICRUSt was used to predict biochemical nutrient transformation pathways and component enzyme functions. Pitchers harbored abundant bacteria representing diverse taxa of aquatic ecosystems and diverse metabolic functions, related to amino acid metabolism required for breakdown of organic materials, biosynthesis of metabolites, and energy metabolism. Bacteria are the nutrient transformation lynch pin within the detrital food-web, and responsible for many metabolic functions within the food-web community. Ph.D. research, Dr. Erica Young, Major Advisor.

Does Growth Rate Shape Defensive Traits Across Resource Gradients?

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Tradeoffs are common in nature and can be mediated by environmental context. One such tradeoff occurs between plant growth and defense. Plant species that evolve in high-resource habitats tend to grow fast and allocate little to defense against herbivores, whereas species in low-resource habitats grow slowly and are highly resistant to herbivores. However, within species, whether resources set the template for growth and defense is an open question. Instead of the classic growth-defense tradeoff that has underpinned much of the thinking about macroevolutionary patterns of plant defense, we propose that within species there is a positive relationship between growth and defense. To test this hypothesis we selected two focal species that co-occur in grasslands at both ends of a steep resource gradient, *Monarda fistulosa* and *Achillea millefolium*. For each species we measured plant size and collected seed at several study sites in western Montana (MT) characterized by low growing-season precipitation (109 mm), and sites in tallgrass prairies in southern Wisconsin (WI) that are characterized by high growing-season precipitation (293 mm). WI sites included the University of Wisconsin-Milwaukee Field Station and Benedict Prairie. In the field, plants grew larger in Wisconsin compared to sites in Montana (P <0.01 for both species). Growth in a common greenhouse environment revealed that growth rates were higher

for the WI populations compared to the MT populations for one species (*M. fistulosa*, $P < 0.05$), suggesting genetic differentiation, whereas there was no difference in plant growth for the other species (*A. millefolium*, $P > 0.1$), suggesting that patterns of plant growth were largely due to plastic responses to environmental conditions. Ongoing work will examine plant resistance using bioassay experiments and will employ reciprocal transplant experiments in the field to test for plastic and genetic effects of growth and defense. Funded by MPG Ranch.

At left: *Monarda fistulosa* growing at Benedict Prairie. Above: Wildflowers in bloom at Benedict Prairie. Photos taken July 26, 2016 by P G Hahn.

Consequences of Loss of an Abundant Pollinator: An Experimental Study

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Pollinator populations are declining worldwide, and this may lower the quantity and quality of pollination services. Since pollinators often compete for floral resources, loss of an abundant pollinator species may release others from competition and potentially alter floral visitation rates. We explored how the removal of a frequent pollinator, bumble bees, influenced pollination success of whorled milkweed (*Asclepias verticillata*). In three small and three large populations we quantified pollinator visitation rates and pollination success for control plots and for plots where bumble bees were experimentally excluded. We found that exclusion of bumble bees did not reduce *A. verticillata* pollination success. Visitation by *Polistes* wasps increased markedly (293%) following bumble bee exclusion, especially in large populations (400%). Because *Polistes* wasps were just as efficient as bumble bees at pollen transport, increased wasp visitation offset lost bumble bee pollination services. This study provides a vivid example of the challenges associated with forecasting how pollinator declines may influence pollination success. When pollinator loss is followed by a shift in the composition of visiting pollinator species, implications for pollination success will depend on the net change in the quantity and quality of pollination services. MS Thesis research, Dr. Jeffrey Karron, Major Advisor.

The Influence of Ambient Light Levels on the Use of Visual Cues During Treefrog Phonotaxis

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Acoustic cues have been the building blocks of communication for anurans; studies now are focusing on effects of visual cues and signals on mate choice. While certain environmental conditions interfere with a long-range call, there has been discovery that complex multiple signal modalities overlap to make up for miscommunication among species. Multimodal communication has both positive and negative impacts but is most effective in getting messages across. The purpose here was to determine if light levels influenced mate-searching female preference. A male frog advertising for mates generates a visual cue in addition to a sound component. I hypothesized that the acoustic cue may be more reliable during lower light conditions, while the visual cue may be more reliable during brighter condition. Using an acoustic stimulus and a clay model of male gray treefrog (*Hyla versicolor*), I found there was no significant difference in the communicative approach directionality of the visual (frog model) cue versus an acoustic (speaker) cue under high or low light levels. Undergraduate research project, Dr. Gerlinde Höbel, advisor, with V. A. Underhill, M.S. student, assisting.

Parasitism and Ornamentation: A Within-Individual Study in the Common Yellowthroat

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Elaborate ornaments are hypothesized to honestly signal individual quality, including the ability of an individual to combat parasitic infection. Although there have been many studies of this hypothesis, the results of these studies have been mixed. One explanation for these varying results is that measures of ornaments and parasitic infection intensity are typically obtained only once for each individual. Therefore, correlations between ornamentation and parasitic infection intensity do not consider within-individual relationships, which may differ from between-individual relationships. We examined the relationship between ornaments and intensity of infection by haemosporidian parasites within individuals (using data from two breeding seasons) in the common yellowthroat, *Geothlypis trichas*. Male common yellowthroats have two ornaments, a melanin-based (black) mask and a carotenoid-based (yellow) bib, and in our study population females prefer to mate with males that have larger black masks. In addition, mask size is positively correlated with antibody production, body condition, survival, resistance to oxidative stress, and immune gene variation (major histocompatibility complex, MHC). Of the males analyzed over two years, 89.3% were infected with haemosporidian parasites during at least one breeding season. Interestingly, we found a positive within-individual relationship between mask size and infection intensity, but no relationship across individuals. This result is potentially explained by the high costs of immune response, which may outweigh the benefits of parasite clearance. Ph.D. dissertation research, Dr. Linda Whittingham, Major Advisor.

Do Plumage Ornaments Signal How Individuals Respond to Stress?

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Male ornaments are thought to honestly advertise the physiological quality of potential mates to females. An important aspect of physiological health is stress response, and there is evidence that increased stress can lead to a number of negative consequences, including reduced expression of ornaments. We tested this hypothesis in the common yellowthroat (*Geothlypis trichas*), a species in which males have two plumage ornaments, a black facial mask and a yellow bib. Females in our study population at the UWM Field Station prefer to mate with males with larger masks and mask size is positively related to body mass, antibody production, resistance to oxidative stress, and immune gene variability. We measured stress in males by quantifying both baseline and stress-induced corticosterone (CORT), which is the main stress hormone in birds. Stress-induced CORT was measured 30 minutes after capture. Plumage ornamentation (mask and bib) was not related to baseline or stress induced CORT levels. However, males with more breeding experience had a smaller increase in CORT after 30 minutes of handling stress. Thus, plumage ornamentation does not signal stress response to females but older males with more breeding experience may be able to better cope with stress than less experienced breeders. Ph.D. dissertation research, Dr. Linda Whittingham, Major Advisor.

Captured male common yellowthroat that has been banded and sampled.

Optimal Foraging Displayed by Pollinating Insects on UW-Milwaukee Sandburg Green Roof

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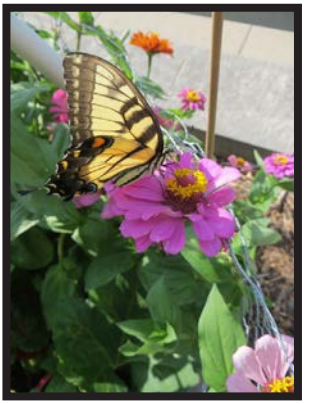
Much research is yet to be done on the importance of urban green roofs to native pollinating insects. My project linked pollination activity with Optimal Foraging Theory. The goal of my experiment was to compare pollinator visitation to two *Sedum* species (*Sedum acre* and *S. purpureum*) and three other plant species (*Monarda fistulosa*, *Phlox pilosa*, and *Dalea purpurea*) at the Sandburg Green Roof on the UW-Milwaukee campus. *Sedum* spp. are preferred green roof species due to their drought

resistance, low growing form, preference for porous soils, and continual production of flowers, and the other three species are native wildflowers that were also common on the green roof. For each species, flowers within a defined area were observed for 10 minutes and the number and kinds of insects that contacted the flowers were recorded. The number of flowers within the sampling area was also counted. There were 4-7 replicates for each plant species. Both pollinator activity and the number of available flowers in bloom differed across the five sampled plant species. These data can be used to guide planting selections on elevated green roofs in southeast Wisconsin that would provide local pollinators the greatest benefit for their visitation. Undergraduate research project, Dr. Gretchen Meyer and Dr. Mai Phillips, advisors.



A Survey of the UW- Milwaukee Campus for Floral Resources for Pollinating Insects

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Plant-pollinator interactions provide an important ecosystem service that benefits our daily lives, but pollinators are currently under stress from human activities. This study focuses on the role that urban environments can have in providing sustainable habitat for pollinators, creating greater security for healthy pollinator populations. Over the course of an eight-week observation period, four different sites were surveyed once a week on the UW-Milwaukee campus. The sites included two green roof habitats, a prairie planting, and an urban community garden. At each observation day, the number of plant species in bloom, as well as the number of plants of each species with flowers and the total number of flowers for each species were recorded in 15 replicate ¼ meter^2 quadrats for each site. The two green roofs both had a much greater abundance of flowers than the other two sites during the first few weeks of the study, but floral abundance fell as the season progressed. By the end of the study period, the prairie planting and the community garden had higher floral abundance than the two green roofs. Both the prairie planting and the community garden had higher species diversity of blooming flowers than the two green roofs by the end of the study period. No one site offered a habitat that would sustain pollinators throughout the whole summer season, but rather the four sites worked together to create a network of habitats on the UWM campus. Undergraduate research project, Dr. Gretchen Meyer and Dr. Mai Phillips, advisors.

Soundscape Ecology of Wisconsin Ecosystems: Underwater Sounds

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This is part of a long-term project investigating the soundscapes of Wisconsin ecosystems. We place long-term recorders in different sites at the Field Station, and program them to record 1 min of sound every hour over several months. In the past we have recorded sounds of different ecosystems (pond, forest and meadow) within the same year, and we have recorded pond soundscapes across several years. In 2016, we placed hydrophones in addition to air-microphones at two locations at Byers pond, to simultaneously record airborne and underwater sounds. We plan to analyze the sound recordings and calculate acoustic complexity indices to compare environmental complexity between sites and describe the diurnal and seasonal characteristics of the soundscapes of different locations. This may allow us to formulate new hypotheses about the sources of selection that shape communication signals of animals that inhabit the different ecosystems.

Pollinator Attraction to Rooftop and Other Gardens on the UW-Milwaukee Campus

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Pollinator numbers have been decreasing in recent years, with one cause being the loss of habitat due to an increase in the conversion of natural spaces to urbanized areas. Urban gardens, including those on roof tops, can provide habitat for pollinating insects and reduce the impact of urbanization on pollinators. This study compared the abundance of pollinating insects in different types of urban gardens. Four gardens on the University of Wisconsin – Milwaukee campus were surveyed, including two rooftop gardens or green roofs, one prairie planting, and a community vegetable garden. Over the course of eight weeks, each site was visited weekly and the number of insects visiting flowers was counted over a 15-minute time interval in three replicate 0.25 m^2 quadrats at each site. The prairie planting attracted the most pollinating insects over the 8-week study period. The numbers of pollinating insects observed at the two rooftop gardens were similar to those seen at the prairie planting early in the study period, but by the end of the study insect visitation to the rooftop gardens had dramatically declined, while the prairie planting was still attracting insects. Very few pollinating insects were observed at the community vegetable gardens compared to the other three sites. This study shows that small urban prairie plantings and rooftop gardens can be important resources for pollinators. Undergraduate research project, Dr. Mai Phillips and Dr. Gretchen Meyer, advisors.

Factors Controlling Diffusive CO2 Transport and Production in the Cedarburg Bog, Saukville, Wisconsin

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Wetlands are vital components of the carbon cycle, containing an estimated 20-30% of global soil carbon. The Cedarburg Bog of Wisconsin contains multiple wetland habitats, including the southernmost string bog found in North America. Carbon dioxide (CO_2) behavior in these systems is the response of multiple interdependent variables that are, collectively, not well understood. Modeling this behavior in future climate scenarios requires detailed representation of relationships, though many previous studies are bound by limited measurement frequencies, potentially misrepresenting CO_2 flux. This study presents a high resolution, long-term temporal data set of soil CO_2 flux alongside controlling parameters. In 2014 and 2015 a LI-COR 8100A automated soil gas flux system was installed in the Cedarburg Bog string bog, measuring CO_2 concentration and CO_2 flux, and soil moisture and temperature. Groundwater data and Field Station weather data were also used for correlation.

LI-COR data display distinct diurnal trends; CO_2 concentration builds overnight while flux increases during the day. The majority of CO_2 fluxes measure < 5 mg/min-m^2, occur across diurnal and seasonal boundaries, and account for 1/4 of CO_2 flux mass (Figures 1, 2). Higher intensity CO_2 flux (> 50 mg/min-m^2) occurs < 2 % of the time,

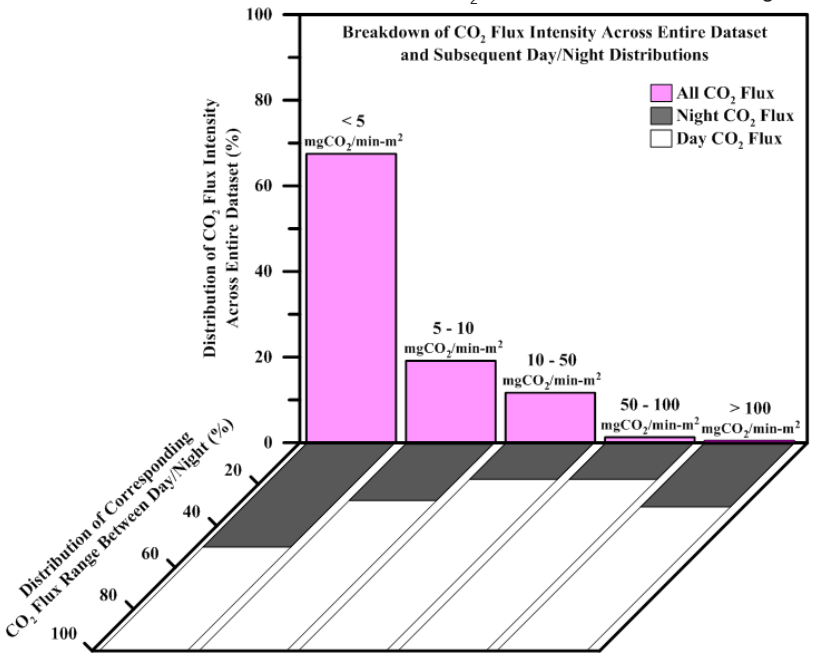

Figure 1: Distribution of LI-COR CO2 flux intensities from all field data (2014 & 2015) and subsequent percentages occurring during day/overnight periods.

typically during the day, and also account for 1/4 of flux mass. In majority, CO_2 flux is a function of the CO_2 concentration gradient, which is typically a function of wind speed. Increased atmospheric/soil temperatures and decreasing atmospheric pressure are all observed to prelude increasing CO_2 flux intensity, though correlation strengths vary. Water level may influence CO_2 flux via hydrostatic pressure changes and oxic layer boundary conditions. However, 2016 imagery from trail cameras in the string bog show the peat surface subsiding as much as 12 cm from May-August (Image 1), leaving uncertainty in direct correlations between groundwater level and CO_2 flux. M.S. Thesis research, Dr. Weon Shik Han, Major Advisor.

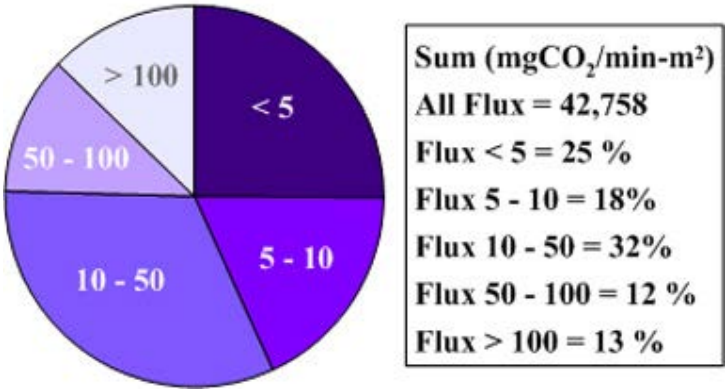

Figure 2: Contribution of CO2 flux intensities to cumulative mass of CO2 flux.

Image 1: Trail camera photos of the Cedarburg Bog string bog area monitoring well May (left) and August (right) of 2016.

Use of Mark-Recapture Techniques to Estimate Turtle Populations on the UW-Milwaukee Field Station Grounds

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Information on long-term trends in reptile populations can yield useful conservation information. This is particularly true because long-term monitoring projects that involve reptile populations are relatively uncommon, especially in Wisconsin. In 2006 we began an annual turtle survey on the Field Station Grounds, lasting for three days each year in late May/early June. We set turtle hoop traps approved by the Wisconsin DNR in several locations, which we checked daily during annual surveys. All of the animals captured were marked via marginal scute notches, following a well-established system. To-date, we have captured a total of 101 painted turtles (*Chrysemys picta*; mean=10.1/year), of which 13 were recaptures (1.3/year). We also captured 13 snapping turtles (*Chelydra serpentina*; mean= 1.3/year), with zero recaptures. During this time we have captured only one other species, a single adult Blanding's Turtle (*Emydoidea blandingii*). Data collection will continue and future analyses will be conducted to elucidate information on abundance and survival rates. Collection of this type of long-term baseline data is critical to understand population fluctuations that may occur over time and the associated conservation implications.

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 University of Wisconsin-Milwaukee 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-baised 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 alternate years from 2004–2016. To-date, ten annual sampling efforts have been completed during this time. 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 5.6 to 12.4 individuals (density estimates of 0.92 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.

Home, Sweet Nest Box: A Comparison of Detection Methods for the Southern Flying Squirrel (*Glaucomys volans*) in Ozaukee and Washington Counties, Wisconsin

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The purpose of this field study was to compare detection methods for *Glaucomys volans* through installation of nest boxes and wildlife cameras in Ozaukee and Washington Counties in Wisconsin, and to determine an optimal setup for using a feeding tray with a wildlife camera. *G. volans* does not have special conservation status, but requires wooded habitat. The wooded areas do not have to be large parcels of land, as proven by documentation of populations of *G. volans* in highly urban and fragmented areas. With the rapid onset of habitat change to address agricultural needs, residential or commercial planning, and the continued import of exotic species, forest compositions are changing. An understanding of the most effective detection methods for this species could facilitate the development of more targeted management strategies for southern flying squirrel populations. *G. volans* had never been documented in the high-quality, old-growth, beech-maple forest at the University of Wisconsin-Milwaukee Field Station in Saukville, Wisconsin. Ten nest boxes were secured to trees transecting the Field Station forest. The boxes were checked once a month for nesting material, nuts, or *G. volans.* An additional method used for detection was a wildlife camera trained on a feeding tray, which captured images of nocturnal visitors. A separate wildlife camera was used in Slinger, Wisconsin, where flying squirrels had been documented previously. The information from these cameras was used to compare the time, temperature, and food preference at the feeding tray between

Gretchen Meyer, Gary Casper, Amanda Keyes and Ron Tagye working on squirrel nest boxes in the woods.

the Slinger and Field Station site in order to discern whether flying squirrels exhibited differential behavior at these sites. At the Field Station, the peak times of activity for the squirrels to visit the feeding tray were between 6 PM - 9 PM and 11 PM – 4 AM. The peak times of activity for the camera in Slinger, Wisconsin were between 5 PM – 7 PM, 9 PM – 10 PM, and 12 AM – 3 AM. At the Field Station, southern flying squirrels exhibited a preference for sunflower seeds over peanuts and the squirrels were most active in the tray around the edges, rather than in the center. Conclusions about food preference and behavior at the Slinger tray were not drawn due to inability to conclusively identify these behaviors in the images. The wildlife camera proved superior to the nest boxes for detection of flying squirrels. It took 18 days to detect flying squirrels at the Field Station using cameras, while flying squirrels were never detected at this location in the nest boxes. An increased understanding of the best detection methods for *G. volans* could lead to the preservation and management of appropriate habitat, leading to continued survivability and sustainability for this species into the future. Undergraduate research project, Dr. Gretchen Meyer, advisor.

Long-term Dynamics of Southeastern Wisconsin Prairie Remnants

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Across the Midwest, less than one percent of pre-settlement prairies exist today – having been largely converted to agriculture via Euro-American settlement. These remnant communities often manifest in tiny, widely scattered and marginal populations of questionable viability. Understanding how the remaining remnants respond to both historical and changing environmental conditions is critical to managing their continued presence on the landscape. We are revisiting 62 prairie remnants in southeastern Wisconsin that were originally surveyed in the 1950s by Philip Whitford, working out of UW-Milwaukee. At each site in the original survey, a list of all vascular species was made, based on observations made at multiple visits during the growing season. At approximately ½ the sites, quantitative measures of abundance were also estimated, using 20, 0.25m^2 quadrats, spaced evenly throughout the site. With these data, we ask how prairie remnants have changed over the past 60 years and how these changes correlate with land-use history and local environmental conditions.

As expected, remnant prairies changed considerably over the past 60 years, with a range of 15-70% species loss at individual sites. Species loss was non-random and was concentrated in species with low height, small seeds and lacking vegetative reproduction. Woody plant density increased dramatically between the 1950s and today, with some sites being totally lost to forest conversion with only an occasional prairie species surviving in edge or gap microhabitats. At the site level, management by fire was the most important variable, with fire-managed sites losing fewer of the original species and generally maintaining a higher floristic quality. In general, prairie remnants along railroad corridors persisted better than did remnants in other settings, particularly those wet prairie remnants that survived into the 1950s along field edges. Apparently, extensive “improvements” (drainage tile, ditches) has effectively eliminated these remnants from the current agricultural landscape, further reducing the total remnant area in Southeastern Wisconsin and reducing the probability of metapopulation persistence, even in higher quality remnants.

Reproductive Allocation in *Hyla versicolor:* Evaluating the Influence of Female Size and Temporal Factors on Egg Production

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Factors influencing reproductive output in frogs have received substantial study in various species around the globe. These relationships were examined in a Wisconsin population of Gray Treefrogs, *Hyla versicolor*. Understanding how organisms expend resources for reproduction is important for ecological and conservation work because it improves our understanding of the effects of selective pressure. In frogs, there commonly is a positive correlation between female size and egg number and a negative correlation between egg number and egg size due to the trade-off of reproductive quantity vs. quality. There is a tendency in some species for female size to correlate with greater egg size. The influence of these variables can vary along the breeding season. We tested these assumptions in a Wisconsin population of *Hyla versicolor*. Female frogs were collected from the UWM Field Station, measured, and allowed to lay eggs with the male they were captured with. Number of eggs and egg sizes were recorded. Six weeks of data was collected for the season overall. Correlation analysis was used for the general relationship between the variables. The variables were then sorted into 2 3-week groups to test for differences in relationships over time using regression analysis. Clutch size and female size were positively correlated in all treatments as expected. There was no statistically significant correlation between egg size and female size in any case. There appeared to be a positive correlation between egg size and clutch size in the overall data, but no significant correlation was found when accounting for which half of the breeding season the clutch was laid. Declining egg counts were also observed as the season progressed. The significance of female size on clutch size increased in the second half, suggesting that larger females come out later in the season. This suggests that there is significant seasonal variation in reproductive output and allocation. Undergraduate research project, Dr. Gerlinde Höbel, advisor.

Breeding Bird Survey at the Cedarburg Bog

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The second year of the Wisconsin Breeding Bird Atlas II (WBBA II) has been completed, and the third year (2017) is soon to begin. The first atlas was conducted from 1995 through 2001, and the second will collect data from 2015 through 2019. Field work for the atlas is conducted in geographic "blocks" based on USGS quads across all of Wisconsin. Given the special significance of the Cedarburg Bog designation as an "Important Bird Area" within the State of Wisconsin, the Cedarburg Bog and the Upland Woods have been determined to be a "specialty block" for purposes of the Breeding Bird Atlas. This is to say that the information collected on the breeding status of birds in the Bog has special conservation significance. The information collected on breeding birds in this second atlas census will be compared to the information collected 20 years ago in the first atlas in order to provide a benchmark to evaluate bird conservation over the past 20 years within the Cedarburg Bog complex as well as within the state as a whole.

In 2016, a number of birders independently conducted atlas surveys in a wide array

of habitats. Whenever a bird of a particular species gave evidence of courtship or breeding or nesting, one of the following breeding designations was assigned to the species: "possible", "probable",or "confirmed". In 2015, 53 species were identified as confirmed breeders within the Bog complex. In 2016, an additional 12 species were added to the "confirmed" list, for a total of 65 species confirmed as breeding within the Cedarburg Bog complex. More breeding bird species have now been confirmed in the first two years of the WBBA II than were confirmed in all five years of the WBBA I conducted from 1995 - 2001. The likely explanations for this are as follows: 1) More people are surveying the Cedarburg Bog complex as part of the WBBA II than was the case 20 years ago with WBBA I; 2) More intensive canvassing is being conducted in difficult to access areas like the string bog and Long and Mud lakes; 3) Finally, the ease of entering recorded bird observation data into the Cornell University Department of Ornithology Ebird system has made it much easier to spend more time in the field as well as making it easier to catalogue and analyze far more data than previously possible.

Species newly confirmed as breeders within the Bog in 2016 are least bittern, great blue heron, blue-winged teal, broad-winged hawk, Virginia rail, northern flicker, eastern kingbird, black-and-white warbler, gray catbird, wood thrush, chipping sparrow, and house finch. It is noteworthy that hooded merganser and pine warbler, two new breeding species added to the Bog's official breeding bird list in 2015, were again confirmed as breeders in 2016. It is also noteworthy that the least bittern, a highly secretive and furtive "species of special concern" in Wisconsin, was found in five different locations within the Cedarburg Bog complex in 2016. Based on these 2016 WBBA II findings, it is surmised that least bittern is likely more prevalent within the Bog complex than has been indicated by previous surveys. The Cedarburg Bog breeding bird atlas survey in 2017 will cover many of the same areas canvassed in 2016 with increased emphasis being placed on canvassing more of the difficult - to- access areas of the inner core of the Bog.

Least Bittern

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

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Over the past five years from 2011 through 2016, fourteen wood duck nest boxes and four nesting/roosting boxes for small owls (i.e., eastern screech and northern saw-whet owls) have been installed, maintained, and monitored in and around the Cedarburg Bog by volunteers affiliated with the Friends of the Cedarburg Bog.

Prior to the 2016 nesting season, two wood duck boxes were taken down due to problems with squirrels being able to elude the predator guards in order to gain access

to the boxes to set up their own nests. These two boxes will be reinstalled prior to the 2017 nesting season. Of the twelve remaining duck boxes monitored over the year of 2016, nine (75%) were actively used for nesting purposes - eight boxes used by wood duck hens and one box successfully used by a hooded merganser hen. Eight of these nine boxes provided evidence of successful fledging indicating an overall 88% fledging success rate in 2016. This also was the second year in a row that hooded merganser has been documented as a breeding species and successful nester in Cedarburg Bog's Mud Lake. Based on nest box location, this was probably the same hooded merganser hen responsible for the first ever recorded nesting and fledging of hooded mergansers in the Cedarburg Bog in 2015. One duck box contained an abandoned clutch of ten intact wood duck eggs.

Two of the four small owl boxes were used by small owls for roosting in 2016 based

Screech owl in wood duck nest box

on evidence found within and/or around the boxes, e.g., owl pellets, bird feathers, and other bird parts such as beaks. One box situated in a flooded woodland off of Cedar-Sauk Road was actively occupied by a gray phase eastern screech owl, inadvertently flushed from inside when the box was opened for monitoring and maintenance in mid-January 2017. Based on the number of pellets and bird feathers within, it appears that this box had been occupied for at least a month or more before the bird was discovered. The other small owl box off of Cedar-Sauk Road providing evidence of owl roosting in 2016 was likely used for at least a few days by either an eastern screech owl or a northern saw-whet owl overwintering in the Bog. A third owl box near Watts Lake was found to contain a nest most likely constructed and used by a great crested flycatcher given the style of nest and given that there was a snakeskin carefully woven into the nest amidst twigs and mosses -- a

Screech owl and red squirrel on nest box

common characteristic of great crested flycatcher nests. To date, there is still yet no evidence of small owls using any of the four small owl boxes for nesting since these were first installed in 2012. Roosting owl box use however has largely remained steady at about 50% over the past five years.

A clear trend is becoming evident over the now six year span of the duck box program. In 2011 when four duck boxes were first installed, nest box use was 25%. By 2014, with ten duck boxes in place, nesting usage

had increased to nearly 38%. In the last two years, duck box nesting usage has increased to rates of 79% in 2015 and 75% in 2016 with wood ducks and at least one Hooded Merganser hen increasingly using the boxes perhaps because the predator proofed boxes are more secure than natural tree cavities which have a higher vulnerability to predation by raccoons and other predators. Studies have also documented that experienced hens and their offspring are historically more likely in subsequent years to reuse boxes where successful nesting has already occurred. Assuming this to be true, the future for wood ducks and other duck cavity nesters in the Cedarburg Bog looks to be promising.

Correlation of Handedness and Ear Preference in Gray Treefrogs

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In humans, there is an association between the preferred hand (handedness) and the brain hemisphere that specializes on processing language. Ninety five percent of people who are right-handed process language with their left brain hemisphere. This lateralization was long considered a uniquely human trait, but recent research has shown that many animals, including monkeys, kangaroos, dogs, fish, and some frogs, have a preferred limb. In mammals, including humans, auditory system lateralization takes the form of right ear advantage. Frogs are highly vocal and depend on their auditory perception of stimuli from their surroundings to survive and reproduce. Therefore, the intake of sound information might be lateralized as well. We tested whether eastern gray treefrogs (*Hyla versicolor*) demonstrate limb and ear preferences, and whether these lateralized behaviors are correlated. Undergraduate McNair Research Project, Dr. Gerlinde Höbel, advisor.

Warming Winters and the Regional Implications for the Subnivean Climate

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Many plants and animals use the stable environment underneath the snowpack, called the subnivium, as a refuge from harsh winter weather. The depth, density, and duration of the snowpack determine the climatic conditions of the subnivium, which are typically much milder due to the insulation provided by the snow. As climate change produces warmer mean temperatures, however, the subnivium becomes colder and more thermally variable. These changing conditions can have significant effects on the physiology, survival, and distribution of species that are dependent on this habitat. Using micro-greenhouses that are automated to maintain set temperature gradients and allow winter precipitation to fall inside, we will assess how changing snow conditions affect the temperature and stability of the subnivium microclimate. In the fall of

2015, we deployed 27 greenhouses to nine sites representing conifer forests, deciduous forests, and open prairies. At the UWM Field Station, we have set up three microgreenhouses in a conifer stand. While we are still in the early stages of our research, we have begun to collect data on the climate conditions within and outside each greenhouse. As expected, subnivium temperatures remained high and stable compared to ambient air temperatures in a control greenhouse maintaining air temperature equal to exterior ambient air temperature during the first winter of our study. These subnivium temperatures reflecting current conditions will be compared to temperatures in greenhouses that maintained air temperature gradients of 3°C and 5°C above exterior air temperatures to mimic projected effects of climate change in the Great Lakes region. We will be continuing this data collection through the winter of 2017. Funded by the National Science Foundation.

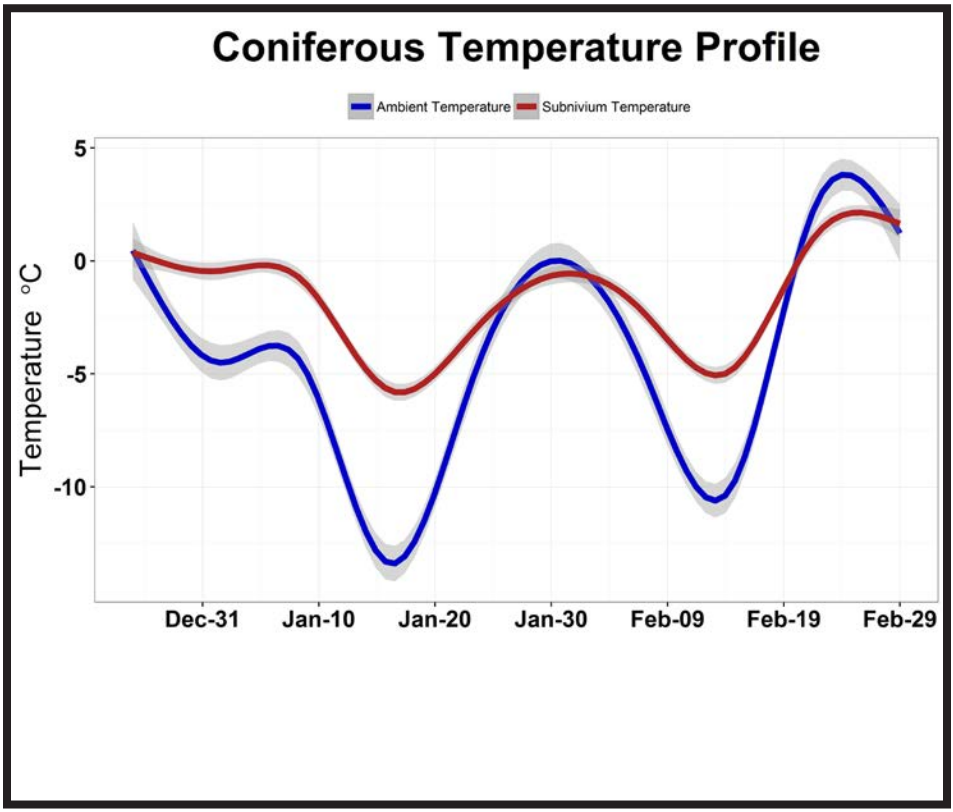

Figure 1. Ambient air temperatures (lower line) and subnivium temperatures (upper line) recorded in a microgreenhouse in a conifer stand at the UWM Field Station during winter 2015-2016. This greenhouse maintained ambient temperatures equal to exterior air temperatures while allowing winter precipitation to fall inside, serving as a control for comparison to greenhouses simulating projected future air temperature conditions.

Bird Use of the Cedarburg Bog Important Bird Area during Spring and Fall Migration

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We studied bird use of three habitats within the Cedarburg Bog Important Bird Area during spring and fall migration. Weekly migration point counts were conducted for three years in the forested portions of the Cedarburg Bog, the adjacent Upland Habitat (including the Cedarburg Beech Woods, plus open fields and forest patches at the University of Wisconsin-Milwaukee Field Station) and on Mud Lake, the largest lake within the Cedarburg Bog. A total of 189 bird species was detected in the three habitats combined. Of these, 135 species were detected in the Bog, 117 species were detected in the Upland Habitat and 174 species were detected in the Mud Lake habitat. Sixty-two species (32.8% or nearly 1/3 of the total) are listed as being of conservation concern in Wisconsin and national plans, emphasizing the importance of this large protected area to birds during spring and fall migration.

Frequency-channel Dependent Selectivity for Temporal Call Characteristics in Gray Treefrogs, *Hyla versicolor*

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Sensory receptors transmit information on multiple stimulus dimensions. Much remains to be understood about how the processing of different signal characteristics is partitioned and integrated in different areas of the nervous system. Amphibian hearing involves two morphologically distinct inner-ear organs that process different components of the frequency spectrum. Many anuran signals contain two frequency peaks, each one matching the sensitivity of one of these two organs. We hypothesized that the processing of temporal characteristics of acoustic signals would differ in these two frequency channels, perhaps because of differences in the response properties of the two inner-ear organs. We tested this hypothesis in the gray treefrog, *Hyla versicolor;* male advertisement calls of this species contain a bimodal frequency spectrum. We generated synthetic male advertisement calls in which we independently manipulated the pattern of amplitude modulation in the low-frequency peak or the high-frequency peak and measured the attractiveness of these stimuli to females in single-speaker and two-speaker phonotaxis tests. We obtained multiple lines of evidence that females were more selective for fine-temporal characteristics in the high-frequency peak. We discuss the potential implications of frequency-channel dependent temporal processing for signal evolution and suggest that additional neurophysiological investigations of the anuran auditory periphery will give important insights into how the nervous system partitions the encoding of multiple characteristics of complex signals.

Missing the Dark? Effects of Anthropogenic Light Pollution on Female Treefrogs

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Anthropogenic habitat change accompanies many of the alterations urbanization has inflicted upon the environment. One of the most apparent changes is caused by artificial lighting at night. Light pollution poses a challenge for organisms that rely on a 24-hour schedule to conduct both their daily and seasonal activities. As many studies suggest, light pollution impacts various species in many ways. While it is generally accepted that the impact on most species is negative, there have been studies that suggest a positive influence. Few studies have been conducted on the impact of unnaturally high artificial light levels on amphibians. While data suggests there is an impact on male calling behaviors, it is unknown how high levels of anthropogenic light affects phonotaxis behaviors in female frogs. Here, we tested the phonotaxis behavior of female gray treefrogs (*Hyla versicolor*) when presented with an average call of 18 pulses at four different light treatments: 0.2, 2.0, 5.0, and 15 lux. (0.2 lux being equivalent to the new moon, and 15 lux being equivalent to standing directly under a street lamp at night). Surprisingly, our study reveals that high levels of anthropogenic light had no impact on phonotaxis behaviors in female gray treefrogs. Undergraduate research project, Dr. Gerlinde Höbel, advisor, with V. A. Underhill, M.S. student, assisting.

Combinatorial Processing in Insect Communication

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We are using laser vibrometry and vibrational playback experiments to study the rules that govern the combinations of discrete signal elements that are acceptable in *Enchenopa* treehoppers. *Enchenopa* are insects that communicate with vibrational signals that have a complex hierarchical structure. Male signals have two elements (a pure-tone "whine" followed by pulses); individual signals are grouped into signal bouts, and bouts into series. We found preliminary evidence of combinatorial signal processing at the level of phonology. Funded by the Research Growth Initiative (UWM) and the National Science Foundation.

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

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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.

Natural Selection by Insect Pollinators and Seed Predators on Floral Head Traits of *Helianthus grosseserratus* (Sawtooth Sunflower)

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Flowering plants must invest energy and resources to produce floral displays that are attractive to pollinators, but these same displays may also attract detrimental insects. How floral traits are shaped by the preferences of both pollinators and herbivores/seed predators is not fully understood. Using *Helianthus grosseserratus* (sawtooth sunflower) as my study species, I investigated these conflicting selective pressures on floral head traits through a 2-year study in a large, unbroken tract of mesic prairie in Wisconsin. In the first season, I followed individual heads over time and recorded insect visitation patterns and phenological changes to floral head traits. I also dissected seed heads at the end of the flowering period and identified all seed predators to order. In the second year, I measured floral head traits (including disc area, ray area, and UV reflectance patterns) on the day when most florets were presenting pollen. I also performed a hand-pollination experiment to determine if the plants were pollen-limited or resource-limited. I recorded the number and percent developed seeds per head as measures of reproductive success and also counted and identified the seed predators in each head. I also measured the number of flowers surrounding the study head as an additional factor that may affect pollinator and herbivore/seed predator preference. Floral heads were visited by a diverse group of insects: 16 species from 7 orders were recorded. Hymenoptera, Coleoptera, and Diptera were the most common visitors. These 3 orders had highest visitation on the second or third day of pollen presentation. Seed head dissection revealed 6 orders of insect, with Thysanoptera and Diptera being the most common. In year 2, I found that pollinators were required for seed set in this system, as heads that were bagged produced negligible seed. Heads in the hand-pollination treatment had fewer developed seeds and a lower percentage of developed seeds than heads that were open-pollinated, although these differences were not significant. These results suggest that the plants were more likely to be resource-limited than pollen-limited. However, hand-pollinated heads did have significantly more seed predators than open-pollinated heads, which likely reduced seed set. Disc area was the most important trait affecting both the number of developed seeds and the number of seed predators, with larger discs having both greater seed production and more seed predators. Disc area did not influence the percentage of developed seeds, suggesting that the effects on seed number reflect the fact that a larger head has more ovules rather than pollinator attraction. The UV patterning on study heads showed significant polymorphism, where some plants had

a strong bulls-eye pattern on rays, while others had no clear demarcation (50% of heads in 2013 had no demarcation; 44% in 2014). My results showed there was no relationship between this patterning and number or percentage of developed seeds, but plants with a stronger bulls-eye pattern (likely because of a reduced amount of UV-absorbing defensive pigments) had more seed predators. These results suggest that UV patterning was important for defense against seed predators. In addition, floral heads with a large ray area had fewer seed insects, while those with a short head height and a large number of flowers in surrounding area had higher number and percentage of developed seeds. Such results highlight the complexities involved in the generalist pollination syndrome and the need to consider a multitude of floral head traits when analyzing plant/insect interactions. M.S. Thesis research, Dr. Gretchen Meyer, Major Advisor.

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.

In 2016 Cooper's hawks at 31 sites that I monitored laid eggs. Twenty-nine of these laying pairs produced 69 young to a bandable age (ca. 18 days; 2.38 young/laying pair, 3.63 young/successful pair, 67.7% nesting success). Six nestlings were not banded. Four young in one nest were too old to band safely, and two of four nestlings in a second nest were not banded for logistical reasons. Two additional nests were successful but productivity was not determined.

Fourteen adult (i.e., breeding) Cooper's hawks (8 males, 6 females) were trapped, banded, measured, colormarked, and processed for additional analyses at 10 different nest sites. All eight males were in adult (ASY) plumage; four of the six females were in adult plumage, and two were in juvenile plumage (SY). One of the adult males was a natal dispersal. This male dispersed 5.22 km east (99.6°) of his natal site.

On 30 May 2016, I documented an adult male Cooper's hawk in the Downer Woods area vocalizing a food delivery call, presumably in an attempt to attract a female. These food delivery vocalizations were east of Downer Woods in the vicinity of several large oak trees. No nesting attempt was subsequently found during several visits to the area. Partial funding provided by the the Wisconsin Society for Ornithology.

Two Cooper's hawk nestlings approximately 18-19 days old with one unhatched egg.

Variation in Ambient Light Levels Does Not Alter Mate Choice Behavior in Female Gray Treefrogs (*Hyla versicolor*)

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Variation in female preferences is important because variation influences the rate and direction of evolution by sexual selection. Variation in female preferences can also provide information about their evolutionary history, and the benefits and underlying mechanisms of mate choice. The origin and maintenance of variation in female preferences is less clear, but one source could be environmental variation. For nocturnal animals like treefrogs, an important source of environmental variation may be caused by the lunar cycle, where nocturnal light levels vary between new and full moon. We tested whether female preferences (i.e., what they like best in a male call) as well as female choosiness (i.e., how much effort they are willing to expend to get what they like) is affected by variation in nocturnal light levels. We found that female mate choice behavior was not affected by natural levels of nocturnal light. M.S. Thesis research, Dr. Gerlinde Höbel, Major Advisor.

Moonlighting? Lunar Effects on Reproductive Activity of Eastern Gray Treefrogs (*Hyla versicolor*)

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While the influence of environmental variables, particularly temperature and rainfall, on the breeding behavior of amphibians is widely recognized, relatively few studies have addressed how the moon affects amphibian behavior. Yet, the lunar cycle provides several rhythmic temporal cues that animals could use to time important group events such as spawning, and the substantial changes in light levels associated with the different moon phases may also affect the behavior of nocturnal frogs. Here we tested for lunar effects on the reproductive activity of male and female eastern gray treefrogs (*Hyla versicolor*). We found that chorusing and breeding increased during phases of half moon, but that reproductive activity also occurred during many other times during the lunar cycle. We also found a pronounced difference in how male and female frogs responded to variation in nocturnal light levels: while female breeding activity was unaffected by nocturnal light, male chorusing activity peaked when light levels were intermediate. We discuss these findings in relation to the two main hypotheses of lunar effects on animals: predator avoidance and temporal synchronization of breeding. M.S. Thesis research, Dr. Gerlinde Höbel, Major Advisor.

Phenological Change among Three Trophic Levels: Birds, Insects and Plants

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Climate influences the phenology- the timing of biotic life cycle events- of plant and animal species. The impacts of climate change on the phenology of organisms at different trophic levels can vary, resulting in synchrony or asynchrony between organisms and their food sources. Temporal and spatial mismatches due to differing phenological responses between predators and prey can result in cascading asynchronous

phenological change within food webs and alter ecosystem dynamics.

By studying the phenology of life events throughout the annual cycles of organisms, researchers are able to better understand how species respond to changes in climate and local weather over time. A species' ability to alter the timing of life-cycle events in response to climate change is not a stand-alone determinant of success, as organisms do not exist in solitude, but rather, they exist in ecosystems wherein complex multi-trophic interactions occur.

The objective of this study is to examine phenological change at the UWM Field Station and nearby sites in Ozaukee and Milwaukee Counties by investigating indicators of spring phenology among three trophic levels; birds, insects, and plants. Due to the complexity of multi-trophic phenology, this research seeks to first investigate the influence of local weather variables and regional weather patterns on each trophic level in isolation to unveil general trends related to climate change over time. Then, associations between trophic levels will be assessed in order to examine ecosystem-level phenological change.

This will be accomplished by adding contemporary data to and filling gaps in long-term phenological datasets from a myriad of sources. Historic bird banding data recorded by Dr. Chuck Weise at the UWM Field Station during the late 1960s through the early 1990s will be analyzed for trends in aspects of bird breeding phenology such as the timing of brood patch development in passerine females. Findings will be compared to contemporary bird banding data from current and ongoing research projects in Ozaukee and Milwaukee counties.

In order to investigate indicators of phenological change among insects, this project will utilize and contribute to an aerial insect dataset spanning 19 years, initiated in 1997 at the UWM Field Station by Dr. Peter Dunn and Dr. Linda Whittingham. Similarly, a dataset initiated in 2000 by Dr. Mark Schwartz containing 16 years of observations recorded by Dr. Gretchen Meyer on the spring phenology of several native tree and shrub species at the UWM Field Station will be utilized to investigate phenological change among plants at the bottom trophic level. Ph.D. research, Dr. Mark Schwartz, Major Advisor.

Survey of Flowering Phenology Along the UWM Field Station Boardwalk in the Cedarburg Bog

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Observations of flowering phenology of 254 plants along the Cedarburg Bog boardwalk at the UWM Field Station were recorded by Kate Redmond between 1984 and 1993. The observations were reported in "Flowering Phenology along the UWM Field Station Boardwalk in the Cedarburg Bog," by Kate Redmond, James A. Reinartz and Scott Critchley in the Field Station Bulletin, Fall, 1993 Vol. 26, No. 2. This project was revived in 2016 with the intent to add contemporary data for comparison to historical trends in flowering phenology along the boardwalk. Flower surveys were conducted on a biweekly basis along the UWM Field Station's Cedarburg Bog boardwalk from March to October in 2016, and will continue in 2017 and 2018. Ph.D. research, Dr. Mark Schwartz, Major Advisor.

Effects of Different Bumble Bee Species on Reproductive Success, Facilitated Selfing, and Mate Diversity in Monkeyflower

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Over the last decade there have been startling changes in the abundance and diversity of bumble bee populations, including significant decline of many species both in North America and Europe. Several species often coexist within a population and it is not known whether these species provide equivalent pollination services for native flowering plants. To address this question we quantified seed set, pollen deposition, outcrossing rate and mate diversity of *Mimulus ringens* flowers following individual visits by *Bombus impatiens* and *Bombus vagans*. The mean number of seeds produced per fruit following single visits by *B. vagans* was significantly higher than from visits by *B. impatiens* (ANOVA; $P < .02$). *B. vagans* also deposited significantly more pollen on to plant stigmas per visit. Outcrossing rates within fruits did not differ between visits by these two species. However, the correlation of paternity among offspring within fruits visited by *B. vagans* was higher than fruits visited by *B. impatiens*. This suggests that pollen deposited by these two species contain a different number of pollen donors. The results of this study suggest that bumble bee species may have unequal contributions to some aspects of plant reproduction. Therefore local plant reproduction may be affected by changes in pollinator composition as well as changes in pollinator abundance. Ph.D. dissertation research, Dr. Jeffrey Karron, Major Advisor.

Bat Activity Surveillance and Monitoring at Neda Mine Hibernaculum

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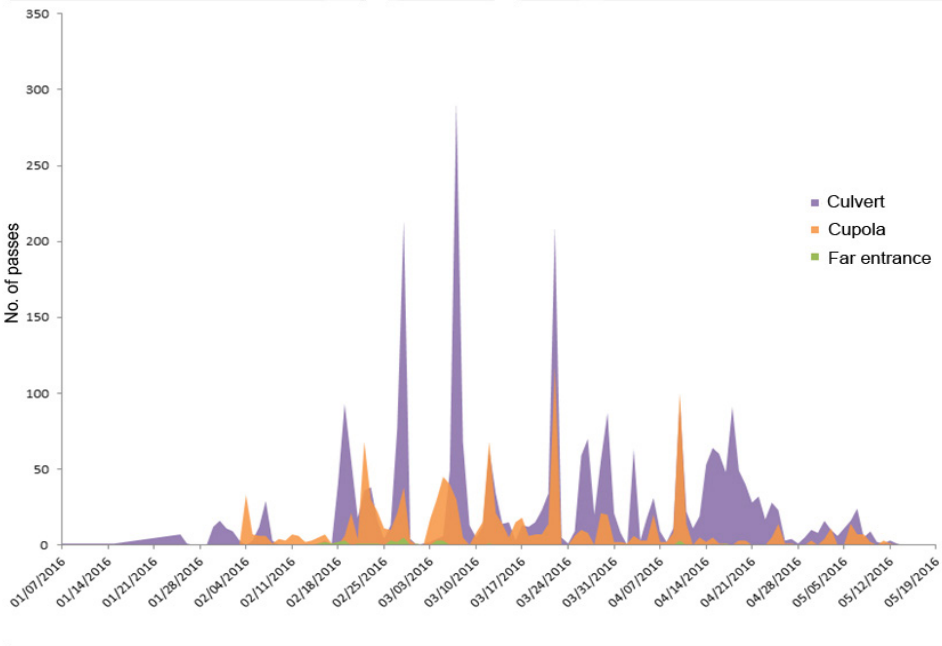
White-Nose Syndrome (WNS) has spread across 29 states and 5 Canadian provinces. The fungus *Psuedogymnoascus destructans* (Pd) that causes the syndrome has been found in three other states (MS, NE and OK). This deadly disease has and continues to cause massive bat mortality in eastern North America. WNS was confirmed in Wisconsin on March 28th, 2014. As of May 2016, 42 sites in 14 counties have been confirmed with either the disease-causing fungus or white-nose syndrome. Closely monitoring WNS-affected and susceptible bat populations is essential to better understand the spread and effects of the disease.

The bat populations of Neda Mine have been inspected (either by internal or

Little brown bats roosting in eaves of UW Milwaukee Field Station equipment shed in winter (2016). Bats infected with WNS will often exit an infected hibernaculum and roost in the immediate vicinity, usually dying of exposure to the winter climate. Photo by Jennifer Redell, Wisconsin Bat Program

external methods) annually for the past six hibernation seasons and continue to be inspected. In April of 2015, Neda mine was confirmed infected with the destructive fungus (Pd) by samples sent-in to the USGS National Wildlife Health Center in Madison, WI. In the following winter (2016), the Wisconsin Bat Program received many public reports from nearby areas that observed aberrant bat behavior. Aberrant bat behavior consisted of bats flying mid-day during the winter season (below-zero temperatures) as well as being found dead in yards and clinging to homes of nearby residents. When feasible, landowners submitted carcasses to the Wisconsin Bat Program which can be used at a later date for genetic archiving or additional research needs.



2016 Neda Mine spring activity of three ultrasound detectors that record bat echolocation calls located at three entrances to the mine. The rise in acoustic recordings in early to mid-February is likely due to WNS-infected bats leaving the mine early. Nearly all of the bat passes recorded in 2016 at Neda were *Myotis* or *Perimyotis*, not *Eptesicus*, which is known to be more active during the winter months in the Midwest.

Experimental Evidence that Brighter Males Sire More Extra-pair Young in Swallows

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Across taxa, extra-pair mating is widespread among socially monogamous species, but few studies have identified male ornamental traits associated with extra-pair mating success, and even fewer studies have experimentally manipulated male traits to determine if they are related directly to paternity. As a consequence, there is little evidence to support the widespread hypothesis that females choose more ornamented males as extra-pair mates. Here, we conducted an experimental study of the relationship between male plumage color and fertilization success in tree swallows (*Tachycineta bicolor)*, which have one of the highest levels of extra-pair mating in birds. In this study we experimentally dulled the bright blue plumage on the back of males (with non-toxic ink markers) early in the breeding season prior to most mating. Compared with control males, dulled males sired fewer extra-pair young, and, as a result, fewer young overall. Among untreated males, brighter blue males also sired more extra-pair young, and in paired comparisons, extra-pair sires had brighter blue plumage than the within-pair male they cuckolded. These results, together with previous work on tree swallows, suggest that extra-pair mating behavior is driven by benefits to both males and females. This research was supported by funds from the College of Letters and Science, UWM.

Microbial Nutrient Transformations in a Novel Aquatic Microecosystem: Hydrolytic Enzyme Activity Regulation and Bacterial Diversity in Carnivorous Pitcher Plant Inquiline Communities

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The carnivorous northern pitcher plant, *Sarracenia purpurea* subsp. *purpurea* grows well in the Cedarburg Bog where it supplements mineral nutrition by capturing insect prey in open-topped pitcher traps. While many carnivorous plants produce digestive enzymes, pitcher plants rely on a food web of invertebrates and microbes to break down prey. The action of hydrolytic enzymes releases nutrients from organic matter. This study aimed to characterize activities of chitinase, phosphatase and protease enzymes in *Sarracenia purpurea* pitcher plant microecosystems. Samples were collected from field-based plants and activities of enzymes measured in microplate based laboratory assays. Samples were also analyzed for universal 16S rRNA gene sequences to screen for bacterial community composition. Greenhouse plants were also used for experimental manipulations to test effects of anti-bacterial additives, and regulation of enzyme activities in response to prey and alternative nutrient sources.

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Recent Theses

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 south-eastern 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

Kolodziej, Robb C. 2014. The effect of female quality on mating preferences in Eastern Gray Treefrogs, *Hyla versicolor.* M.S. Thesis.

Graham, Jackson. 2015. Climate impact on groundwater flow processes in the Cedar Creek Watershed and Cedarburg Bog. M.S. Thesis.

Hallett, Allysa. 2016. Consequences of loss of an abundant pollinator: an experimental study. M.S. Thesis.

Servi, Jason S. 2016. Natural selection by insect pollinators and seed predators on floral head traits of *Helianthus grosseserratus* (Sawtooth Sunflower). M.S. Thesis.

Aerial view of the newly constructed boardwalk into Mud Lake. Photo: Ron Tagye

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. In 2016 the Field Station helped FOCB build and install a boardwalk to Mud Lake for the WDNR.

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

6. Regional School Systems. Biology classes and clubs from several high schools in the region (Milwaukee, Ozaukee, and Washington counties) use the Field Station for ecology field classes.

7. National Oceanic and Atmospheric Administration – Milwaukee Office. Weather records are provided monthly and frost and snow depth data are collected in winter.

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

9. Urban Ecology Center—Milwaukee. Gretchen Meyer serves on the Citizen Science Advisory Council.

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

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

12. Wisconsin Phenological Society. Gretchen Meyer serves on the Board of Directors.

2016 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. Nine workshop topics were offered in 2016.

Workshop	Instructor	Date
Ecology and Physiology of Plants in Winter: Surviving the Big Chill	James Reinartz	January 8 & 9
Invasive Plant Management Techniques	James Reinartz	May 21
Field Herpetology: Identification of Wisconsin Amphibians and Reptiles	Josh Kapfer	June 3 & 4
Sedges: Identification and Ecology	Anton Reznicek	June 10 & 11
Vegetation of Wisconsin	James Reinartz	June 13 - 18
Forest Communities of Southeastern Wisconsin	Gretchen Meyer and Robert Clare	July 29 & 30
Wetland Hydrology	Roger Kuhns	August 5 & 6
Unraveling the Mysteries of Bird Migration Through Bird Banding and other Techniques	Vicki Piaskowski	September 16 & 17
Creative Writing About the Natural World	Kimberly Blaeser	October 14 & 15

Jim Reinartz teaching the Invasive Plant Management workshop

Class and Group Use

Winter - Spring 2016

	Number of Student Hours
Ecology and Physiology of Plants in Winter Workshop	360
Invasive Plant Management Techniques Workshop	180
Winter Ecology Hike and Friends Chili Dinner	390
Friends of Cedarburg Bog – Building for Wildlife workshop	20
Friends of Cedarburg Bog – Owl-prowl hike	70
Friends of Cedarburg Bog – Woodcocks and frogs	40
Friends of Cedarburg Bog – Frogs & amphibians	40
Friends of Cedarburg Bog – Bird walk	20
Friends of Cedarburg Bog – Ethnobotany	40
Friends of Cedarburg Bog – Native Orchids of the Region	60
Friends of Cedarburg Bog – Ecology of the Bog – North	30
Friends of Cedarburg Bog – Spring Bird walk	20
Friends of Cedarburg Bog – Meetings	140
Field Station Garlic Mustard Search/Pull	50
UWM Alumni Group – Volunteer buckthorn control	80
Schlitz Audubon Nature Center – Duck workshop	30
Urban Ecology Center – Volunteer Outing	70
Glendale Women's Club – Bog Walk	60
Natural Resources Foundation – Woodcocks & Frogs Hike	50
Natural Resources Foundation – Bird-a-thon	40
Marquette University High School – Environmental Science	60
Shorewood High School – Watershed Wisdom Class	190
Wisconsin Phenology Society – Phenology program tour	50
UW – Oshkosh – Ecology Field Trip	110
UWM – BioSci 310 – General Ecology (Downer Woods)	1,500
UWM – Ornithology	140
UWM – Geography 120 – Our Physical Environment	290
UWM – Geophysics – Neda Mine exploration	120
TOTAL	**4,250**

Summer 2016

Vegetation of Wisconsin Workshop	1,240
Field Herpetology Workshop	380
Sedges: Identification and Ecology Workshop	380
Forest Communities of Southeastern Wisconsin Workshop	380
Wetland Hydrology Workshop	380
Friends of Cedarburg Bog – A Walk in the Bog	20
Friends of Cedarburg Bog – Dragonflies & Butterflies	60
Friends of Cedarburg Bog – Ethnobotany	30
Friends of Cedarburg Bog – meetings	80
Urban Ecology Center – Bog tour for interns	30
Schlitz Audubon Nature Center – Master Naturalist Class	50
Marshfield High School – Ocean Science Bowl team tour	40

Summer 2016	Number of Student Hours
American Indian High School – Science Scholars	60
UW – Oshkosh – Ecology Field Trip	140
TOTAL	**3,270**

Fall Winter 2016

Bird Migration Workshop	380
Creative Writing about the Natural World Workshop	380
Friends of Cedarburg Bog / UWM BioSci – Annual Picnic	240
Friends of Cedarburg Bog – Open House Neighbor Event	60
Friends of Cedarburg Bog – Forest Ecology walk	70
Friends of Cedarburg Bog – How do Trees Grow?	50
Friends of Cedarburg Bog – Owl Prowl	60
Friends of Cedarburg Bog – Introduction to the Ferns	30
Friends of Cedarburg Bog – Mud Lake boardwalk party	60
Friends of Cedarburg Bog – meetings	80
Cedarburg High School – Ecology Class	440
Shorewood High School – AP Science (Downer Woods)	120
Riveredge Nature Center – Christmas Bird Count	60
Great Lakes 2016 State of Stopover Symposium – Tour	70
Alverno College – Ecology Class	80
Milwaukee Area Technical College – Biotechnology Club	60
University of Illinois-Chicago– Ecology field trip	800
UW – Whitewater – Ecology class	30
UWM – ROTC (Downer Woods)	40
UWM – BioSci 310 – General Ecology (Downer Woods)	1,500
UWM – Geography – Soils	180
UWM – Geography 120 – Our Physical Environment	280
UWM – Geography 475 – Geography of Soil (Downer Woods)	110
UWM – Geography 340 – Biogeography (Downer Woods)	110
UWM – Geology – Hydrogeology	60
TOTAL	**5,350**

TOTAL 2016 Class & Group Use Hours **12,870**

Meteorological Data for 2016

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^2)

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.

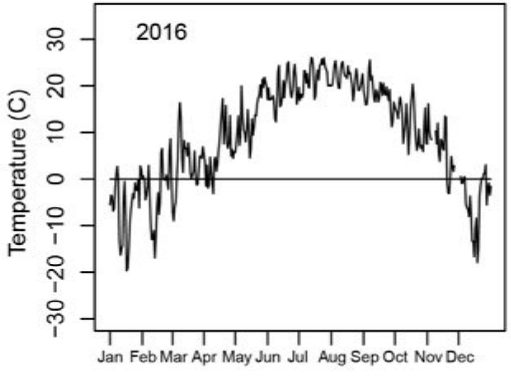
Maximum Speed (m/s): Highest mean wind speed during a 30-min period.

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.

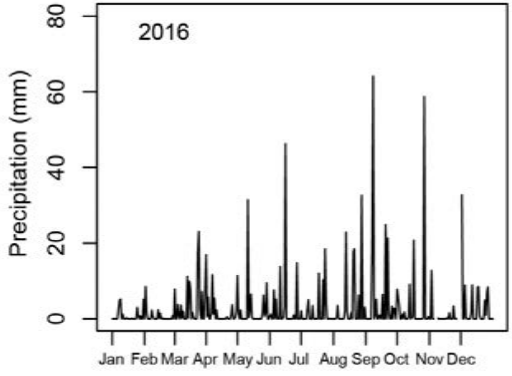
Meteorological Data for 2016

	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	OCT	NOV[1]	DEC[2]
Temperature (C°)												
Average Daily Maximum	-2.6	0.7	8.1	10.7	19.7	24.7	27.2	27.1	23.3	16.7	11.3	-2.1
Average Daily Minimum	-10.1	-7.2	-1.4	0.8	7.8	12.9	16.3	16.3	13.3	6.1	1.1	-8.2
Daily Average	-5.9	-2.8	3.3	5.8	13.8	19.1	21.9	21.7	18.2	11.7	6.3	-4.9
Highest (Date)	7.2 (30)	15.1 (28)	21.6 (8)	27.1 (18)	29.3 (6)	31.8 (10)	33.0 (22)	31.9 (4)	32.8 (6)	25.1 (17)	23.3 (1)	8.7 (26)
Lowest (Date)	-22.4 (18)	-22.6 (14)	-17.4 (2)	-7.9 (9)	0.7 (15)	7.7 (8)	9.9 (3)	9.4 (22)	9.0 (28)	-0.9 (25)	-6.4 (21)	-23.5 (18)
Degree Days												
Sum at 5°	0.0	7.1	40.9	71.3	273.5	423.7	523.2	517.9	395.8	207.0	65.6	0.0
Sum at 10°	0.0	0.0	12.4	24.1	135.6	273.7	368.2	362.9	245.8	86.1	15.7	0.0
Radiation (kW/m^2)												
Mean	0.06	0.10	0.12	0.18	0.25	0.28	0.26	0.22	0.16	0.10	0.08	0.04
Maximum	0.53	0.65	0.87	0.96	1.01	1.07	1.03	1.01	0.85	0.67	0.53	0.42
Relative Humidity (%)												
Hour 00-06 mean	82.9	79.2	86.9	81.7	80.8	86.0	90.1	91.6	90.0	89.7	84.3	80.0
Hour 06-12 mean	78.4	73.2	78.4	66.9	59.0	63.8	70.4	73.4	75.9	78.6	77.2	76.6
Hour 12-18 mean	70.6	65.3	67.7	59.5	50.6	54.5	59.5	61.4	66.7	69.2	64.4	70.6
Hour 18-24 mean	78.8	75.8	81.8	75.0	71.6	77.5	81.0	86.4	88.1	86.5	79.8	79.6
Number of Days												
Precip. 0.25mm or more	9	7	16	13	13	10	7	11	14	11	4	12
Max Temp 32° and above	0	0	0	0	0	0	3	0	1	0	0	0
Max Temp 0° and below	19	12	3	0	0	0	0	0	0	0	0	17
Min Temp 0° and below	30	26	18	10	0	0	0	0	0	2	9	28
Min Temp -18° and below	7	3	0	0	0	0	0	0	0	0	0	3
Pressure (mbars)												
Mean	1014.47	1014.64	1013.77	1016.54	1015.43	1014.97	1015.40	1016.64	1017.90	1018.29	1018.86	1017.54
Precipitation (mm)												
Total	24.3	18.2	125.5	48.1	65.3	96.3	56.9	110.9	160.6	103.2	18.5	92.0
Greatest (24 hrs) (Date)	5.2 (9)	8.6 (2)	23.1 (24)	11.7 (6)	31.5 (10)	46.3 (15)	18.5 (23)	32.6 (27)	64.2 (7)	58.7 (26)	12.8 (2)	9.0 (11)
Wind												
Mean Speed (m/s)	1.6	1.8	1.5	1.9	1.6	1.3	1.2	0.9	1.2	1.3	1.4	2.0
Maximum Speed (m/s)	4.7	6.5	6.1	5.7	5.2	4.6	4.5	3.5	4.2	5.0	5.9	5.2

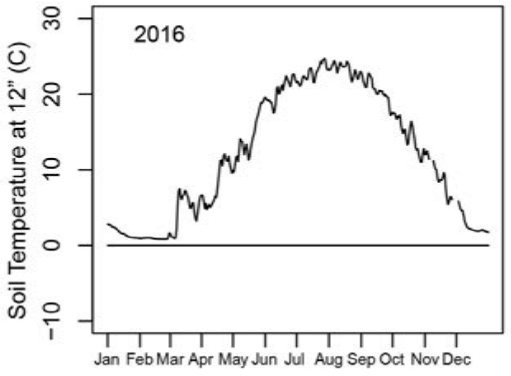
[1]Data for Nov. 5-7 and Nov. 27-30 are missing. [2]Data for Dec. 1 are missing.



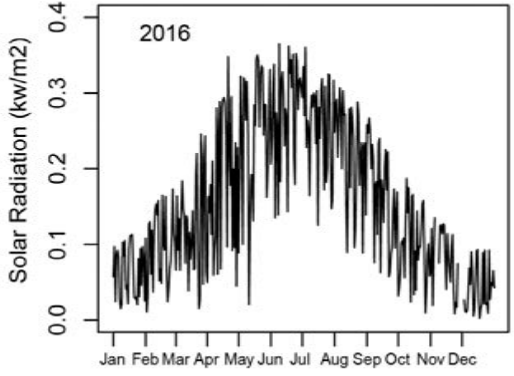
Mean Daily Temperature



Total Daily Precipitation



Soil Temperature at 12 Inches Depth



Mean Daily Radiation

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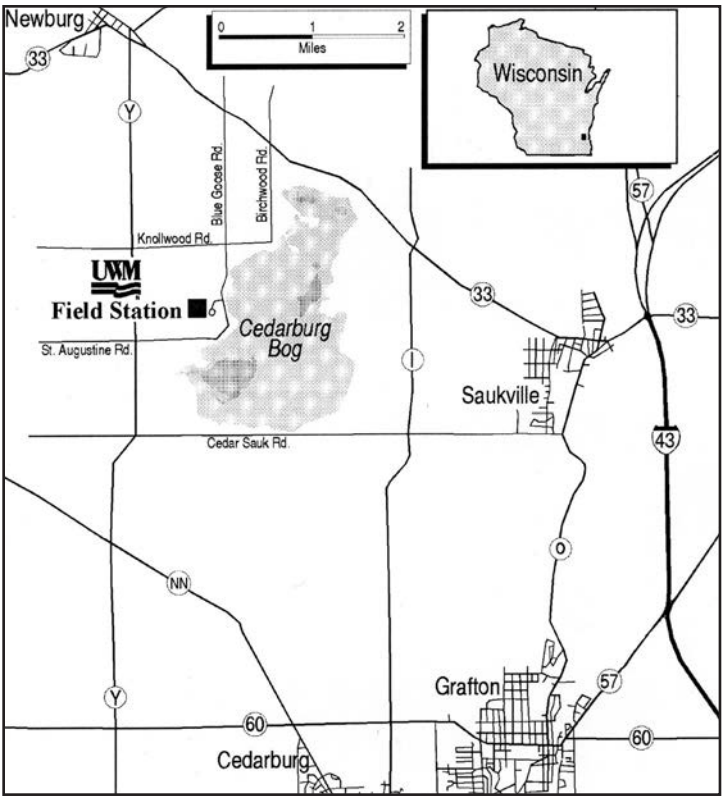

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