2017 Field Station Annual Report

UNIVERSITY of WISCONSIN
UWMILWAUKEE
Field Station

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On the Cover: Students in the Field Methods in Conservation class sample the Milwaukee River for aquatic invertebrates. This new UWM class was developed and offered for the first time in the Fall 2017 semester. It was taught entirely at the Field Station by Jim Reinartz and Gretchen Meyer.

A digital version of the Annual Report with color photos can be found at the UWM Field Station website: https://uwm.edu/field-station/research/publications/annual-reports/.

About Us

2017 Highlights

- Field Station staff constructed six new temporary research gardens including fencing and water supplies for a major NSF-funded study of plant mating systems. (See abstract by Karron, Mitchell, Trapnell and Christopher)
- A new UWM course, Field Methods in Conservation, taught entirely at the Field Station, was developed and taught for the first time in the Fall semester.
- A second year of work funded by a grant from the Southeastern Wisconsin Invasive Species Consortium continued eradication of invasive shrubs and garlic mustard in Downer Woods. Management of Downer Woods is entering a 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 over $200,000 in grants from the US EPA, and others. A crew of five was hired to work on the project in 2017. The Field Station helps direct and manage the project.
- The exterior of the Shop/Maintenance building was painted and the parking lot was re-surfaced with a new layer of gravel, funded in part by the Friends of Cedarburg Bog.
- 35 research projects in 2017.
- Over 15,000 person-hours of instruction and group use in 2017 is a new record for the Field Station. 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 379 scientific publications and 150 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. However, in 2017 the beetle population appeared to have been reduced and there was more flowering of the purple loosestrife again. 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 Mid-west. 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 have seen a large decline in the bat populations in 2017. We must analyze the 2018 spring emergence data to estimate the approximate percentage of the population that has been lost. The mine is also of geo-logical 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. We completed that funded control project in 2017, and management work in Downer Woods has entered 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

• 35 active research projects conducted at the Field Station in 2017.

• Including: 3 M.S. theses, 4 Ph.D. and 8 studies by researchers from outside of the University.

• 8 papers published during 2017. 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

• Over 15,000 person-hours of instruction and group use in 2017 is a new record of usage for the Station.

• Nine workshops on topics in natural history.

• A new UWM course, Field Methods in Conservation, taught entirely at the Field Station, was developed and taught for the first time in the Fall 2017 semester.

• 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 (uwm.edu/field-station/category/bug-of-the-week/). Bug of the Week has become by far the most visited feature of our website.

• 4 undergraduate student projects.

• 23 *Friends of the 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 – 2017

The Friends of the Cedarburg Bog (FOCB) was founded in 2005 to support stewardship, understanding and appreciation of the Bog through land management, preservation, research and education. The FOCB Board of Directors continues to follow and adapt their strategic Action Plan focusing their effort in five areas:

• Strengthen Community Support for the Bog – Develop strong, informed community-based support for sustaining the unique nature of the Cedarburg Bog through a focused outreach effort.

• Expand FOCB's Conservation Impact – Expand the FOCB's area of conservation focus to the Bog's natural boundaries through: (1) sustainable stewardship programs within that perimeter; (2) focused partnerships that work towards landowner commitment to conservation practices.

• Extend the use of the Bog as a Natural History Classroom and Laboratory-Support science-based understanding of the Bog and use its' unique character to foster a sustainable land ethic.

• Be a Good Partner – Establish strong, supporting relationships with our DNR and UWM partners; and also with like-minded organizations that further the FOCB's mission impact.

• Be a Healthy Organization – Have an active, focused, learning and mutually-supportive board and staff, with the competencies and capacity to advance the mission of the FOCB.

Some of the main highlights and challenges for FOCB in 2017 include:

• FOCB launched the Bog Guardian Program, with supporting funds from the Ozaukee Washington Land Trust and the WI DNR – Citizen Based Monitoring Program. This multi-faceted program is designed to stop the advancement of 5 target invasive plants that are nearly absent from the Bog area, and that are spread primarily along

roadways, before they reach the area. The program also engages neighboring land owners through education and outreach.

• The FOCB is stronger financially than ever due to memberships and private donations. The organization is putting together a strategic action plan to look at long-term financial sustainability including building on the endowment.

• FOCB for the first time celebrated International Bog Day with music, crafts, hikes, drone video flights over the Bog, and ice cream floats.

• FOCB continues to benefit from the creation of a Communications Committee full of talented Board Members that is looking to upgrade web and social media presence.

• The Friends continue to expand and strengthen their educational programming for the general public with 23 educational events and programs and several new topics in 2017.

• The Friends continued to be the primary provider of stewardship of the Cedarburg Bog. 2017 was FOCB's third year of working on a $197,000 grant from the EPA to control buckthorn 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.

• FOCB continues to support the Field Station's Natural History Workshops through annual sponsorship of $5,000.

• FOCB also provided one-half of the funding for improvements for the Field Station parking lot.

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 Friends of the Cedarburg Bog website, www.bogfriends.org.

Julia Robson checks under a snake board during the Mammals of our Area event in April

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 2017 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 2017, 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 2017 we monitored seven parks and additional analysis and reporting was commissioned for 2018. Funded by the National Park Service.

Salamander Survey at Riveredge Nature Center

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This project will determine the occurrence status of several regionally rare salamanders at the Riveredge Nature Center, Ozaukee County, WI.

Spotted Salamander egg mass
(Apostle Islands survey)

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. In 2017 we added new Ozaukee County areas and began reporting. Funded by the Wisconsin DNR and the U.S. Environmental Protection Agency.

Collaborative Native Orchid Conservation and Restoration Project

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North America is home to over 200 species of native orchids. Nearly half of these species are under severe threat due to habitat destruction, and many species are likely to become extinct unless action is taken to conserve them and their fungal partners. Promoting efforts to conserve habitats and to restore native orchids where populations have declined will be essential to the future of these fascinating plants. Since 2012, a coalition of partners has focused on native orchid conservation by developing a large-scale, collaborative project addressing threats to native orchid species in Wisconsin with an emphasis on trying to understand their recovery and conservation potential. This project relies on shared resources across a network of partners including nonprofits, local municipalities, federal and state agencies, research institutions and private individuals. The project's main objectives are to support regional and national conservation efforts by supplying partner organizations with local genotypes for ex situ propagation, seed and fungal banking, and to advance the science of native orchid restoration through experimental outplantings of lab-propagated orchids in native habitats. Project tasks include investigating the biological requirements of several orchid species by collecting baseline data at reference sites where they occur; collecting seed for propagation experiments; collecting seed and root material for regional banking; identification of suitable outplanting sites; implementation of trial outplantings; and monitoring to evaluate the success of the introduced populations.

Three survey events were completed at Cedarburg Bog State Natural Area and the UW-Milwaukee Field Station in 2017 focused on documenting the distribution and abundance of orchid species and collecting

Platanthera clavelllata

leaf and root samples for regional banking initiatives. Leaf and root material was collected from seven orchid species in 2017. Additional surveys and sample collections will be performed in 2018, specifically targeting species with limited distribution within the Cedarburg Bog. Pending funding, long-term monitoring protocols will be developed and implemented in 2018. Conservation of native orchids requires a thorough understanding of the ecological requirements of each species, their historic and current distribution, associated pollinators and fungal relationships. Monitoring is needed at sites where orchids occur in abundance to ensure the sites selected for reintroduction

match the existing habitat in its vegetation characteristics, soil composition, geology and hydrology; this level of understanding is critically important for ensuring the long-term survival of reintroduced orchids, and Cedarburg Bog will play a significant role as a living laboratory for orchid conservation studies.

Platanthera leucophaea

Stable Isotopes and Seasonal Recharge in Cedarburg Bog State Natural Area

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The ratio of stable isotopes of hydrogen (^{1}H and ^{2}H) and oxygen (^{16}O and ^{18}O) in precipitation that has not been evaporated are linearly related by the equation known as the Global Meteoric Water Line (GMWL):

$d^{2}H = 8\ d^{18}O + 10$

The slope and intercept of any Local Meteoric Water Line (LMWL) can be different or very similar to the GMWL and is a result of several natural processes including evaporation and seasonal temperature variation. Typically, rain in the summer is isotopically heavier than rain in the winter primarily due to seasonal temperature differences. This study takes a look at the ratio of stable isotopes in waters collected over a five-week period from the Cedarburg Bog State Natural Area in Ozaukee County, Wisconsin. Samples were collected from four groundwater monitoring wells, two in the upland area just northwest of the UWM Field Station and two from the bog itself. The isotopic composition of the samples were compared to the GMWL and a linear regression analysis produced the following equation:

$d^{2}H = 5.75\ d^{18}O - 7.85$

A slope of 5.75 indicates that evaporation is likely a dominant process as evaporation lines commonly have slopes between 2 and 5. The $d^{18}O$ and $d^{2}H$ values in bogs and shallow groundwater reflect local average

precipitation values so they were compared to stable isotope values for precipitation in Madison, WI. Measured values from the bog and upland area plotted closer to the GMWL than the precipitation from Madison, WI but were less enriched than the precipitation in both $d^{18}O$ and $d^{2}H$ values for the same time period. This makes sense because the values vary to some extent by selective recharge and fractionation processes (evaporation of rain during infiltration, selective recharge, interception of precipitation by the tree canopy, and exchange of infiltrating water with atmospheric vapor) which may alter the $d^{18}O$ and $d^{2}H$ values of the precipitation as it moves through the bog or before the water reaches the saturated zone. Based on where the values plot relative to the precipitation data, recharge to the shallow aquifer and bog during the time period samples were collected is primarily from summer and fall precipitation and not from melting of snow from the previous winter. More samples collected over a longer period of time will help determine whether waters from the bog fall along the GMWL on an annual basis, and where they will plot relative to precipitation in the region.Undergraduate research project, Dr. Shangping Xu, advisor.

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 2017 we completed the 21st 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.

The Effects of Pollination on Reproductive Success in Self-Pollinating Tomatoes

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Successful pollination in agriculture is extremely important to avoid crop loss and maintain fruit quality and yield. This study looked at the effects of biotic pollinators and abiotic pollination on fruit yield and fruit weight in self-pollinating tomatoes. Cherry tomatoes were grown inside a virtually pollinator-free enclosed plastic hoop house and two treatments were applied. One set of tomato plants grown inside the hoop house were hand pollinated using an electric toothbrush. The second set of tomato plants

grown in the hoop house served as the control and did not receive supplemental pollination. To record insect visitors to flowers and measure the effects of insect pollination, a third set of tomato plants were grown outdoors where their flowers would be fully accessible to a variety of pollinators. Number of flowers, fruit set and weight of the first ripe fruit for each cluster were compared for all three treatments. Types of pollinators visiting the tomatoes were compared to other outdoor crops to observe possible pollinator competition and to see which pollinators could access pollen from the poricidal anthers of the tomato plants. Results show that the hand-pollinated tomatoes grown in the hoop house had the highest percent fruit set, while tomatoes grown outdoors had the highest fruit weight. Based on these results, self-pollination is not sufficient to ensure full fruit set in hoop-house grown tomatoes. Hand-pollination can impact reproductive success by increasing fruit set in hoop-house environments. Visits by insect pollinators to the tomatoes grown outside could have contributed to their higher fruit weight, although environmental differences between the outside garden and the hoop house cannot be ruled out. Undergraduate research project, Dr. Gretchen Meyer, advisor.

Jennifer Gordon in the hoop house

Diversity and Function of Detrital Food-web Communities in *Sarracenia purpurea*: Food Web Differences Amongst Two Wetland Populations

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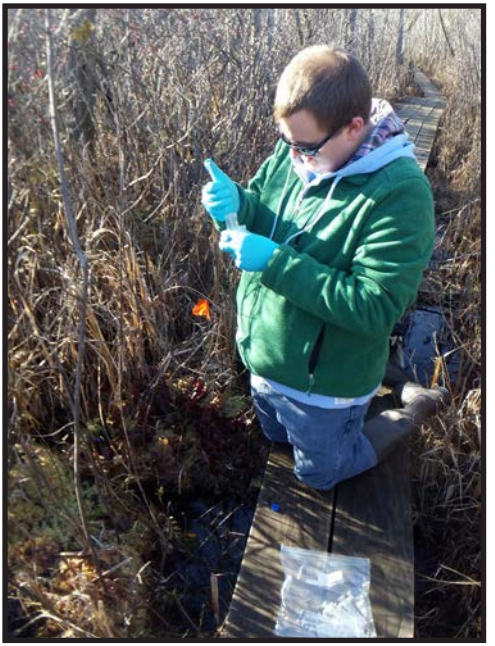
Sarracenia purpurea is a plant that lives in the Cedarburg Bog, supplementing its mineral nutrition through carnivory. As the plant grows it produces new pitchers, sterile until they open and fill with rainwater, capture prey, and recruit a food-web for prey digestion. Insect prey is first shredded by invertebrates but bacteria produce hydrolytic enzymes to digest prey releasing nutrients for plant absorption. Collectively the food-web members are well-studied as a model system in ecology but the microbial components of the food-web are often represented as a “black box” in food-web models. Detailed analysis of pitcher bacterial and eukaryotic taxa and their functions in the food-web are lacking. This research addressed two questions: Which eukaryotic and bacterial taxa are found within pitcher communities? How does community composition and diversity vary between pitchers and between plant populations from two wetlands? Community DNA was isolated from pitcher fluid from two wetland populations and used for sequencing of 16S and 18S rRNA amplicons. After processing

in the bioinformatic programs mothur and QIIME, taxa were identified using SILVA database. Eukaryotic taxa identified represent known inhabitants (e.g. mosquito larvae, rotifers, and algae) and probable prey (e.g. flies, ants, mites). Bacterial composition in pitchers was distinct between the two populations - some bacterial families were either absent from or significantly more common in one wetland population than the other. Using 16S rRNA based bacterial taxa, PICRUSt was used to predict biochemical nutrient transformation pathways. Pitchers harbored abundant bacteria representing diverse taxa of aquatic ecosystems and equally diverse metabolic functions, related to amino acid metabolism, biosynthesis of metabolites, and energy metabolism. Pitchers of *S. purpurea* harbor diverse bacteria and invertebrates, and recruitment into pitchers may depend on nearby sources in the habitat for these populations. Ph.D. dissertation research, Dr. Erica Young, Major Advisor.

Withdrawing water from Pitcher Plant



Jacob Grothjan working in the field

Does Growth Rate Shape Defensive Traits Across Resource Gradients?

Phil Hahn and John Maron
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We are interested in comparing growth and defense among populations of plant species that occur in low- vs. high-resource environments. We have previously shown that plants (*Monarda fistulosa* and *Achillea millefolium*) from tall-grass prairies in Wisconsin (WI) were larger in the field and grew faster in a greenhouse than plants from arid grasslands in Montana (MT), suggesting grasslands in WI support populations with faster growth rates than MT. In 2017 we conducted a bioassay experiment using the generalist insect herbivore *Spodoptera exigua* (Lepidoptera) to test differences in herbivore resistance between *M. fistulosa* and *A. millefolium* plants originating from WI and MT. We also surveyed herbivore damage on seven plant species in the field in WI and MT (n = 5-20 individuals/species at each of 2-5 populations per state) to determine if differences in herbivore pressure between the states may drive differences in defense. Field sites in WI included the University of Wisconsin-Milwaukee Field Station and Benedict Prairie.

In the bioassay experiment, larvae of *S. exigua* grew larger on MT plants compared to WI plants (P=0.05) for both plant species. This finding suggests that WI plants were more resistant than MT across both species. In field surveys, we found that plants in WI received more insect herbivore damage than plants in MT when averaged across all species (P<0.01). Herbivore damage was significantly greater on WI than MT populations for four focal species. Collectively, these results support our hypothesis that there are positive growth-defense relationships, both plastically and genetically based, among populations from divergent resource environments likely driven by differences in herbivore pressure. In the future, we plan to test the generality of these patterns using the seven species we surveyed in the field.
Funded by MPG Ranch.

Male Stress Response is Related to Ornamentation and Resistance to Oxidative 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 the ability to cope with stressful situations, such as interactions with predators or competitors. When individuals encounter these situations, stress hormones in the body increase to redirect resources from long-term to short-term processes. Despite these benefits, stress hormones can also be harmful because they increase oxidative stress. Thus, we hypothesized that individuals with more elaborate ornaments have the strongest stress responses and that they mitigate some of the negative effects of a strong stress response by being more resistant to oxidative stress. We tested this hypothesis in the common yellowthroat (*Geothlypis trichas*). Male yellowthroats 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 antibody production, resistance to oxidative stress, and immune gene variability. We measured the stress response in males by quantifying both

baseline and stress-induced corticosterone (CORT), which is the main stress hormone in birds. Stress was induced in males with 30 minutes of capture and handling. We found that males with both larger masks and a greater resistance to oxidative stress had a larger increase in CORT after 30 min of stress. This suggests that the most ornamented males may be able to mitigate some of the negative effects of a strong stress response if they are also the most resistant to oxidative stress. Ph.D. dissertation research, Dr. Linda Whittingham, Major Advisor.

Throat Color in Eastern Gray Treefrogs

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As part of a larger research agenda investigating variability and color change in gray treefrogs, this particular project focuses on the throat color of gray treefrogs. Over the breeding season (May/July) we took pictures of the throat and belly area of males and females collected at Byers Pond for our behavioral studies. To obtain frogs outside the breeding season, we deployed PVC frog traps in the Field Station forest (frogs accept those pipes as shelter, and can then be sampled). Preliminary analysis revealed that males and females differ in their throat color (males have darker throats) and that the darkness of male throat coloration increases as the breeding season progresses. Undergraduate research project, Dr. Gerlinde Höbel, advisor.

Variation in frog throat color

Chorusing Behavior in Eastern Gray Treefrogs

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We have placed long-term recorders at the same location in Byers Pond for several years. Recorders are set to record one minute of sound every hour for the duration of the frog breeding season. We analyzed several years of these recordings to see whether choruses form every night once the breeding season starts, and how long the choruses last each night. Data analysis so far indicates that choruses form less often then expected (i.e., fewer days), but that daily calling activity lasts longer than expected (i.e., if frogs call, choruses last for more hours). The next step in this analysis is to correlate chorusing duration with environmental factors such as rainfall, temperature and moon phase.

Midwest Conservation Dogs Training

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Professional detection dogs are increasingly used to aid in ecological and conservation research. They can identify plants and animals at multiple life stages, on land, hidden under logs, and even in water. Searches are thus completely non-invasive and have minimal ecological impact. Milwaukee is now home of one of the first conservation dog organizations in the Midwest (Midwest Conservation Dogs, https://www.midwest-conservationdogs.com). After the dogs have learned the scents of the target species they are being trained on, they need to practice in real-life situations. Two of the MCD canines are currently being trained to find salamander species (Blue-spotted Salamanders, Tiger Salamanders), and since these salamanders occur at the UWM FS (Höbel, pers. obs) we chose it as one of the training locations. Training has just started, but eventually we hope that allowing the Midwest Conservation dogs to train on Field Station property will result in a win-win situation where the dogs train under realistic conditions, and the Field Station obtains better data on the occurrence and distribution of salamander species on the property.

Salamander Cover Board Survey

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As part of a larger inventory project of amphibians at the Field Station property (the Höbel lab already has call and visual surveys of anurans in place), we placed cover board arrays in several locations in the Field Station forest. The short-term goal is to re-assess presence of species at the Field Station, for which data has not been collected since the last published report in 2007, and to provide a comparative data set about salamander abundance to be compared with the effectiveness of conservation dogs also training at the site. Since deployment of the boards in late summer 2017, we have captured Blue-spotted salamanders and Eastern Newts under the boards.

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 the global soil carbon reservoir. The Cedarburg Bog of southeastern Wisconsin boasts a myriad of wetland habitats including the southernmost string bog found in North America. Soil carbon dioxide (CO_2) behavior in these systems is the response of multiple interdependent variables that are, collectively, not well understood. Many studies have measured and modeled soil CO_2 flux (soil respiration) based on isolated, intermittent measurements that do not account for the full range of soil CO_2 flux intensity. In the Cedarburg Bog, high-resolution measurements of soil CO_2 flux were recorded over two field seasons using a LI-COR 8100A soil gas flux analyzer at 30 minute (May-Nov., 2014) and 60 minute (June-Oct., 2015) intervals. Additionally, soil moisture and temperature data were collected, and weather station variables (atmospheric temperature, radiation, wind, pressure, precipitation) were acquired for correlations. Stable isotope signatures were interpreted from a peat core ($\delta^{13}C$, $\delta^{15}N$) and from gaseous CO_2 at the surface ($\delta^{13}C$) to determine sources of soil respired CO_2 .

The intensity of soil CO_2 flux was broadly distributed across the entire data set, ranging from less than 1 to over 650 mg/min-m^2. Average for all soil CO_2 flux measured was 6.49 mg/min-m^2, with a median of 3.39 mg/min-m^2. Soil respiration was attributed to two main sources: 1) microbial respiration, and 2) root respiration (including rhizomicrobial respiration). Microbial respiration was, in part, influenced by soil temperature, and produced a constant, low flux (< 5 mg/min-m^2). The addition of root respiration generally resulted in a diurnal increase in soil CO_2 flux (medium flux, 5-50 mg/min-m^2) in response to radiation and temperature trends reflecting photosynthetic assimilation of CO_2. In addition, infrequent, high flux (> 50 mg/min-m^2) were observed, but were not correlated to the included parameters. Although high flux occurred much less frequently, it produced a significant amount of the CO_2 mass respired from the soil. Correlations between soil CO_2 flux and controlling parameters were addressed using JMP; multiple linear regression models presented weak and significant correlations due to the absence of lag/response time variables for assimilation and transport mechanisms of CO_2 . Wetland soils are structurally complex, and can be highly variable through time; improving correlations for soil respiration models requires high-resolution data sets, and determination of lag/response times of CO_2 transport processes above ground and in the soil. M.S. Thesis research, Dr. Timothy Grundl and Dr. Weon Shik Han, Major Advisors.

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 Josh Kapfer and Tim Muehlfeld, 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.

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.

Evolutionary Tradeoffs Between Outcross Siring Success and Selfing: the Role of Ecological Context in the Stability of Mixed Mating Systems

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A major unsolved question in biology is why plant populations often maintain a mixture of two reproductive strategies. Long standing genetic theories predict that the extreme form of inbreeding known as self-fertilization should rarely co-exist with outcrossing. Yet this dual strategy is surprisingly common in nature, suggesting that existing theory does not adequately explain the maintenance of mixed mating. This project tests the hypothesis that ecological interactions among plant species help maintain dual strategies. When plant species flower together and share pollinators, pollen is often wasted on flowers of other species, reducing the benefits of cross-pollination. We are testing this hypothesis through a combination of field studies of pollinator behavior, measurement of floral traits, and molecular genetic lab studies of parentage.

Most studies of plant mating systems quantify selfing rates for entire populations, using multilocus estimation models. However, natural selection operates on individuals, and we know surprisingly little about how floral traits influence individual selfing rates. Through the use of unambiguous paternity analysis (100% exclusion), we are determining whether selfing rates and male fertility of individual plants are consistent within clonal lines, and whether they correlated with heritable floral traits. Funded by the National Science Foundation.

An aerial view of the experimental garden

Breeding Bird Survey at the Cedarburg Bog: 2017

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The third year of the Wisconsin statewide breeding bird atlas survey has been completed with 13 additional species having been confirmed as breeding in the Cedarburg Bog in 2017 to make a total of 78 confirmed breeding species of birds within the Bog complex. Notables among the newly confirmed breeding species in 2017 were black-billed cuckoo, brown creeper, veery, Nashville warbler, and northern waterthrush. Several noteworthy "probable" breeders in 2017 were Canada warbler, hooded warbler, and spotted sandpiper. The breeding bird survey continues for two more years.

Wood Duck Nest and Owl Nest/Roosting Box Project: 2017

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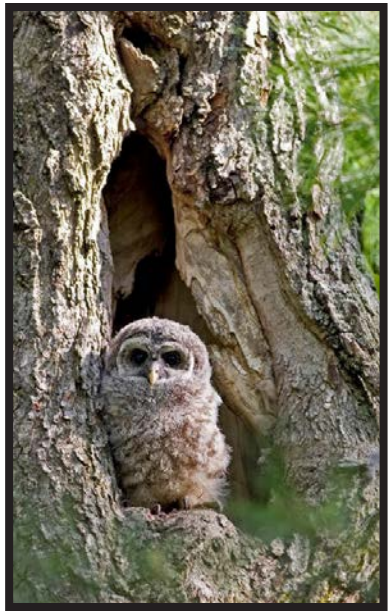
As of 2017, 23 wood duck nest boxes, two nesting platforms, and six nesting and/or roosting boxes for eastern screech, northern saw-whet, and barred owls have been installed with accompanying stainless steel predator or PVC pipe predator guards in multiple locations around the Cedarburg Bog boundaries by board members, volunteers affiliated with the Friends of the Cedarburg Bog, an Eagle Scout under the supervision of the Friends of the Cedarburg Bog, and three private landowners having property within the Cedarburg Bog complex in collaboration with the Friends of the Cedarburg Bog Nest Box project. Thirteen of the duck boxes have been installed on private land owner property within the Cedarburg Bog complex and the remainder are on DNR land. The two nesting platforms are on private property in a cattail marsh west of the Mud Lake big island. Five of the six owl boxes are scattered about the Bog complex on DNR property, and one Barred Owl nest box is on a private landowner's property.

Duck nesting success continues to average about 75% overall with 16 broods of wood ducks having successfully fledged from nest boxes in 2017 and two broods of hooded merganser also successfully fledged from nest boxes in 2017. As of yet there is no evidence of small owls using the owl boxes for nesting; however, 50% of the owl boxes were used for roosting in 2017. Two barred owl boxes were put up in 2017 in hopes of attracting a pair of nesting barred owls in 2018.



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

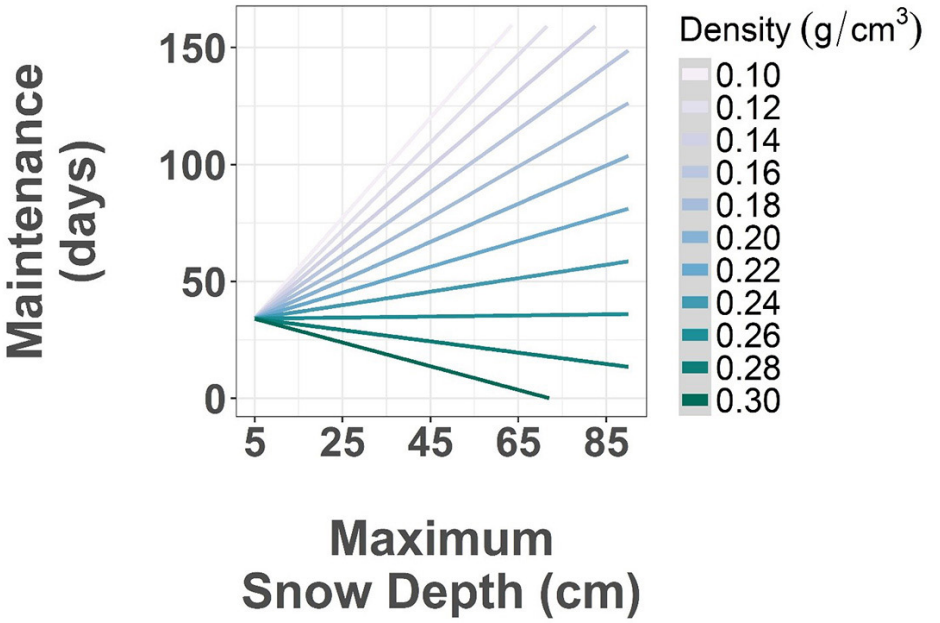

Figure 1. Relationship between duration of subnivium existence (days) and maximum snow depth across a variety of snow densities at greenhouse sites in winter 2015/16 and 2016/2017. When snow has a lower density (i.e. fluffier snow with better insulation capacity), higher snow depths promote longer subnivium maintenance. However, the effect of snow depth is negated if snow density is too high. Disentangling these factors will improve predictions of subnivium duration in the future, as both snow density and depth are predicted to change.

this habitat. Using micro-greenhouses that are automated to maintain set temperature gradients and allow winter precipitation to fall inside, we are assessing 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 set up three microgreenhouses in a conifer stand and collected data on the climate conditions within and outside each greenhouse during winter 2015/16 and winter 2016/17. As expected, subnivium temperatures remained high and stable compared to ambient air temperatures in a control greenhouse that maintained air temperatures equal to exterior ambient air temperatures. To understand how these temperature relationships will change in the future, we are identifying key drivers affecting subnivium duration. For example, deeper snow promotes longer subnivium maintenance, but this can be countered if snow density is too high (Fig. 1). Understanding the interactions between factors like snow depth, snow density, and air temperature will allow us to predict how the subnivium will be affected by climate change and warming winters. Funded by the National Science Foundation.

Using Camera Traps to Assess the Presence of Bobcat (*Lynx rufus*) in Southeastern Wisconsin

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After being overharvested in the early 1900's, it appears the bobcat (*Lynx rufus*) is recolonizing its former range in southern Wisconsin based on the Department of Natural Resources reporting an increased number of citizen observations in that area. However, it is unknown if this range expansion includes southeastern Wisconsin, a dense urban and agricultural region. We assessed the presence of a bobcat population in southeastern Wisconsin with two camera trap survey grids of 4x4 km^2 cells at the Kettle Moraine State Forest Northern Unit (Washington County, WI, USA) and Cedarburg Bog State Natural Area (Ozaukee County, WI, USA). In order to increase

Trail camera captured these otters at the Cedarburg Bog State Natural Area

the probability of detecting bobcat, camera traps were placed along game trails at sites with habitat conditions assumed to be optimal for bobcats based on literature related to bobcat habitat relationships in the Upper Midwest. Due to the difficulty of detecting a wide ranging carnivore such as a bobcat, visual and scented lures were equipped at each camera station to encourage any bobcats in the area to visit the camera. If one of our camera traps does confirm bobcat presence, we plan to relate the probability of bobcat presence at a site to various human related variables such as distance to urban dwellings or presence of domestic animals. The 2017 bobcat presence survey is a first step to determining the viability of a bobcat population in the heavily anthropogenic landscape of southeastern Wisconsin and better understanding how human related factors influence habitat selection by bobcats.

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 have evidence of combinatorial signal processing, and we are testing the temporal extent of this effect --- is it limited to individual whine-pulse combinations or does it span broader ranges? We are also comparing the strength of this effect in relation to variation in signal attractiveness associated with basic signal features such as dominant frequency. Funded by the Research Growth Initiative (UWM).

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.

UWM Field Station Phenocam photo, August 2017

Influence of Flower Color on Pollinator Attraction in *Hesperis matronalis*

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The attractiveness of flowers to pollinators is influenced by floral characteristics such as color and scent. It can be difficult to separate the effects of a single floral trait, such as color, on pollinators, because flowers of different plant species typically vary across many traits. *Hesperis matronalis* (Dame's rocket) is an invasive species which blooms in spring producing flowers that are visually indistinguishable apart from variations in color, providing the opportunity to examine the effects of flower color on pollinators.

Interactions between pollinators and flower color, as well as the effects of sun and shade were studied in *H. matronalis.* Pollinators were monitored for timed intervals on 2 m^2 plots with both purple and white floral color morphs in sun and shade locations. Pollinators were classified as bee, fly, wasp, or other, and were identified to family within each group. Primary pollinators were in the families Apidae and Syrphidae. The results suggest that color preference is dependent on pollinator species, with a strong preference for white color morphs among bees, and purple morphs among flies. There was no evidence for a strong preference for sun or shade locations for any species. Further research may help ecologists plan for better reconstruction of natural systems to positively impact native pollinators. Undergraduate research project, Dr. Gretchen Meyer, advisor.

Oviposition Behavior and Egg Parasitism of the Bog Buckmoth (*Hemileuca* sp.) in Cedarburg Bog

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Like the well-studied bog buckmoths of New York and Ontario, the buckmoths of Cedarburg Bog feed as larvae on buckbean (*Menyanthes*), but little else is known of their biology. The goals of this project were to investigate the feeding and oviposition behaviors of the Cedarburg moths, to see how this population compares to those in NY and Ontario; and to determine whether the egg parasitoid *Anastatus furnissi* (Eupelmidae), a significant mortality factor in NY, also occurs in Wisconsin. The population this year was sparse, and I was not able to collect as many specimens as I had hoped. The few that were found, however, provided useful information.

One sixth (final) instar and two fifth-instar larvae were observed. One was resting on birch and two were feeding on *Menyanthes*, which was still lush and abundant. This suggests that Cedarburg Bog has sufficient *Menyanthes* to allow complete development on this plant, and that the caterpillars will feed on it at these late stages if it is available.

Three egg clusters, two on bog birch and one on glossy buckthorn, were found. Both represent new oviposition records for Wisconsin. The clusters were situated 26-39 cm above the surface and 15-18 cm from the nearest *Menyanthes*, and averaged around 200 eggs. The placement and size of egg clusters is similar in NY.

One cluster yielded parasitoids. Approximately 1/3 of the 183 eggs were parasitized, producing 53 female *A. furnissi* and 14 males. In NY, also, the female:male ratio skews female. The wasps' emergence pattern was unexpected. In NY, almost all *A. furnissi* emerge soon after the caterpillars hatch in May, and presumably use an alternative host over the summer (buckmoth eggs are unavailable until September). Here, none emerged until the end of July, and they steadily emerged through late September. Funded by a SUNY Oswego Scholarly & Creative Activities Grant.

A bog buckmoth caterpillar on buckbean

Female *Hyla versicolor* Often Unable to Detect Call Variation Among Neighboring Males

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Mate choice is an important evolutionary phenomenon, and a major mechanism in driving morphological and behavioral trait evolution. This typically involves female selection of mates based on preferences for male advertisement traits. Research on the role of mate choice in sexual selection usually focuses on 1) female response to male traits across a spectrum of natural variation (i.e., preference functions), and 2) male trait distributions in a population. While the shape of female preference functions can indicate the *direction* of sexual selection, such analysis does not address the *strength* of selection exerted by female mate choice. Using the population of eastern gray treefrogs (*Hyla versicolor*) at Byers' Pond, we examined females' ability to discriminate differences in male call traits using two-choice trials. We also surveyed the male chorus to better characterize the signal variation available to approaching females. When analyzed in the chorus context, females' ability to identify attractive calls can be used to estimate the occurrence of "random" phonotaxis; mate choice events in which a female cannot detect differences among neighboring displays, and simply chooses the closest male. By examining the assumption that females can consistently select "attractive" calls in the wild, our research provides a more detailed picture of trait evolution via sexual selection. M.S. Thesis research, Dr. Gerlinde Höbel, Major Advisor.

Mate Choice Behavior of Female Eastern Gray Treefrogs (*Hyla versicolor*) is Robust to Anthropogenic Light Pollution

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Human activities are drastically changing the amount of artificial light entering natural habitats. Because light pollution alters the sensory environment, it may interfere with behaviors ranging from prey detection and vigilance to mate choice. Here we test the hypothesis that anthropogenic light pollution affects the mate choice behavior of female eastern gray treefrogs (*Hyla versicolo*r). We tested this hypothesis under two experimental light treatments that simulate the light pollution created by streetlights (i.e., expansion of lit areas and increased light intensity), and the light pollution created by headlights of passing vehicles (i.e., rapid fluctuations between bright and dark conditions). We predicted that females tested under conditions simulating light pollution will show behavioral changes geared towards mitigating detection by predators, such as relaxed preferences, decreased choosiness for the normally preferred call, and more directional, faster, or stealthier phonotactic approach movements. Contrary to our prediction, we found that light pollution did not affect mate choice behavior in gray treefrogs, and should therefore neither interfere with population persistence nor affect the sexual selection regimes on male call traits of this species. However, we caution that this result does not imply that anthropogenic light pollution is of no concern for amphibian conservation, because behavioral responses to variation in nocturnal light levels (both in the natural as well as anthropogenically enhanced range) seem to be highly species-specific in anurans. We encourage additional studies to help gauge the vulnerability of anurans to anthropogenic light pollution. 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 standalone determinant of success, as organisms do not exist in solitude, but rather, they exist in ecosystems wherein complex multi-trophic interactions occur.

Trap used for insect sampling

Jana photographing plants from the Cedarburg Bog Boardwalk

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. Charles 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.

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 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. Morphology among these species is relatively similar, except for tongue length. Perhaps tongue size influences bee behavior within the flower and subsequent plant reproduction. 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 31 states and 5 Canadian provinces. The fungus *Pseudogymnoascus destructans* (Pd) that causes the syndrome has been found in two other states (MS and TX). This deadly disease has and continues to cause massive bat mortality in North America. WNS was confirmed in Wisconsin on March 28th, 2014. As of May 2017, 64 sites in 24 counties have been confirmed with either Pd or WNS. Closely monitoring WNS-affected bat populations is essential to better understand, identify and protect surviving populations.

The bat population of Neda Mine has been inspected (either by internal or external methods) annually for the past seven hibernation seasons and continues to be inspected. Neda Mine was confirmed Pd infected in April of 2015 and the proceeding hibernation season (2016) Wisconsin Bat Program (WBP) received many public reports from nearby areas that observed aberrant bat behavior, almost all reports resulting in the collection of dead bat carcasses. WBP did not receive any public reports of bat activity in or around Neda mine during the winter of 2017.

WBP only inspected the mine through external methods in the 2016-2017 season and was limited to two trapping sessions. The goal was to trap a sample of bats late in the pre-hibernation period to 1) understand fall weight gain cycle, 2) collect standard measurements (weight; forearm length; species; sex) and 3) repeat measurements during spring emergence.

WBP harp-trapped at mine entrances for two nights, once during fall swarm and once during spring emergence. Twenty-one bats were captured in September (2016), 20 little brown bats (*Myotis lucifugus*) (18 male, 2 female) and one northern long-eared bat (*M. septentrionalis*) male. Spring trapping in April (2017) yielded only three female little brown bats, all with visual infection from WNS.

Identification of Microorganisms From Soil at UWM Field Station

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We collected soil samples from the root areas of various plants at the UWM Field Station. Different media were used to isolate microorganisms from soils collected from the rhizosphere. The bacterial colonies of different types or colors were picked and the single colonies were further purified by streaking them on the agar plates. To identify the bacteria isolated in the rhizosphere, the chromosomal DNA of each bacterium was isolated and the 16S rDNA was amplified through PCR and sequenced. Different bacteria such as *Lysobacter*, *Pseudomonas*, *Duganella*, *Brevibacillus*, and *Rhizobium* spps were identified in this study. Funded by the Research Growth Initiative (UWM), USDA-NIFA, the National Science Foundation, and T3 Bioscience.

Recent Publications and Theses

Recent Publications Resulting from Field Station Projects

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Recent Theses

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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.

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Joynt, Emily K. 2017. Factors controlling diffusive CO_2 production and transport in the Cedarburg Bog, Saukville, Wisconsin. M.S. Thesis

The Friends of the Cedarburg Bog celebrated International Bog day in July. Here a crowd is listening to wildlife rehabilitator Jean Lord. There was music, hiking, food, face painting and more.

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 the Cedarburg Bog in cooperation with the Wisconsin DNR and UWM.

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

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

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

5. 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.

2017 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 2017.

Workshop	Instructor	Date
Ecology and Physiology of Plants in Winter: Surviving the Big Chill	James Reinartz	January 6 & 7
Introduction to the Algae	Robert Pillsbury	June 2 & 3
Vegetation of Wisconsin	James Reinartz	June 12 - 17
Sedges: Identification and Ecology	Anton Reznicek	June 16 & 17
Wildlife Inventory and Monitoring	Gary Casper	July 14 & 15
Aquatic Invertebrates	Gretchen Meyer and Robert Clare	July 28 & 29
Grasses: Identification and Ecology	Robert Freckmann	August 4 & 5
Aquatic Vascular Plants: Identification and Ecology	Tim Gerber	August 18 & 19
Invasive Plant Management Techniques	James Reinartz	September 30

Gretchen Meyer teaching about insects for the Field Methods in Conservation Class

Class and Group Use

Winter - Spring 2017

Number of Student Hours

Ecology and Physiology of Plants in Winter Workshop	320
Winter Ecology Hike and Friends Chili Dinner	420
Friends of Cedarburg Bog – Mammals of the Region	70
Friends of Cedarburg Bog – Owl-prowl hike	80
Friends of Cedarburg Bog – Woodcocks and Frogs	50
Friends of Cedarburg Bog – Frogs & amphibians	60
Friends of Cedarburg Bog – Bird walk	30
Friends of Cedarburg Bog – Spring Migrant Bird walk	50
Friends of Cedarburg Bog – The Bog in Spring	60
Friends of Cedarburg Bog – Ecology of the Bog – North	40
Friends of Cedarburg Bog – Glacial Geology of the Region	40
Friends of Cedarburg Bog – Meetings	120
Field Station Garlic Mustard Search/Pull	50
Wisconsin DNR Environmental Analysis and Review	110
Urban Ecology Center – Volunteer Outing Bog tour	70
Urban Ecology Center – Staff retreat and potluck	30
Great Lakes Earth institute – Bog Walk	40
Great Lakes Earth Institute – Meeting	10
Great Lakes Earth Institute – Discussion Group	10
Kettle Moraine Garden Club – Bog tour	50
Ozaukee Children's Tour Club – Bog tour	120
Natural Resources Foundation – Woodcocks & Frogs Hike	50
Natural Resources Foundation – Bird-a-thon	40
Marquette University High School – Owl-prowl hike	30
Shorewood High School – Watershed Wisdom Class	210
Wisconsin Phenology Society – Phenology program tour	40
UWM – BioSci 310 – General Ecology (Downer Woods)	1,500
UWM – Birds of Wisconsin	140
UWM - ROTC class orienteering and navigation	60
UWM – Geography 120 – Our Physical Environment	230
UWM – Geology	90
UWM – Geophysics – Neda Mine exploration	120
TOTAL	**4,340**

Summer 2017

Introduction to the Algae Workshop	320
Vegetation of Wisconsin Workshop	1,240
Sedges: Identification and Ecology Workshop	320
Wildlife Inventory and Monitoring Workshop	320
Aquatic Invertebrates Workshop	320
Grasses: Identification and Ecology Workshop	320
Aquatic Vascular Plants Workshop	320
Friends of Cedarburg Bog – Bog Guardians meetings	30
Friends of Cedarburg Bog – Celebrate the Bog event	480
Friends of Cedarburg Bog – Summer in the Bog	50

Summer 2017	Number of Student Hours
Friends of Cedarburg Bog – Dragonflies & Butterflies	60
Friends of Cedarburg Bog – Natural History of Wood Ducks	50
Friends of Cedarburg Bog – Ethnobotany	40
Friends of Cedarburg Bog – Foraging	60
Friends of Cedarburg Bog – meetings	80
Treasures of Oz – Bog tours	220
Urban Ecology Center – Bog tour for interns	30
American Indian High School – Science Scholars	110
UWM - Hoebel Lab picnic	20
UWM – Karron Lab research talks	30
TOTAL	**4,420**

Fall Winter 2017

Wetland Delineation Workshop	320
Invasive Plant Management Techniques Workshop	180
Friends of Cedarburg Bog / UWM BioSci – Annual Picnic	260
Friends of Cedarburg Bog – Ethnobotany	50
Friends of Cedarburg Bog – Forest Ecology walk	30
Friends of Cedarburg Bog – How do Trees Grow?	50
Friends of Cedarburg Bog – Owl Prowl	80
Friends of Cedarburg Bog – Introduction to the Ferns	40
Friends of Cedarburg Bog – Glacial Geology of the Region	40
Friends of Cedarburg Bog – meetings	110
Cedarburg High School – Honors Biology class	440
Shorewood High School – AP Science (Downer Woods)	120
St. John's Lutheran School, Newburg – Bog Tour	60
Riveredge Nature Center – Christmas Bird Count	60
Natural Resources Foundation meeting	20
Sierra Club executive committee meeting	80
WI Association for Environmental Education's (WAEE) tour	50
Saukville YMCA staff – Bog tour	40
Alverno College – Ecology Class	40
Carroll College – Ecology	60
Milwaukee School of Engineering (MSOE) – Hydrogeology	60
University of Illinois-Chicago– Ecology field trip	720
UWM – ROTC (Downer Woods)	40
UWM – BioSci/CES 451 – Field Methods in Conservation	1,300
UWM – BioSci 310 – General Ecology (Downer Woods)	1,500
UWM – Architecture Site Planning (Downer Woods)	460
UWM – Geography – Soils	70
UWM – Geography 120 – Our Physical Environment	130
UWM – Geography 475 – Geography of Soil (Downer Woods)	110
UWM – Geography 340 – Biogeography (Downer Woods)	110
UWM – Geology – Physical Hydrogeology	100
TOTAL	**6,730**

TOTAL 2017 Class & Group Use Hours 15,490

Meteorological Data for 2017

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.

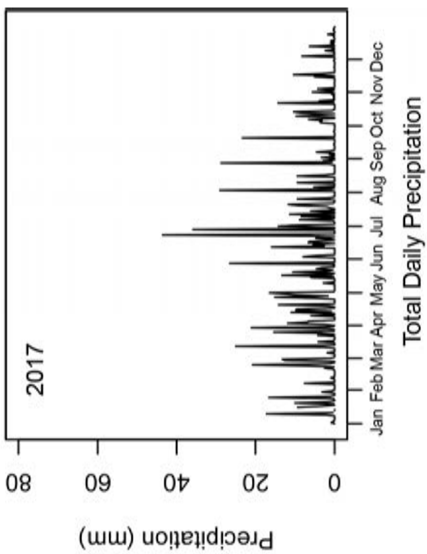
Maximum Speed (m/s): Highest mean wind speed during a 30-min period.

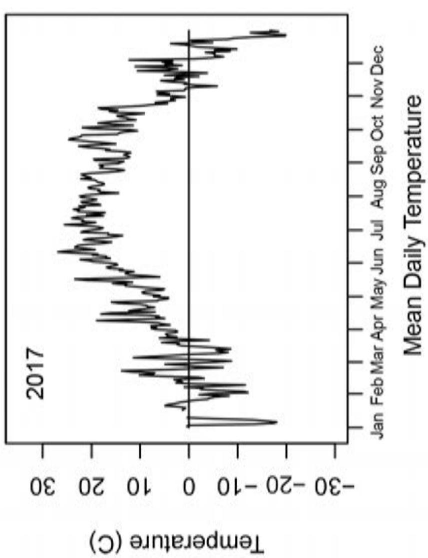
The Field Station can provide weather data in electronic format; datasets go back to 1989. Please contact us if you would like to receive the weather data.

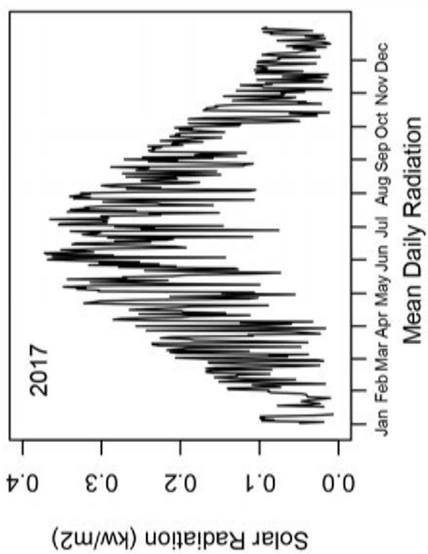
Meteorological Data for 2017

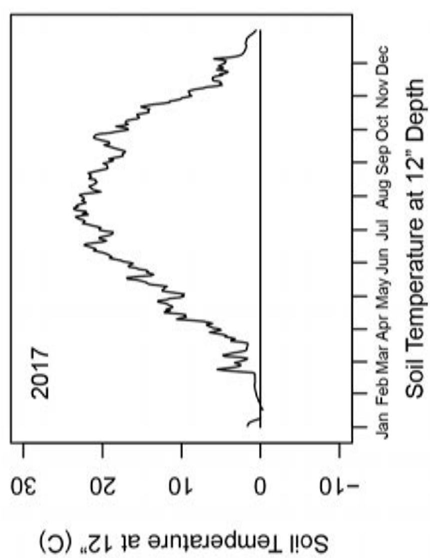
	JAN[1]	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	OCT	NOV	DEC
Temperature (C°)												
Average Daily Maximum	-1.0	4.8	4.5	14.8	17.3	25.2	26.2	23.8	23.6	16.9	6.8	-1.9
Average Daily Minimum	-6.8	-4.9	-3.9	3.9	6.4	13.6	15.1	13.4	10.8	7.5	-2.2	-9.5
Daily Average	-3.7	0.2	0.1	9.1	12.1	19.7	20.8	18.6	17.1	12.0	2.7	-5.6
Highest (Date)	8.0 (21)	21.3 (22)	17.8 (7)	25.5 (15)	29.6 (16)	32.3 (11)	31.0 (6)	28.2 (1)	34.0 (22)	26.3 (20)	18.5 (24)	16.7 (4)
Lowest (Date)	-20.2 (6)	-14.8 (9)	-13.6 (14)	-1.8 (1)	-2.6 (8)	5.3 (1)	9.9 (25)	6.9 (25)	4.1 (30)	-1.3 (26)	-11.6 (10)	-22.2 (27)
Degree Days												
Sum at 5°	0.0	25.6	10.8	124.9	219.4	440.3	490.8	421.9	363.8	228.3	16.8	7.7
Sum at 10°	0.0	5.6	1.4	40.0	92.6	290.3	335.8	266.9	213.8	110.1	1.6	2.2
Radiation (kW/m^2)												
Mean	0.05	0.11	0.14	0.19	0.24	0.28	0.28	0.21	0.20	0.10	0.07	0.05
Maximum	0.51	0.67	0.87	0.97	1.02	1.04	1.01	0.95	0.87	0.69	0.61	0.43
Relative Humidity (%)												
Hour 00-06 mean	86.6	78.7	80.8	79.3	83.6	83.4	91.1	90.9	90.9	82.1	76.0	78.6
Hour 06-12 mean	84.8	73.1	71.6	66.1	63.1	65.1	70.6	74.0	72.1	15.3	71.4	74.8
Hour 12-18 mean	78.8	62.6	64.1	58.4	54.6	53.4	61.0	61.7	59.7	64.5	62.1	66.8
Hour 18-24 mean	83.7	73.2	78.1	73.8	73.6	72.3	83.6	86.4	86.4	78.0	73.6	75.1
Number of Days												
Precip. 0.25mm or more	14	8	12	16	12	12	14	10	5	13	6	9
Max Temp 32° and above	0	0	0	0	0	1	0	0	2	0	0	0
Max Temp 0° and below	10	8	9	0	0	0	0	0	0	0	2	21
Min Temp 0° and below	18	22	22	2	3	0	0	0	0	4	22	29
Min Temp -18° and below	4	0	0	0	0	0	0	0	0	0	0	6
Pressure (mbars)												
Mean	1011.14	1012.35	1020.06	1014.18	1011.48	1012.12	1016.46	1016.72	1017.88	1014.57	1017.21	1016.94
Precipitation (mm)												
Total	68.1	53.9	94.2	126.1	86.8	141.3	95.4	90.2	34.2	70.7	29.3	22.4
Greatest (24 hrs) (Date)	17.3 (10)	20.8 (24)	25.0 (13)	15.1 (27)	26.5 (28)	43.6 (23)	14.2 (1)	29.0 (3)	23.3 (20)	14.4 (22)	10.5 (17)	8.3 (4)
Wind												
Mean Speed (m/s)	1.8	1.9	1.9	1.9	1.6	1.5	1.1	1.1	1.1	1.6	1.7	1.8
Maximum Speed (m/s)	6.0	6.4	6.8	5.4	4.9	4.8	4.8	4.0	4.5	5.3	5.5	5.5

[1]Most data for Jan 1 and Jan 11-16 are missing. Precipitation data are missing only for Jan 12 and 15.


2017
Total Daily Precipitation
Precipitation (mm)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec


2017
Mean Daily Temperature
Temperature (C)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec


2017
Mean Daily Radiation
Solar Radiation (kw/m2)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec


2017
Soil Temperature at 12" Depth
Soil Temperature at 12" (C)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

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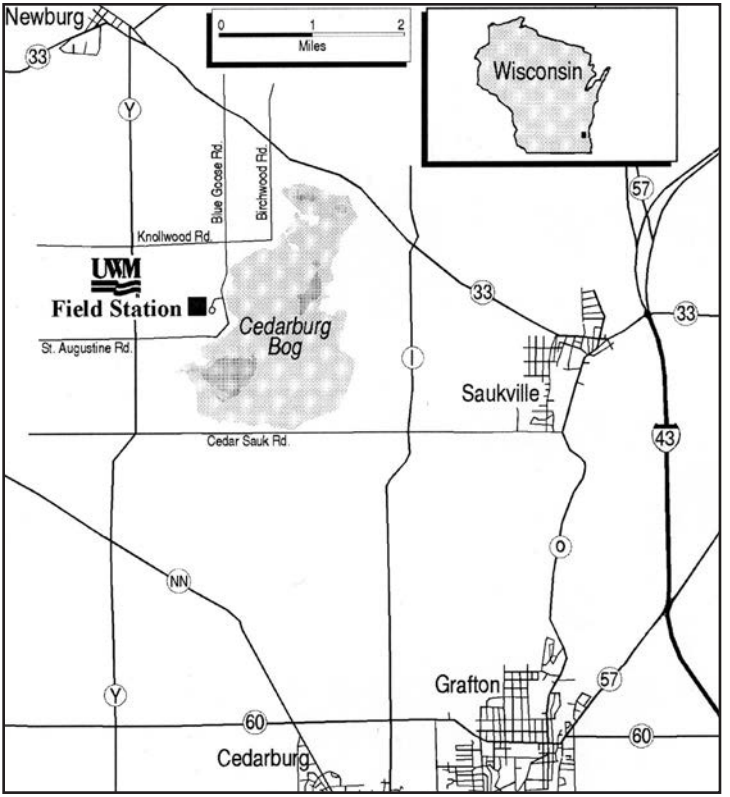

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