2021 Field Station Annual Report

UNIVERSITY of WISCONSIN
UWMILWAUKEE
Field Station

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On the Cover: Phil Hahn and his research group are studying how plants interact with their herbivores and pollinators, including sites at the Field Station and nearby prairies and sites in Montana (see abstracts by Cammarano et al., Calixto et al., and Hahn et al.). They documented the federally-endangered rusty-patched bumble bee (*Bombus affinis*) at the Field Station for the first time in 2021. Main photo: Joseph Cammarano working on a seed addition experiment. Photo by E. Calixto. Inset: a rusty-patched bumble bee. Photo by J. Cammarano.

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

2021 Highlights

• We are grateful to Ronald Horn for leaving a bequest to the Field Station in his will. This bequest will be used to set up the Ronald Horn Field Station Fund, an endowed fund that will provide long-term support to the Field Station. Ron Horn was a friend, neighbor and volunteer at the Field Station for many years, and he also participated in Field Station classes and events. We will miss him. See photo on page 35.

• The endangered rusty-patched bumble bee (*Bombus affinis*) was discovered at the Field Station for the first time. Joseph Cammarano, a graduate student working with Dr. Phil Hahn, found and photographed the bee while conducting surveys for pollinators. See the cover photo, and abstracts by Cammarano et al., Calixto et al., and Hahn et al.

• A rare salamander, the four-toed salamander (*Hemidactylium scutatum*), was discovered for the first time at the Field Station. Morgan Schmanski (UWM undergraduate) and Joseph Cannizzaro (UWM MS student) found the salamander while participating in a field exercise for the Field Methods in Conservation class (BioSci/CES 451). In addition to being a new record for the Field Station, it was also a new record for Ozaukee County. The four-toed salamander is listed as a Special Concern species for Wisconsin and this find extended its known occurrence in the state. An article documenting the new county record will appear in the journal Herpetological Review in 2022. A news story can be found here: https://uwm.edu/news/uwm-students-make-a-rare-find-while-on-a-class-hike/

• Dr. Erica Young was awarded a National Science Foundation grant to continue her work with pitcher plants. The collaborative research will examine *Sarracenia pupurea* pitcher plant microbiome composition and functions in populations across North America and Europe, and use experimental manipulations at the Cedarburg Bog to investigate host-microbe interactions to help determine 'rules' defining microbiome succession.

• The James and Dorathea Levenson Endowment for Ecology and Field Biology awarded three fellowships in 2021, to Olivia Feagles, Kane Stratman, and Wendy Semski. The endowment was established in 2018 to provide fellowships to UWM graduate students who are conducting research at the Field Station and/or in the Cedarburg Bog. Dr. James B. Levenson conducted research at the Field Station while working towards his PhD in Botany at UWM (awarded in 1976).

• The Friends of the Cedarburg Bog Field Biology Scholarship was awarded to three students in 2021: Katherine Kolpin, Allyn Lottouzee and Jacob Stanley Yarbrough. The scholarship was established in 2020 to assist UWM undergraduates taking summer natural history workshops at the Field Station.

• The Farm House kitchen and bathrooms were remodelled in 2021. New flooring, moldings and shower stalls were installed and the walls were painted.

• The Conservation Club at UWM sponsored a clean-up of Downer Woods.

• 30 research projects in 2021.

• Field Station use by classes and groups in 2021 was still depressed below normal levels because of the COVID-19 pandemic. Class and group use was 3823 person-hours; including 3182 hours of in-person use and 673 hours of synchronous online use.

The COVID-19 Pandemic

The Field Station continued to be impacted by the COVID-19 pandemic in 2021. We restricted use of the buildings during the winter and spring, and gradually began to open up over the summer and fall. We developed fully-online natural history classes for the first time in 2021. These proved to be popular with our students and we will continue to offer fully-online classes in the future. We also

developed a hybrid format that incorporated both an online and a face-to-face component for our summer workshops, so that students could visit and explore the natural areas here at the Field Station. We offered 3 fully-online and 3 hybrid workshops in 2021, and all filled to capacity. We cautiously began to offer public events again in late spring and continued through the summer and fall. We restricted public events to activities that could be held completely outside. The Fall semester Field Methods in Conservation class (Biological Sciences/ Conservation and Environmental Science 451) was offered face-to-face in 2021, but we held the lectures in the Research Lab rather than the classroom because it is larger and offers better ventilation. As conditions related to the pandemic continue to improve, we look forward to returning to our normal levels of research, teaching, and public outreach.

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, 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 433 scientific publications and 154 theses since 1970.

The Field Station is also heavily used for teaching. Our Natural History Workshop program offers both online and in-person classes on various topics in field biology and environmental science. In-person classes are typically offered over 1-5 days with students having the option of staying over at the Field Station; most are 2 day, Friday-Saturday classes. These workshops are open to non-credit students. They are popular with members of the general public and they provide continuing education opportunities for professionals. Many of our workshops are also open to UWM students for college credit, allowing UWM students to gain field experience and to interact with the non-credit students in the class. We also offer the semester class, Biological Sciences/

Students in the Herpetology workshop met under a tent. Use of the tent for the in-person session of hybrid workshops reduced the risk of COVID-19 transmission. Photo by G. Meyer.

Conservation and Environmental Science 451, Field Methods in Conservation, for UWM students. This class gives students an opportunity for hands-on learning in the natural areas available at the Field Station. Many classes from other universities and schools use our facilities and properties for field trips.

The Field Station has active outreach programs that invite the general public to visit our properties for hikes and other events. These programs are primarily sponsored by our Friends group, the Friends of the Cedarburg Bog.

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 has been designated a National Natural Landmark by the Department of Interior, a Wetland Gem by the Wisconsin Wetlands Association, and an Important Bird Area by the Wisconsin Bird Conservation Initiative. A "Guide to the Natural History of the Cedarburg Bog" serves as an introduction and reference source for researchers and educators using the Bog and is available online (https://dc.uwm.edu/cgi/viewcontent.cgi?article=1110&context=fieldstation_bulletins). 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 had killed essentially all 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. The emerald ash borer beetle was first detected in the woods in 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 is included in the National Natural Landmark designation for the Cedarburg Bog and is also included in the Important Bird Area.

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 is maintained. Six separate areas in the old fields have been planted with prairie species native to Wisconsin. A controlled burn of the prairie and old-field area was conducted in April 2021. These areas had previously been burned in 2016.

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

Controlled burn of the old field area at the UWM Field Station in April 2021. Photo by C. Boettcher.

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. 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 our efforts to control invasives.

Only glossy buckthorn in the Cedarburg Bog and Oriental bittersweet (particularly 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 on buckthorn control work in 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) used the hibernaculum. 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 the population of bats in the mine has declined. A vaccine against WNS has been developed and field trials were conducted at Neda Mine in 2021 (see abstract by Rocke

The Neda Mine caving crew prepares to the enter the mine to collect temperature data from dataloggers in the mine. Photo by G. Meyer.

et al.). 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 in April 2016. The Prairie Enthusiasts assumed management of the prairie in 2020, under a management agreement with UWM. They conducted two burns at the prairie in 2021: one in March and one in December. They have also made substantial progress at cutting brush at the prairie. Work days at the prairie under the direction of the Prairie Enthusiasts are continuing.

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. Field Station management of the woods includes control of invasive plants, trail clearing and maintenance, and managing use of the woods. 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 invasive plant control work in Downer Woods has entered a new maintenance phase requiring substantially less annual effort. The trails in Downer Woods receive heavy use and they can become muddy and slippery when wet. The entire trail system in the woods was regravelled in 2020, to eliminate the wet, muddy areas that had been developing following rain fall or snow melt. Planting of tree seedlings continued in 2021, with 100 shagbark hickories planted. Over 600 tree seedlings of various species have been planted in the woods since 2006.

Field Station Programs

• 30 active research projects conducted at the Field Station in 2021.

• Including: 5 UWM Ph.D. projects, 3 studies that included UWM undergraduates, and 7 studies by researchers from outside of the University.

• 8 papers published during 2021. 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.

• Lists of vertebrates, including birds, mammals, and reptiles and amphibians.

• 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.

• 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.

• 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.

• Phenocams for monitoring phenological changes in vegetation. Cameras are mounted both at the Field Station property in Saukville and in Downer Woods on the UWM campus.

• Long-term weather records from a stan-

dard 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.

• Drs. Peter Dunn and Linda Whittingham have conducted long-term studies on tree swallows and other bird species.

• 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 Höbel, 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.

• Monitoring of bat activity levels at the Neda Mine Bat Hibernaculum from 2000-2019 and of temperatures in the mine since 1997.

• Records of long-term (30 year) research projects conducted by Dr. Charles Weise, on Black-capped Chickadees and Dark-eyed Juncos.

• GIS developed for the Field Station area.

Educational Programs

• 3823 person-hours of instruction and group use in 2021 including both in-person and synchronous online classes and events

• Six natural history workshops – 3 fully online and 3 hybrid.

• Field Methods in Conservation, a UWM course taught entirely at the Field Station, has been offered in the Fall semester since 2017. The course was offered face-to-face in 2021.

• 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.

• 3 undergraduate student projects.

• 13 Friends of the Cedarburg Bog in-person programs for the general public on a variety of topics.

Lee Olsen led an Ethnobotany walk for FOCB. Participants were eager to learn how the plants found in the Cedarburg Bog were used by Native Americans for food and medicine. Photo by L. Weiss.

• The Field Station Bulletin, covering various topics related to natural history in southeastern Wisconsin, is available online (https://dc.uwm.edu/fieldstation_bulletins/)

• Educational videos produced by the Friends of the Cedarburg Bog and available for viewing on YouTube (Youtube.com, Friends of the Cedarburg Bog).

The Friends of the Cedarburg Bog – 2021

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.

FOCB continued their work in 2021. Highlights for the year include:

• The Friends of the Cedarburg Bog Field Biology Scholarship was awarded to three students in 2021: Katherine Kolpin, Allyn Lottouzee and Jacob Stanley Yarbrough. The scholarship was established in 2020 to assist UWM undergraduates taking summer natural history workshops at the Field Station. It was awarded for the first time in 2021, as all workshops were cancelled in 2020 because of the pandemic.

• The Friends joined the Ozaukee-Washington County Bird Coalition. The coalition is an umbrella organization that includes Lac Lawrann Conservancy, Riveredge Nature Center and Mequon Nature Preserve in addition to FOCB. Its mission is to educate about birds and promote bird conservation by holding regular events.

• The Friends sponsored a project to conduct acoustic monitoring for breeding birds in the Cedarburg Bog. See abstract by Casper.

• The Friends supported a project to install nesting platforms for black terns in Mud Lake. Braden Meyer built and installed the nesting platforms as part of a project to attain the rank of Eagle Scout. John O'Donnell of FOCB provided advice and other assistance. See abstract by O'Donnell and Meyer.

• The Friends continued their strong educational programming for the general public with 13 in-person educational events and programs in 2021.

• The Friends held 4 stewardship work days in 2021.

• The Friends continued to produce their quarterly newsletter, The BogHaunter. Past issues of The BogHaunter can be found on the FOCB website (https://bogfriends.org/boghaunter/).

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

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, https://bogfriends.org/

Volunteers participating in a FOCB workday to control invasive plants along the trail to Mud Lake.

The Friends of the Cedarburg Bog arranged a volunteer work day in December to pull oriental bittersweet in the Cedarburg Beech Woods.

Abstracts of Research

Untangling the Environmental and Genetic Drivers of Phenological Timing in Red Oak (*Quercus rubra*) to Improve Predictions

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The phenological emergence of leaves from buds of temperate eastern North American trees has advanced 5 to 10 days over the past 50 years. This early onset of spring creates a feedback with the climate system, making our ability to predict phenological timing a key component of predicting climate change. To date, scientists have detailed the environmental drivers and the genetic controls of leaf-out variation in plants, finding both significant plasticity and heritability. However, researchers have yet to unite this knowledge into a unified model of phenology, despite our knowledge that an individual's phenotype is the sum of its environmental and genetic components. This project leverages a wide-spread system of phenological cameras (phenocams) in a novel way to quantify the genetic and environmental drivers of leaf out variation in the dominant species red oak (*Quercus rubra*). We are whole-genome sequencing red oak individuals in phenocam "viewsheds", including at the UWM Field Station. These sequences will be used to derive population structure and develop a set of candidate loci associated with phenological timing using a GWAS analysis, with long-term goals of integrating population-level information into process-based models of species ranges. So far, we have collected tissue from all phenocam sites with red oak and extracted their DNA. Samples are now awaiting sequencing at a local facility. Funded by the National Science Foundation

Newly emerged oak leaves and catkins. Photo by G. Meyer

Environmental Conditions and Conspecific Density Influence Herbivore Pressure and Plant Fitness

Eduardo S. Calixto[1], Joseph Cammarano[1], Sarah Kroening[1], John Maron[2] and Philip G. Hahn[1]
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Insect herbivores can be highly damaging to plants, but the extent to which damage translates into reductions of plant fitness is highly context dependent. At large spatial scales, climate or resource availability (rain, temperature) may be important predictors of herbivore pressure (i.e., how strongly herbivores impact plant fitness). At local scales, conspecific density can be an important predictor of herbivore pressure. Using wild bergamot, *Monarda fistulosa,* as a focal plant species, we sampled populations from low- and high-resource regions, such as Montana and Wisconsin respectively. In Montana, samples were done in populations located in intermountain grasslands, and in Wisconsin, samples were done in populations located in tallgrass prairies, such as the University of Wisconsin-Milwaukee Field Station (UWMFS) and Benedict Prairie. Within each population, we estimated density of conspecifics, herbivore damage by estimating seed loss to pre-dispersal seed predators, and seed production. At large scales, we found that both seed loss and seed weight were approximately 2-fold greater in the high-resource region compared to the low-resource region. At local scales, as the density of conspecific increases the seed loss also increases, suggesting a role of negative density dependence. A supplementary seed addition experiment in both regions, including UWMFS and Benedict, showed that seed limitation was also greater in the high resource region, suggesting that pre-dispersal

Bumblebee, *Bombus auricomus*, visiting flowers of the wild bergamot (*Monarda fistulosa*). Photo by Eduardo Calixto.

seed predation might limit population size in the high resource populations. Our study suggests a predictable influence of environmental context (large scale) and conspecific density (local scale) on herbivore pressure with greater negative impacts in high-resource regions. These results improve understanding of context-dependent herbivory and the negative conspecific density dependence process. Funded by the National Science Foundation.

Seed predator in wild bergamot (*Monarda fistulosa*). Photo by Eduardo Calixto.

Influences of Trait Similarity of Neighbors on Pollinator Visitations of a Native Plant Species

Joseph Cammarano, Eduardo S. Calixto, Sarah Kroening and Philip G. Hahn
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Neighborhood effects in plant-insect ecology describe the ways neighboring flower species may indirectly influence the pollination or herbivory of a nearby focal flowering plant. Neighboring species can help increase pollination for a focal species or may compete for pollinators, yet these effects can be highly variable in ways that are currently difficult to predict. Our study used *Monarda fistulosa*, or common beebalm, a perennial herb common in temperate grasslands of North America pollinated primarily by long-tongued bees, as our focal plant species. We observed patterns of visits to *M. fistulosa* with regards to the surrounding flower species of the plant communities surrounding *M. fistulosa* plants at multiple prairie sites in southeastern Wisconsin, including the restored meadow at the University of Wisconsin-Milwaukee Field Station and Benedict Prairie. We found that the diversity of neighboring flowering species increased the visitation of flowers of *M. fistulosa* by bumblebees, and neighbors with similarly colored flowers showed this effect to a greater extent. Our results imply that trait similarity is likely a key factor in neighborhood effects in plant-pollinator interactions, and that diverse neighborhoods of flowers may be beneficial to individual species in terms of pollinator visitation. Funded by the National Science Foundation.

Bioacoustic Monitoring

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Bioacoustic monitoring for frogs and toads continued throughout the western Great Lakes region in national parks and private preserves, with work in 2021 continuing to refine survey protocols and data analysis procedures. Funding was provided by the National Park Service, Kohler Foundation, Milwaukee Audubon Society, Friends of Wehr Nature Center, Glacial Lakes Conservancy, Friends of the Cedarburg Bog, Oneida Nation of Wisconsin, Crossroads at Big Creek, and several private property owners.

National Park Service Great Lakes Network Amphibian Monitoring Program

Gary S. Casper
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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 acoustic recording systems is now fully implemented in seven national parks. In 2021 annual data collection continued and we analyzed and reported on 2019 and 2020 data. Funded by the National Park Service.

Sound Production in Turtles

Gary S. Casper and Gregory A. Geller
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We continued investigating sound production in embryonic turtles in Wisconsin, building on 2019 discoveries that both northern map turtle and snapping turtle embryos emit sounds while in the egg, with sound production increasing just prior to hatching. In 2021 we collected and analyzed data from nests of three turtle species; results are pending.

Field Guide to Amphibian Eggs and Larvae

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In 2019 we produced a field guide to the eggs and larvae of the amphibians of the western Great Lakes region for the National Park Service. In 2021 a revised edition went on sale to the general public, supported by Midwest Partners in Amphibian and Reptile Conservation, Wisconsin Wetlands Association, and Deborah S. Kern. The guide provides new identification keys, and species accounts with full color photographs of all life stages, for 23 species including all Michigan and Wisconsin species.

Wildlife Monitoring in Southeastern Wisconsin

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Wildlife monitoring in southeastern Wisconsin, dating back to the 1980s, continued in 2021 at a somewhat reduced rate due to the COVID-19 pandemic. Monitoring was completed for several private landowners, Milwaukee Audubon Society, Glacial Lakes Conservancy, Big Cedar Lake Property Owners Association, Friends of the Cedarburg Bog, and Wehr Nature Center. Monitoring data assists with natural resource inventories, informs habitat management, and expands our regional understanding of wildlife distribution and conservation status. Projects included sampling for birds, mammals, herptiles, and invertebrates; as well as collecting and vetting historical and third party data. These studies are funded by a variety of grants and private donations.

Bioacoustic bat monitoring device deployed at Afterglow Farm, Ozaukee County. Photo by Gary Casper.

Bioacoustic Monitoring at the Cedarburg Bog

Gary S. Casper
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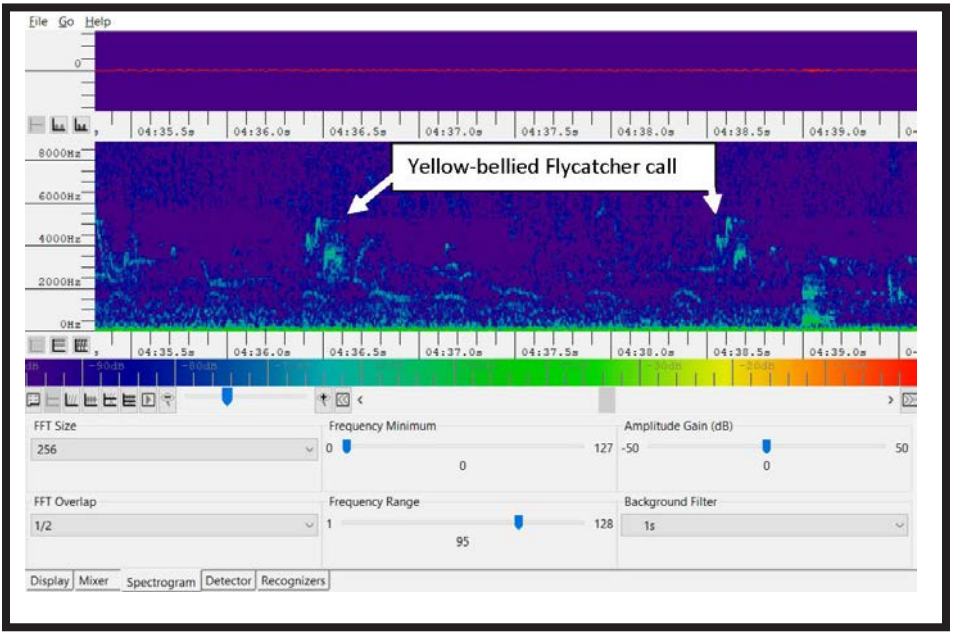
In 2021 we began bioacoustic monitoring focused on the breeding bird community in the southeastern part of the Cedarburg Bog, where ruffed grouse formerly occurred. This technology holds promise for improved confidence in monitoring statistics, and for monitoring of hard to reach areas. Two automated recorders collected 25 5-minute and 4 10-minute digital acoustic samples daily, from March 15 through August 11. Data analyses are underway. An initial analysis of 15 early morning June samples for breeding birds yielded checklists of 35 and 37 species, including alder flycatcher, black-and-white warbler, black-billed cuckoo, chimney swift, Cooper's hawk, eastern screech owl, Nashville warbler, northern bobwhite, northern waterthrush, ovenbird, purple martin, red-breasted nuthatch, sora, veery, wood thrush, and yellow-bellied flycatcher. Additional analyses of avian data are underway, and the acoustic archive can be analyzed for other sounds in the future, such as frogs or insects. Funding was provided by the Friends of the Cedarburg Bog. Nathaniel Reinartz and Tim Hahn assisted with data analyses.



Yellow-bellied Flycatcher spectrogram from Cedarburg Bog.

Metabolic Fingerprints of Pitcher Plant Microbiomes Show Dynamic Community Succession

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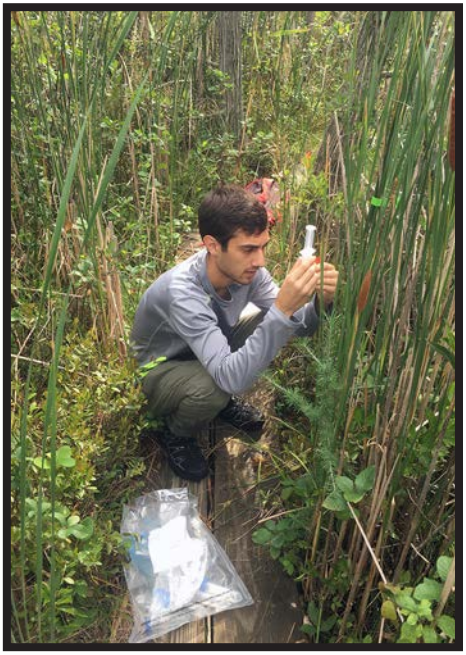
Pitcher plants in the Cedarburg Bog supplement their mineral nutrient acquisition through the adaptation of carnivory. *Sarracenia purpurea* uses pitcher-shaped leaves to trap insect prey which are then digested and release nutrients for plant uptake. To achieve prey digestion, pitchers are colonized by a diverse food web and community of invertebrates and microbes which produce hydrolytic enzymes for insect prey breakdown. As new pitchers open, and insects are captured, the community increases enzyme activity, but little is known about broader metabolic functional capacities of the microbial community during succession. This study tested Biolog Ecoplates and applied these metabolic fingerprinting assays to examine changes in functional capacities of pitcher communities over time, and variability between pitchers. Six replicate Cedarburg Bog pitcher microbial communities were sampled on days 0, 3, 6, 13 and 27 after opening and samples assayed for community capacity to use 31 diverse carbon substrates, alongside lipase and chitinase activity using fluorometric enzyme assays. From day 0 to 6 there were rapid, early changes in capacity to use EcoPlate substrates but different pitcher communities gained capacities for diverse substrates at different rates, suggesting colonization by bacteria with different metabolic functions at different rates. By day 13, community metabolic capacity had converged functionally, with more similar metabolic fingerprints, and all pitcher communities could metabolize the 5 substrates selected for more detailed comparisons. Hydrolytic enzyme activities showed similar early trajectories with maximum chitinase activity at day 13 although lipase activity increased to day 27. Some differences between replicate pitchers may relate to stochastic prey capture and colonization by invertebrate food web organisms, including mosquito larvae. This study shows that dynamic early successional changes in the plant microbiome result in diverse functional capacities between communities, but pitcher community differences decline over time with bacterial recruitment and prey capture. Undergraduate research project (David Deshpande and Joan Kaiser), Erica Young, faculty advisor.



David Deshpande working with pitcher plants along the boardwalk. Photo by Erica Young.

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 2021 we completed the 25th 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 Ron Tagye and Gretchen Meyer for their assistance, particularly in collecting data.

North American Insect Abundance Survey

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A growing number of studies have found declines of insects and, as a consequence, there is concern among ecologists that this might have cascading effects throughout the food web. Most of these studies of insects have been in Europe; we have little evidence of widespread insect declines in North America, although there are some studies showing declines among butterflies, bees, and mayflies. To address the lack of data, we have organized researchers at over 30 sites, including the UWM Field Station, to monitor insect abundance using Malaise traps. The sites stretch from New Brunswick to Alaska and south to North Carolina. This study aims to standardize collection methods so we can directly compare abundance of insects in different areas and over time. Preliminary analyses of data from three years (2019-21) suggest that, early in the spring, sites in the eastern US and Canada have greater total biomass of insects than sites in the Central and Western parts of the continent. However, this pattern reverses later in the season (mid-June). These results will be published in 2022 and will provide a baseline for future studies of changes in insect abundance. We thank Ron Tagye and Gretchen Meyer for their assistance throughout the project, particularly in collecting data.

Mate Preferences and Choosiness Vary Independently in Eastern Gray Treefrogs (*Hyla versicolor*)

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Mate choice is an important cause of natural and sexual selection, driving the evolution of ornaments and promoting diversification and speciation. Mate choice decisions arise from the interaction of several components, and knowledge of whether they interact, and how, is crucial for understanding their contributions to selection. Here we focus on the relationship between preference functions (attractiveness ranking of prospective mates) and choosiness (effort invested in obtaining the preferred mate) and test the hypothesis that they are independent components of mate choice decisions. We examine individual variation in preference functions and choosiness for call duration in female *Hyla versicolor* treefrogs; and show that measures describing preference functions and choosiness are not correlated. We further show that both components are influenced by different factors: while variation in preferences was associated with variation in body measures (size, condition), variation in choosiness was associated with variation in hormonal state (testosterone, corticosterone). Independence of preference and choosiness suggests that the joint study of variation in both components is required to gain a complete understanding of how mate choice contributes to sexual selection and speciation. Funded by a Field Research Grant in Herpetology (Society for the Study of Amphibians and Reptiles), a Student Research Grant (Animal Behavior Society) and a Joseph G. Baier Memorial Scholarship (University of Wisconsin Milwaukee). PhD. dissertation research, Dr. Gerlinde Höbel, Major Advisor.

Eastern gray treefrogs (*Hyla versicolor*) in amplexus, their mating position. The male (on top) grasps the female (on bottom) for a few hours prior to oviposition. The Anuran Lab at UWM collects frogs in amplexus for experimental studies because then we know the female is receptive to males and will cooperate in mate choice trials. Photo by Olivia Feagles.

Choosiness and Preferences Covary with Behavioral Phenotypes Unrelated to Mate Choice in Gray Treefrogs

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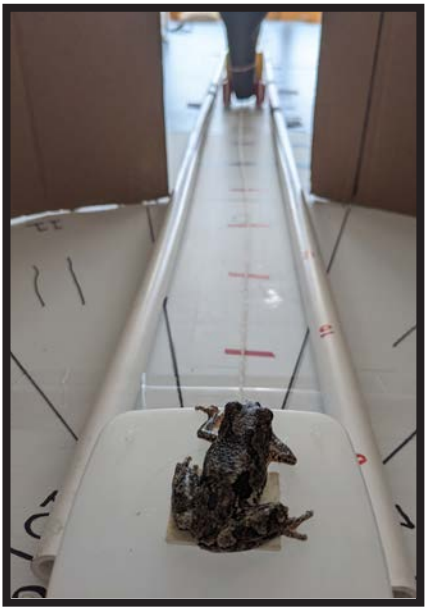
Female mate choice is a remarkably dynamic cause of sexual selection and varies immensely between individuals. There are many external and internal factors responsible for variation in mating decisions, and here we focus on personality as a potential contributor. Animal personality is defined as behavioral consistency within an individual across contexts and over time. The goal of this project is to compare personality traits observed in survival contexts to female mate preferences (attractiveness ranking of prospective mates) and choosiness (effort invested in obtaining the preferred mate). We test the hypothesis that personality traits revealed in natural selection contexts are echoed in behaviors involved in sexual selection in female *Hyla versicolor* treefrogs. This predicts that bolder individuals are choosier and more selective. To test survival behaviors (representative of personality), each frog was placed into three different experiments to gather the following measures: (1) anti-predator responses, (2) time spent actively foraging, and (3) duration and location of movements in a novel environment. We scored their behavior along a bold-shy axis, with 'bolder' individuals showing decreased predator response, more active foraging, more exploratory movements, and more time spent in exposed locations. When comparing these survival traits to mate choice behaviors, we found that females that were bolder in the exploration and predator response contexts were choosier, and that females that were shy in the predator response context showed more selective preferences. We also found that what females deem most attractive (peak preference) is not related to any survival-based personality trait. These results support the possibility that personality is reflected in female mate choice, and will be expanded upon in field season 2022. Funded by Joseph G. Baier Memorial Scholarship and a Louise Neitge Mather Scholarship, both from the University of Wisconsin Milwaukee. PhD. dissertation research, Dr. Gerlinde Höbel, Major Advisor.



An eastern gray treefrog (*Hyla versicolor*) participating in one of the personality experiments from 2021. Pictured here is the predator escape experiment which assesses boldness – the bolder the frog, the less escape behaviors they should show. Photo by Olivia Feagles.

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.

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. PhD. dissertation research, Dr. Alison Donnelly and Dr. Mark Schwartz, Major Advisors.

Microbial Communities Hosted by Carnivorous Pitcher Plants: Diversity, Recruitment, Functions and Succession in *Sarracenia purpurea* Microbiomes

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The pitcher plant *Sarracenia purpurea* supplements nutrient acquisition through carnivory, capturing insect prey which are digested by a food web community of eukaryotes and bacteria. Analysis of both bacterial and eukaryotic diversity, and an understanding of bacterial recruitment into pitchers and succession of bacterial and

eukaryotic communities over time have not been well explored. This thesis presents three studies designed to address these gaps using field sampling and manipulative greenhouse experiments. *Study I* compared bacterial and eukaryotic composition and diversity of pitcher communities within and between populations of plants in two distinct wetland habitats. Genetic sequence analysis revealed an underappreciated eukaryotic diversity of ciliates, mites, and fungi. Significant differences in bacterial composition were observed between the two populations which experience differences in habitat and eukaryotic visitation. *Study II* examined sources of bacteria for recruitment, how the host plant affects microbial community development, and contrasts between established and assembling communities. An important source of bacterial input was air, contributing many dominant taxa. Distinct communities in artificial pitchers confirmed an important influence of host plant tissue on community development, possibly mediated via nutrients. Established communities with higher initial diversity showed more stability over time. Community functions were examined as hydrolytic enzyme activities showed that insect prey additions result in rapid nutrient transformation. *Study III* examined succession of the eukaryotic and bacterial community in field pitchers from opening until senescence. Bacterial diversity in <40 mL pitchers was shown to rival that of larger aquatic communities (such as Lake Michigan). In field succession pitchers, eukaryotic composition was often dominated by a few eukaryotic taxa which had greater variation among replicate pitchers than bacterial composition which showed greater richness over time. Succession showed clear early and late stages for microbial composition and functions. Within 14-28 days early succession showed high compositional and functional changes and after day 28, communities were more stable. These studies broadly suggest that early stochastic bacterial recruitment, prey capture and colonization by eukaryotes drives microbial food web composition over the 1-2 year lifespan of a pitcher. PhD. dissertation research, Dr. Erica Young, Major Advisor.

Jacob Grothjan pointing out pitcher plants blooming in the Cedarburg Bog.

Effects of Plant Phytochemical Diversity on Insect Damage

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Plants have evolved a diverse array of defenses to protect against insect damage. However, even within a single plant species there can be tremendous variability in phytochemical traits (i.e., chemical toxins) among individuals. While there is evidence that phytochemical diversity can reduce insect damage, the extent to which increased phytochemical diversity protects plant fitness remains unclear. We grew wild bergamot, *Monarda fistulosa*, plants in a common garden at the University of Wisconsin-Milwaukee Field Station (UWMFS) and measured plant phytochemical diversity, insect damage, and seed production. Insect damage by lepidopteran larvae that consume the developing seeds were found to reduce seed production of *M. fistulosa* by approximately 58%. Additionally, we identified and measured the concentrations of 25 monoterpenes and two sesquiterpenes across the 131 plants measured. Total terpene concentration, phytochemical richness (i.e., the number of compounds identified in a sample), and phytochemical composition all reduced damage by insect seed predators. The abundance of one specific compound, thymol, was particularly effective at reducing damage. Thus, our data reveal a clear link between not only phytochemical abundance, but also diversity, in providing a protective role in defending against insect damage and enhancing plant fitness. Funded by the National Science Foundation.

Phil Hahn in the research garden at the UWM Field Station. Photo by Eduardo Calixto.

White-nose Syndrome Dynamics in Neda Mine

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Infectious diseases are a key threat to ecosystem health. The introduction of white-nose syndrome, a fungal disease of bats, has caused the collapse of temperate bat populations in North America. The disease is caused by the pathogen *Pseudogymnoascus destructans* which first invaded Wisconsin in the winter of 2013/14 and rapidly spread throughout the state. Despite initial predictions that several once abundant species would be driven to extinction, multiple populations of bats now persist with WNS, including one at Neda Mine. Our research seeks to understand the mechanisms underlying population persistence by exploring differences in bat behavior, mine environmental conditions, and host physiological responses to assess their respective roles in bat survival with WNS. Through research at Neda, we have found that sex plays an important role in bat survival with disease, with males suffering from less severe infections than female bats. Differences in infections between sexes may be due to differences in bat torpor patterns during the fall. RFID systems installed at the mine entrances show that male bats are more active throughout the fall season than females, who may be lowering their body temperatures (e.g. using torpor) which permits the fungus to grow. Our research has also revealed that bats surviving with disease have fungal loads that increase at slower rates over winter, suggesting bat resistance may play a key role in surviving white-nose syndrome. Collectively, our work will aid in determining the most effective management strategies for bat populations affected by white-nose syndrome. Funded by the U.S. Fish and Wildlife Service and the National Science Foundation.

Joseph Hoyt, Kate Landwig and their crew entering Neda Mine. Photo by G. Meyer.

Strong Support for Bateman's Principle in a Hermaphroditic Plant

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Variation in male reproductive success (RS) is fundamental to models of reproductive trait evolution, yet rarely quantified in hermaphroditic flowering plants. Bateman (1948) hypothesized that variation in male RS will often exceed variation in female RS, since it is usually limited by mating opportunities, rather than by resources. Although Bateman's principles have largely been studied in dioecious animals, Bateman suggested that they could be extended to hermaphroditic plants. However, this idea has been challenged by other researchers who note that hermaphroditism imposes a constraint on the evolution of sexually-selected traits. Here we quantify male and female RS and mate diversity in a hermaphroditic plant to test Bateman's predictions: 1) Higher variance in RS for male function than female function. 2) Higher variance in mate number for male function than female function. 3) Male RS is strongly dependent on mate number, whereas female RS is only weakly influenced by mate number. We established replicate experimental populations of monkeyflower and utilized genetic markers and paternity assignment to quantify male and female function and male and female mate number. We found strong support for Bateman's principles. Both the opportunity for sexual selection, and the intensity of sexual selection were greater through male function. Funded by the National Science Foundation.

Bumble bee visiting monkeyflower blossom.
Photo by Jeff Karron.

Wood Duck/Hooded Merganser Nest Box and Owl Nest Box/ Roost Box Project

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Beginning in 2012 and continuing through 2021, 23 duck boxes for nesting use by wood ducks and hooded mergansers have been installed in and around the Cedarburg Bog by the Friends of the Cedarburg Bog (FOCB). Four small owl nest/roost boxes and two large nest/roost boxes for barred owls have also been put up by the FOCB; and, in conjunction with the FOCB project, nine duck nest boxes have been installed by landowners on their own properties in or near the Bog. However, five of these boxes placed on what are now dead ash trees are currently decommissioned due to the toppling of the trees, killed by the emerald ash borer. Another eight boxes unfortunately await the same fate. The plan in 2022 is to remove as many of these boxes as possible from ash trees and place them on iron pipe poles in areas away from potentially toppling trees. No small undertaking! This enterprise has just begun and will continue with the help of volunteers. With the assistance of the private landowner, two new duck boxes were installed in 2021 near ephemeral ponds on the east side of the Cedarburg Bog. Duck nest boxes now encompass all four sides of the Bog.

Cavity nesting ducks used 14 of the 18 duck boxes maintained by the Friends of the Cedarburg Bog in 2021 -- a 77% usage rate. Of these 14 boxes, nine fledged ducklings indicating a respectable 64% fledgling success rate. Two of the boxes were primarily occupied by hooded mergansers and seven primarily by wood ducks. The word "primarily" is used because the hens of each of these species often "dump" some of their eggs into the nest of another hen when the brooding hen leaves the box to feed. Nest box success rates with the private landowners who maintain their own boxes were not available at the time of this report.

To date, there is no evidence of barred owls using either of the two large owl boxes; however, a barred owl has been often seen in close proximity to one of the boxes. This box will be closely observed around dusk for possible barred owl nesting through the 2022 spring season. It is possible that some of the small owl boxes were used for nesting, however, this has yet to be confirmed. An eastern screech owl was found roosting inside a wood duck box during a maintenance check, and pellet analysis and passerine bird feathers indicate that two additional duck boxes were also occupied for a while by roosting eastern screech owls. Both of these boxes earlier fledged ducklings, and one box also contained a great-crested flycatcher nest. One of the small owl boxes in an area near Watts Lake was probably occupied by a northern saw-whet owl given the location of the box and given that pellet analysis showed that voles were the primary prey. Northern saw-whet owls are more likely to be found in cedar-tamarack forest areas where they feed mainly on voles. On the other hand, the eastern screech owl has a much more varied diet with mice and small birds being taken in addition to voles. The eastern screech owl is also more likely to be found in a deciduous tree environment; however, this is not a hard and fast rule. Both species occasionally coexist in the same habitat.

Black Tern Nesting Platforms in the Cedarburg Bog

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Black terns used to be abundant in suitable habitat all throughout Wisconsin; however, the black tern population in the state is now in serious decline with an overall 50 to 70% population reduction from the 1950s to the present. The only black terns currently being observed in the Cedarburg Bog are temporary migrants. Although they were probably never abundant in the Cedarburg Bog, at least a few pairs of black terns were documented as nesting in the Bog in two or three locations from the 1950s through the early 2000s. Is it possible that they can be lured back?

Nest fragility is one of the issues affecting nesting success. Black terns build their nest on floating vegetation which can easily be compromised by wind or waves.

To address this problem and to meet the requirements of an Eagle Scout project, Braden Meyer constructed and installed five nesting platforms in Mud Lake using a new and vastly improved floating nest platform design shown to have resulted in increased black tern nesting success elsewhere in Wisconsin. The platforms were installed on April 25, 2021, just about the time that the terns begin to return to Wisconsin from their over-wintering sites in South America and Mexico. Even though several black terns were in the area on at least one day in May, it appeared that none found or took to the newly installed platforms. The platforms were moved into storage prior to winter and will again be installed in Mud Lake in 2022 prior to the return of the black terns in the early spring.

Braden Meyer with black tern nesting platform. Photo by John O'Donnell.

Use of Trail Cameras for Species Documentation and Monitoring in and around the Cedarburg Bog State Natural Area

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Trail cameras have been historically used on a periodic basis in and around the Cedarburg Bog to document and confirm the presence of specific mammalian and avian species of interest. Recent examples of first ever documentation of new species were provided through trail camera photos of southern flying squirrel in 2015 and badger in 2017. In 2021, a decision was made by the Friends of the Cedarburg Bog in collaboration with the UWM Field Station to systematically employ trail cameras on a prolonged basis in select habitat locations in order to gather data about which species might be utilizing these habitats in what frequency over the course of the four seasons of a full calendar year. In this regard, a trail camera provided by the DNR Snapshot program was placed in September 2021 on a Mud Lake outflow creek site where a game trail intersects the creek. Pictures from this camera have already provided evidence of difficult to observe species such as mink, short and/or long tailed weasel, coyote, barred owl, and Cooper's hawk. Species found to be abundant at this site included white-tailed deer, raccoon, opossum, and great blue heron. The use of trail cameras in various habitats in and around the Cedarburg Bog is recommended for expansion in 2022.

A coyote captured on a trail camera.

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. 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 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. The data that we measured allowed us to predict the extent, duration, and resiliency of the subnivium habitat. Overall, our work reveals that the subnivium was resilient under an intermediate warming scenario of +3°C. Warming above this level, however, represents a crucial tipping point: at +5°C, we predict an abrupt loss of approximately 200,000 km2 of subnivium habitat and a reduction in duration of one month. These results show that the current trajectory of warming expected for temperate regions of North America will likely lead to the widespread collapse of this critical refuge, and therefore will have severe consequences for winter biodiversity and ecosystem processes. Funded by the National Science Foundation.

Vaccination of Bats Against White-Nose Syndrome at Neda Mine and Other Hibernacula in Wisconsin

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A multi-state effort was initiated in Wisconsin in 2019 to evaluate vaccination as a potential tool to mitigate the fungal disease, white-nose syndrome (WNS), which has decimated bat populations throughout North America. A recombinant virally vectored vaccine, developed jointly by USGS National Wildlife Health Center (NWHC) and University of Wisconsin, Madison, was first confirmed for safety and efficacy in laboratory trials at NWHC. Authorization to conduct limited field trials with potential vaccine candidates was obtained from the USDA Center for Veterinary Biologics in the fall of 2019. Field studies began shortly thereafter at 2 hibernacula in northern Wisconsin. Results of the initial trials were very promising, showing higher rates of spring emergence (survival) in vaccinated bats compared to unvaccinated bats and

lower fungal loads on vaccinated bats during winter surveys. In 2021, the trial was extended to include other locations including the Neda Mine, as well as sites in Texas, WA, and Idaho. On 8/30/2021, we captured free-flying little brown bats outside the Neda Mine using Harp nets. We orally administered vaccine to 68 bats and a placebo to 70 bats. All bats were uniquely tagged with forearm bands and passive integrated tags (PIT tags). Radio frequency identification systems, installed by co-investigators, are being used to monitor spring emergence and fall returns in 2022. Comparisons will be made between rates of return of vaccinated and unvaccinated bats. Bats will be similarly trapped and vaccinated in the fall of 2022.

Social Causes of Variation in Mating Signals and Mate Preferences

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We are using laser vibrometry and vibrational playback experiments to study the causes of variation in the communication system of

Enchenopa binotata nymphs on a *Viburnum lentago* host plant.

Enchenopa treehoppers that may promote speciation. *Enchenopa* are plant-feeding insects that communicate with plant-borne vibrational signals. *Enchenopa* have surprisingly complex systems of communication, with developmental and social causes of variation in their mating signals and mate preferences.

We are currenty testing a hypothesis that offers a simple solution to a problem in the theory of speciation: how distinct "packages" of ecological and sexual traits originate as populations begin to diverge. The most straightforward solution (change in a single gene that causes both the use of different environments and reproductive isolation) is often not applicable, because speciation often involves divergence in traits controled by many genes in linkage disequilibrium, which is liable to break up due to gene flow.

We tested the hypothesis that *social plasticity generates signal-preference co-divergence*. Interactions in mixed aggregations may reduce or enhance signal-preference differences. If the latter occur upon first encounter, social plasticity might spontaneously impede gene flow. Alternatively, there may be reinforcement in the form of plasticity in signals and preferences. Rearing two recently diverged *E. binotata* species in mixed versus own-species aggregations resulted in enhanced signal-preference differences between species. The form of

plasticity did not differ between individuals from sympatric and allopatric sites. We propose that such social plasticity may facilitate rapid bursts of diversification, even in cases where gene flow would otherwise hinder the establishment of linkage disequilibrium.

We are also comparing the patterns of variation induced in the above "social hybrids" with those resulting from genetic hybridization between the two species. Funded by the National Science Foundation and a UWM Discovery and Innovation Grant.

Dr. Lauren Cirino, Dr. Clint Sergi, Madi Rittinger, Dr. Ignacio Escalante, Sara Seidita, and Dr. Bretta Speck

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. The Downer Woods camera had to be replaced during the summer of 2021, but was back to full operation by September, and thus did not miss recording the autumn tree senescence period.

Understanding the Causes and Consequences of Among-population Variation in Flowering Patterns in Monkeyflower

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In angiosperms, the degree to which an individual's flowering phenology coincides with that of conspecifics can have important consequences for reproductive success and fitness. The date of flowering onset, the duration of flowering, and the size of the daily floral display often vary widely and may influence the number and quality of mates. Large floral displays enhance pollinator attraction and promote pollen export and receipt, but plants with large displays also often experience higher levels of among-flower within-plant self-fertilization because pollinators tend to visit multiple flowers sequentially on a single plant. In populations with substantial inbreeding depression, selection should favor plants that produce small displays over many days because their flowers have greater fitness than those of plants that produce large displays over few days. This temporal pattern of flower deployment may be dependent on branching architecture. Furthermore, plants may alter patterns of branching and/or flowering to compensate for resource limitation.

In the wild, populations of monkeyflower vary widely in selfing rate, inbreeding depression, and total flower production as well as pollinator identity and visitation rates. My research utilizes common garden studies to tease apart the influence of genetic and environmental factors in variation in flowering strategies and reproductive success. At the UWM Field Station, I established experimental arrays of plants from 9 monkeyflower populations and quantified the extent of variation in components of flowering phenology, such as the date of flowering onset, flowering duration, and total flower number. I also tracked patterns of flower deployment across the flowering season and established whether the size of the daily floral display influences population selfing rate. Finally, I investigated the extent of phenotypic plasticity on vegetative growth and flowering patterns in response to resource limitation. Funded by a Prairie Biotic Research Grant (awarded to Wendy Semski) and the James and Dorothea Levenson Ecology and Field Biology Fellowship (awarded to Wendy Semski). Ph.D. dissertation research, Dr. Jeffrey Karron, Major Advisor.

A monkeyflower plant in an experimental plot.

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 2021, I monitored over 71 Cooper's hawk nest sites. Thirty-six of these sites were occupied nesting territories with birds observed in the area. I saw no Cooper's hawks at the other 35 nest sites. Twenty-four of the 36 nest sites were active (breeding or laying pairs) with eggs laid. These 24 breeding pairs produced 74 young. Fifty of the 74 young were banded with USGS bands and color coded leg bands (males: purple A/##; females: green A/##). The remainder of the young were not banded because they were too old or the tree was not safe to climb, but I was able to get an accurate count of the young. The 24 active nests produced 74 young (3.08 young/laying pair, N = 24; 3.70 young/successful pair, N = 20; 83.3% nesting success). Twenty-seven adult breeding Cooper's hawks were trapped at their nest sites. Twenty-four of the 27 adults were banded with USGS bands and color coded leg bands. Three were banded and color marked in previous years. Twenty-five of these adults were at least two to six years old, one was 11 years old, and one

Number of Young in Nest	Number of Nests	Total Young
0	4	0
1	1	1
2	3	6
3	5	15
4	5	20
5	4	20
6	2	12
Total	24	74

Table 1. Cooper's Hawk reproductive success for 2021. Twenty-four breeding pairs produced 74 young (3.08 young/laying pair, N = 24; 3.70 young/successful pair, N = 20; 83.3% nesting success)..

Bill Stout holds a great horned owl nestling. Photo by G. Meyer.

was 13 years old. In 2021, a great horned owl nested in Downer Woods in the nest used by Cooper's hawks in previous years. One nestling was banded on 9 April. This nestling was approximately 22 days old. UW-Milwaukee staff and students observed the banding. No project color coded bands were available to put on this nestling.

Woe is the Loner: Female Frogs Prefer to Have Options Even if it Means Rejecting an Isolated "Hotshot"

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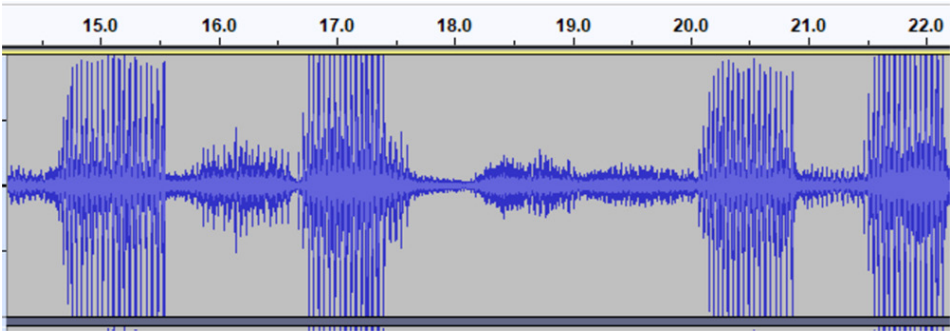
Lekking is a puzzling phenomenon, as it is not obvious why signalers or choosers should aggregate. It has been hypothesized that signalers enjoy higher per capita reproductive success because choosers prefer to sample among dense configurations that are easier to compare. While female preferences as well as the signal features of attractive males are well characterized in many chorusing species, we know little about how mate sampling is influenced by the spatial dynamics within communal displays. Here we ask how female eastern gray treefrogs (*Hyla versicolor*) respond to isolated and clustered call stimuli in a simple 1 vs. 3 playback design. We explored i) whether females exhibit a general preference for call clusters, ii) whether spatial preference is robust to call-feature preference, and iii) how this affects the relative success of attractive and unattractive males in different spatial combinations. We found generalized spatial discrimination against lone callers but did observe fine-scale assessment of call features within clusters. The prominence of the spatial preference impacts the attractiveness of males, conferring particular advantage to attractive callers within clusters, while reducing attractiveness of isolated males regardless of their acoustic features. Our findings indicate that female frogs navigate complex choruses by initially orientating toward call aggregates, and then assess call-features within them. This study provides novel insight into the mate choice heuristics involved in animal choruses. Ph.D. dissertation research (Kane Stratman) and undergraduate research project (Emma Oldehoeft), Gerlinde Höbel, Major Advisor

Calling male eastern gray treefrog; possibly attractive-sounding, possibly unattractive. Photo by Olivia Feagles.



Sonogram of a eastern gray treefrog call. Blue bars are the trills of his call.

Identification of Microorganisms and their Metabolites for Crop Disease Control

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Microorganisms that were isolated from the soils and insects collected at the UWM Field Station were cultured in the medium broth. To classify the bacterial strains, the 16S rRNAs of the isolated bacteria were sequenced. Housekeeping genes were further sequenced on some bacterial strains for classification purposes. The housekeeping genes for multilocus sequence analysis (MLSA) were extracted from genome samples. The maximum likelihood inference was performed using PhyML. The natural compounds produced from the microorganisms were evaluated for their inhibition on the growth of plant pathogens, such as *Erwinia* and *Botrytis* species. Potential compound candidates are analyzed by mass spectra and nuclear magnetic resonance spectroscopy for their chemical structures. Greenhouse and field assays will be conducted to learn the efficacies of these natural metabolites. Funded by the United States Department of Agriculture-National Institute of Food and Agriculture, T3 Bioscience LLC, a UWM Discovery and Innovation Grant, a UWMRF Catalyst grant and a UWMRF Bridge grant.

Ron Horn working with Jim Reinartz building the boardwalk in 2007.

Recent Publications and Theses

Recent Publications Resulting from Field Station Projects

Casper, G.S., C.E. Smith, S.M. Nadeau, and A.Lewanski. 2017**.** Geographic Distribution. *Acris blanchardi* (Blanchard's Cricket Frog). USA: Minnesota: Dakota Co. Herpetological Review 48(4):805.

Fowler-Finn K.D., D.C. Cruz and R.L. Rodríguez. 2017**.** Local population density and group composition influence signal-preference relationships in *Enchenopa* treehoppers (Hemiptera: Membracidae). Journal of Evolutionary Biology 30: 13-25.

Hallett, A.C., R.J. Mitchell, E.R. Chamberlain, and J.D. Karron. 2017**.** Pollination success following loss of a frequent pollinator: the role of compensatory visitation by other effective pollinators. AoB PLANTS 9: plx020; doi:10.1093/aobpla/plx020.

Henschen, A. E., L.A.Whittingham and P.O. Dunn. 2017. The relationship between blood parasites and ornamentation depends on the level of analysis in the common yellowthroat. Journal of Avian Biology 48:1263-1272.

Hileman, E.T., R.B. King, J.M. Adamski, T.G. Anton, R.L. Bailey, S.J. Baker, N.D. Bieser, T.A. Bell, Jr, K.M. Bissell, D.R. Bradke, H. Campa, III, G.S. Casper, K. Cedar, M.D. Cross, B.A. DeGregorio, M.J. Dreslik, L.J. Faust, D.S. Harvey, R.W. Hay, B.C. Jellen, B.D. Johnson, G. Johnson, B.D. Kiel, B.A. Kingsbury, M.J. Kowalski, Y.M. Lee, A.M. Lentini, J.C. Marshall, D. Mauger, J.A. Moore, R.A. Paloski, C.A. Phillips, P.D. Pratt, T. Preney, K.A. Prior, A. Promaine, M. Redmer, H.K. Reinert, J.D. Rouse, K.T. Shoemaker, S. Sutton, T.J. VanDeWalle, P.J. Weatherhead, D. Wynn, and A. Yagi. 2017**.** Climatic and geographic predictors of life history variation in Eastern Massasauga (*Sistrurus catenatus*): A range-wide synthesis. PLoS ONE 12(2): e0172011. doi:10.1371/journal.pone.0172011.

Joneson, S. and H. O'Brien. 2017. A molecular investigation of free-living and lichenized *Nostoc* sp. and symbiotic lifestyle determination. The Bryologist 120(4): 371–381.

Reichert, M.S. and G. Höbel. 2017**.** Frequency channel-dependent selectivity for temporal call characteristics in gray treefrogs, *Hyla versicolor.* Journal of Experimental Biology 220: 1256-1266. doi:10.1242/jeb.152330

Piaskowski, V.D., J.M. O'Donnell, and G.A. Meyer. 2017**.** Bird use of the Cedarburg Bog Important Bird Area during spring and fall migration. Passenger Pigeon 79 (2): 139 – 161.

Underhill, V.A. and G. Höbel. 2017**.** Variation in nocturnal light levels does not alter mate choice behavior in female eastern gray treefrogs (*Hyla versicolor*). Behavioral Ecology Sociobiology 71:151. DOI 10.1007/s00265-017-2386-1

Ambardar, M., P.O. Dunn and L.A. Whittingham. 2018**.** Reproductive and foraging success of the Eastern Bluebird (*Sialia sialis*) in relation to vegetation height. Wilson Journal of Ornithology 130(2):362–370.

Casper, G.S. and R.D. Rutherford. 2018. Geographic Distribution: *Lithobates catesbeianus* (American Bullfrog). USA: Wisconsin: Shawano Co. Herpetological Review 49(2):282.

Casper, G.S. 2018. Geographic Distribution: *Ambystoma maculatum* (Spotted Salamander). USA: Wisconsin: Shawano Co. Herpetological Review 49(2):280.

Casper, G.S. and R.D. Rutherford. 2018. Geographic Distribution: *Hemidactylium scutatum* (Four-toed Salamander). USA: Wisconsin: Shawano Co. Herpetological Review 49(2):280.

Casper, G.S. and R.D. Rutherford. 2018**.** Geographic Distribution: *Notophthalmus viridescens louisianensis* (Central Newt). USA: Wisconsin: Shawano Co. Herpetological Review 49(2):281.

Casper, G.S. and R.D. Rutherford. 2018**.** Geographic Distribution: *Hyla versicolor* (Gray Treefrog). USA: Wisconsin: Shawano Co. Herpetological Review 49(2):282.

Clark, R.G., D.W. Winkler, R.D. Dawson, D. Shutler, D.J.T. Hussell, M.P. Lombardo, P.A. Thorpe, P.O. Dunn and L.A. Whittingham. 2018**.** Geographic variation and environmental correlates of apparent survival rates in adult tree swallows *Tachycineta bicolor.* Journal of Avian Biology 49 (6). DOI: 10.1111/jav.01659

Fowler-Finn, K.D., J.T. Kilmer, D.C. Cruz, and R.L. Rodriguez. 2018**.** Female mate choice of male signals is unlikely to promote

ecological adaptation in *Enchenopa* treehoppers (Hemiptera: Membracidae). Ecology and Evolution 8: 2146-2159.

Gafvert, U. and G.S. Casper. 2018. Quality assurance plan for amphibian monitoring in the Great Lakes Network. Natural Resource Report NPS/GLKN/NRR—2018/1713. National Park Service, Fort Collins, Colorado.

Graham, L.E., M.T. Trest, S. Will-Wolf, N.S. Miicke, L.M. Atonio, M.J. Piotrowski and J.J. Knack. 2018. Microscopic and metagenomic analyses of *Peltigera ponojensi*s (Peltigerales, Ascomycota). Int. J. Plant Sci. 179(3):241–255.

Han, W.S., J.P. Graham, S. Choung, E. Park, W. Choi, and Y.S. Kim. 2018. Local-scale variability in groundwater resources: Cedar Creek Watershed, Wisconsin, U.S.A. Journal of Hydro-environment Research 20: 38-51.

Henschen, A.E., L.A. Whittingham and P.O. Dunn. 2018**.** Male stress response is related to ornamentation but not resistance to oxidative stress in a warbler. Functional Ecology 32:1810–1818.

Karol, K.G., M.S. Alix, R.W. Scribailo, P.M. Skawinski, R.S. Sleith, J.A. Sardina and J.D. Hall. 2018**.** New records of the rare North American endemic *Chara brittonii* (Characeae), with comments on its distribution. Brittonia 70(3):277-288.

Minnaar, C., B. Anderson, M.L. de Jager, and J.D. Karron. 2018**.** Plant-pollinator interactions along the pathway to paternity. Annals of Botany 123: 225–245.

Murphy, J.C., J.R. Downie, J.M. Smith, S.R. Livingstone, R.S. Mohammed, R.M. Lehtinen, M. Eyre, J.N. Sewlal, N. Noriega, G.S. Casper, T. Anton, M.G. Rutherford, A.L. Braswell and M.J. Jowers. 2018**.** A Field Guide to the Amphibians and Reptiles of Trinidad & Tobago. Trinidad & Tobago Field Naturalists' Club, Port of Spain, Trinidad and Tobago. R.J. Auguste (managing Editor).

Rodriguez, R. L., J.E. Wojcinski and J. Maliszewski. 2018. Between-group variation in *Enchenopa* treehopper juvenile signaling (Hemiptera Membracidae). Ethology Ecology & Evolution 30: 245–255.

Thompson, K.L., B. Zuckerberg, W.P. Porter and J.N. Pauli. 2018**.** The phenology of the subnivium. Environ. Res. Lett. 13: 064037.

Underhill, V.A. and G. Höbel. 2018**.** Moonlighting? - Consequences of lunar cues on anuran reproductive activity. Acta Oecologica 87: 20-28.

Underhill, V.A. and G. Höbel. 2018. Mate choice behavior of female Eastern Gray Treefrogs (*Hyla versicolor)* is robust to anthropogenic light pollution. Ethology 124: 537-548.

Whitehead, M.R., R.J. Mitchell and J.D. Karron. 2018. Plant mating systems often vary widely among populations. Frontiers in Ecology and Evolution 6:38.

Whittingham, L.A., P.O. Dunn, C.R. Freeman-Gallant, C.C. Taff and J.A. Johnson. 2018. Major histocompatibility complex variation and blood parasites in resident and migratory populations of the common yellowthroat. Journal of Evolutionary Biology 31:1544-1557.

Young, E.B., J.R. Sielicki, and J.J. Grothjan. 2018**.** Regulation of hydrolytic enzyme activity in aquatic microbial communities hosted by carnivorous pitcher plants. Microbial Ecology 76: 885-898.

Casper, G.S., T.G. Anton and R.D. Rutherford. 2019. Guide to Amphibian Eggs and Larvae of the Western Great Lakes. National Park Service, Fort Collins, Colorado. 100 pp.

Christopher D.A., R.J. Mitchell, D.W. Trapnell, P.A. Smallwood, W.R. Semski and J.D. Karron. 2019. Hermaphroditism promotes mate diversity in flowering plants. American Journal of Botany 106: 1131–1136. https://doi:10.1002/ajb2.1336

Desjonquères, C., J. Maliszewski, E.N. Lewandowski, B. Speck and R.L. Rodríguez. 2019. Social ontogeny in the communication system of an insect. Animal Behaviour 148: 93-103.

Desjonquères, C., B. Speck and R.L. Rodríguez. 2019. Signalling interactions during ontogeny are a cause of social plasticity in *Enchenopa* treehoppers (Hemiptera: Membracidae). Behavioural Processes 166: 103887. https://doi.org/10.1016/j.beproc.2019.06.010

Fitzpatrick, M.J., B. Zuckerberg, J.N. Pauli, M.R. Kearney, K.L. Thompson, L.C. Werner II and W.P. Porter. 2019. Modeling the distribution of niche space and risk for a freeze-tolerant ectotherm, *Lithobates sylvaticus.* Ecosphere, 10 (7):e02788. 10.1002/ecs2.2788

Geller, G.A., and G.S. Casper. 2019. Natural History Notes. *Chelydra serpentina* (Snapping

Turtle). Hatchling sounds. Herpetological Review 50(4):768–9.

Geller, G.A. and G.S. Casper. 2019. Late-term embryos and hatchlings of Ouachita Map Turtles (*Graptemys ouachitensis*) make sounds within the nest. Herpetological Review 50(3):449–452.

Grothjan J.J. and E.B. Young. 2019. Diverse microbial communities hosted by the model carnivorous pitcher plant *Sarracenia purpurea*: analysis of both bacterial and eukaryotic composition across distinct host plant populations. PeerJ 7:e6392 http://doi.org/10.7717/peerj.6392

Huebschman, J.L., S.A. Hoerner, J.P. White, H.M. Kaarakka, K.L. Parise and J.T. Foster. 2019. Detection of *Pseudogymnoascus destructans* on Wisconsin bats during summer. Journal of Wildlife Diseases 55 (3): 673-677.

Stratman, K.D. and G. Höbel. 2019. Opportunity for female choice in the wild is frequently curtailed by low male trait variation in *Hyla versicolor*. Behavioral Ecology and Sociobiology 73(5): 59. https://doi.org/10.1007/s00265-019-2666-z

Christopher, D.A., R.J. Mitchell, D.W. Trapnell, P.A. Smallwood, W.R. Semski, and J.D. Karron. 2020. Edge effects and mating patterns in a bumblebee-pollinated plant. AoB Plants 12(4). https://doi.org/10.1093/aobpla/plaa033

Christopher, D.A., R.J Mitchell, and J.D. Karron. 2020. Pollination intensity and paternity in flowering plants. Annals of Botany 125: 1–9. doi.org/10.1093/aob/mcz159

Desjonquères C., R.B. Holt, B. Speck and R.L. Rodríguez. 2020. The relationship between a combinatorial rule and a continuous preference function in an insect. Proceedings of the Royal Society B 287: 20201278. https://doi.org/10.1098/rspb.2020.1278

Donnelly, A., R. Yu, C. Rehberg, G. Meyer, and E.B. Young. 2020. Leaf chlorophyll estimates of temperate deciduous shrubs during autumn senescence using a SPAD-502 meter and calibration with extracted chlorophyll. Annals of Forest Science 77:30 https://doi.org/10.1007/s13595-020-00940-6

Fitzpatrick, M.J., W.P. Porter, J.N. Pauli, M.R. Kearney, M. Notaro, and B. Zuckerberg. 2020. Future winters present a complex energetic landscape of decreased costs and reduced risk for a freeze-tolerant amphibian, the Wood Frog (*Lithobates sylvaticus*). Global Change Biology 26 (11): 6350-6362. http://doi.org/10.1111/gcb.15321

Hoyt, J.R., K.E. Langwig, K. Sun, K.L. Parise, Y. Wang, X. Huang, L. Worledge, H. Miller, T. Görföl, S.A. Boldogh, D. Fukui, M. Sakuyama, S. Yachimori, A. Sato, M. Dalannast, A. Jargalsaikhan, N. Batbayar, Y. Yovel, E. Amichai, I. Natradze, W.F. Frick, J.T. Foster, J. Feng and A.M. Kilpatrick. 2020. Environmental reservoir dynamics predict global infection patterns and population impacts for the fungal disease white-nose syndrome. Proceedings of the National Academy of Sciences 117 (13): 7255-7262. https://doi.org/10.1073/pnas.1914794117

Mueller, W. P., and G. S. Casper. 2020. Winter waterfowl abundance and distribution in the Milwaukee estuary and harbor. Passenger Pigeon 82 (1):7-19.

Rosenfield, R.N., A.C. Stewart, W.E. Stout, S.A. Sonsthagen, and P.N. Frater. 2020. Do British Columbia Cooper's Hawks have big feet? British Columbia Birds 30:10-14

Speck, B., S. Seidita, S. Belo, S. Johnson, C. Conley, C. Desjonquères and R.L. Rodríguez. 2020. Combinatorial signal processing in an insect. American Naturalist 196: 406-413

Yi, X., D.M. Donner, P.E. Marquardt, J.M. Palmer, M.A. Jusino, J. Frair, D.L. Linder, and E.K. Latch. 2020. Major histocompatibility complex variation is similar in little brown bats before and after white-nose syndrome outbreak. Ecology and Evolution 10(18): 10031-10043. https://doi.org/10.1002/ece3.6662

Bittleston, L., Z. Freedman, J. Bernadin, J.J. Grothjan, E.B. Young, S. Record, B. Baiser and S. Gray. 2021. Exploring microbiome functional dynamics through space and time with trait-based theory. mSystems 6: e00530-21

Blais, B.R., B.E. Smith, J.S. Placyk Jr., G.S. Casper and G.M. Spellman. 2021. Phylogeography of the Smooth Greensnake, *Opheodrys vernalis* (Squamata: Colubridae): divergent lineages and variable demographics in a widely distributed yet enigmatic species. Biological Journal of the Linnean Society 134: 940-957. https://doi.org/10.1093/biolinnean/blab124

Christopher D.A, J.D. Karron, W.R. Semski, P.A. Smallwood, D.W. Trapnell and R.J. Mitchell. 2021. Selfing rates vary with floral display, pollinator visitation and plant density

in natural populations of *Mimulus ringens*. Journal of Evolutionary Biology 34: 803-815. doi.org/10.1111/jeb.13781

Desjonquères C., J. Maliszewski and R.L. Rodríguez. 2021. Juvenile social experience and practice have a switch-like influence on adult mate preferences in an insect. Evolution 75: 1106-1116. https://doi.org/10.1111/evo.14180

Hahn, P.G., K. Keefover-Ring, L.M.N. Nguyen, and J.L. Maron. 2021. Intraspecific correlations between growth and defense vary with resource environment and differ within- and among-populations. Functional Ecology 35(11):2387-2396. DOI: 10.1111/1365-2435.13878

Rosenfield, R.N., W.E. Stout, A.C. Stewart, T.G. Driscoll, S.A. Sonsthagen and J.P. Seibel. 2021. Are there Gloger tail bands in British Columbia Cooper's Hawks? British Columbia Birds 31:51-57.

Stratman, K.D., E.A. Oldehoeft and G. Höbel. 2021. Woe is the loner: Female treefrogs prefer clusters of displaying males over single "hotshot" males. Evolution 75: 3026-3036.

Thompson K.L., B. Zuckerberg, W.P. Porter and J.N. Pauli. 2021. The decline of a hidden and expansive microhabitat: the subnivium. Frontiers in Ecology and the Environment 19: 268-273. https://esajournals.onlinelibrary.wiley.com/doi/10.1002/fee.2337

Recent Theses

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

Henschen, Amberleigh E. 2018. Plumage ornaments signal male physiological quality in common yellowthroats. Ph.D. dissertation.

Underhill, Victoria. 2018. Influence of natural and anthropogenic light levels on female preferences in eastern gray treefrogs (*Hyla versicolor)*. M.S. Thesis.

Rehberg, Chloe. 2020. An analysis of temperate deciduous shrub phenology in Downer Woods, University of Wisconsin-Milwaukee, Wisconsin. M.S. Thesis.

Grothjan, Jacob. 2021. Microbial communities hosted by carnivorous pitcher plants: Diversity, recruitment, functions and succession in *Sarracenia purpurea* microbiomes. Ph.D. dissertation.

Pitcher plants (*Sarracenia purpurea*) grown in the greenhouse. Photo by J. Grothjan.

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. The Station also assists the DNR with bat monitoring programs at Neda Mine.

3. UWM at Waukesha Field Station. The Station cooperates with the Waukesha Field Station which is also part of UWM.

4. Wisconsin Phenological Society. G. Meyer serves on the Board of Directors and the Field Station hosts the Annual Meeting each spring. We were not able to hold the Annual Meeting at the Field Station in 2021 because of the COVID-19 pandemic.

5. 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.

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

10. The Prairie Enthusiasts. The Field Station has entered into a management agreement with this non-profit group to restore Benedict Prairie.

11. Upham Woods Outdoor Learning Center. Upham Woods is a residential field campus of the University of Wisconsin-Madison. G. Meyer serves on the Research and Innovation Advisory Committee.

Monarch butterfly. Photo by Kate Redmond.

2021
Natural History Workshops

This is a series of intensive workshops on various topics in field biology and environmental science. The workshops are popular with members of the general public and provide continuing education opportunities for professionals. Some workshops are also open to UWM students for college credit, allowing UWM students to gain field experience and to interact with the non-credit students in the class. In 2021 we developed fully online workshops for the first time and we shifted our face-to-face workshops into a hybrid format. For the hybrid workshops, we moved the lecture portion of the class online and included one day of in-person field work at the Field Station. We retained the 20 student enrollment limit, but half of the students came on Friday and half came on Saturday so that we had a maximum of 10 students per day. We offered 3 online workshops and 3 hybrid workshops in 2021.

Workshop	Instructor	Date	Format
Introduction to Bird Song	William Mueller	February 6 - March 27	Online
Making Your Nature Film	Roger Kuhns	April 7 – May 26	Online
Field Herpetology: Identification of Wisconsin Amphibians and Reptiles	Josh Kapfer	June 4 & 5	Hybrid
Fishes of Wisconsin: Taxonomy, Ecology, and Identification	Michael Pauers	July 16 & 17	Hybrid
Plant-Insect Interactions: Ecology and Evolution	Gretchen Meyer	August 6 & 7	Hybrid
Identifying Raptors in Fall Migration in Wisconsin	William Mueller	August 14	Online

Fishes of Wisconsin class sampling in Cedar Creek.

Semester Classes

UWM semester classes taught at the Field Station or by Field Sation staff.

Conservation and Environmental Science 471, Practicum in Natural Resources Management, Spring 2021.

In this class, students work on a real-world environmental project in order to learn about preparing management plans and project proposals. The class was taught by Dr. Neal O'Reilly and was held online in 2021. Dr. Gretchen Meyer led one project, where a team of students developed a wildlife management plan for the Field Station. The project included two field trips: one to Downer Woods and one to the Field Station

Biological Sciences/Conservation and Environmental Science 451, Field Methods in Conservation, Fall 2021.

This course is taught entirely at the Field Station by Dr. Gretchen Meyer. The course gives students interested in conservation biology and natural area management an opportunity for hands-on learning in the field. Students can go directly from the classroom to natural areas located on the Field Station property, where they practice techniques that have been presented in the lecture. After moving the class online in 2020 because of COVID-19, we returned to the face-to-face format in 2021.

In 2021 two students in the class discovered a four-toed salamander (*Hemidactylium scutatum)* at the Field Station. Morgan Schmanski and Joseph Cannizzaro found the salamander while participating in a class exercise. This was the first time this species had been found at the Field Station and was also a new record for Ozaukee County. The students will publish their observations in the journal Herpetological Review in 2022. A news story can be found here: https://uwm.edu/news/uwm-students-make-a-rare-find-while-on-a-class-hike/

Four-toed salamander discovered at the UWM Field Station.

Students in the Field Methods in Conservation class donned waders and used nets to sample for aquatic invertebrates in the Milwaukee River. Photo by C. Boettcher.

Students visited the Cedarburg Beech Woods to learn about forests for the Field Methods in Conservation class. Photo by C. Boettcher.

Class and Group Use

In-person Use	Number of Person Hours

Winter - Spring 2021

Friends of the Cedarburg Bog - Memorial Day bird walk	14
Friends of the Cedarburg Bog - Spring bird walk	10
Friends of the Cedarburg Bog - Stewardship work day	30
Marek Landscaping - Boardwalk tour	24
Natural Resources Foundation - Woodcocks and Frogs	45
Riveredge High School - Bog tour	24
Shorewood High School - Watershed Wisdom	70
TOTAL	**217**

Summer 2021

Friends of the Cedarburg Bog - Butterfly & dragonfly walk	13
Friends of the Cedarburg Bog – Ethnobotany	51
Friends of the Cedarburg Bog - Spring flower hike	20
Friends of the Cedarburg Bog - Summer in the bog	25
UWM - Field Herpetology workshop	168
UWM - Fishes of Wisconsin workshop	160
UWM - Plant-Insect Interactions workshop	168
Washington County Master Gardeners - Boardwalk tour	23
TOTAL	**627**

Fall - Winter 2021

Friends of the Cedarburg Bog - Annual Meeting & picnic	96
Friends of the Cedarburg Bog - Beech-Maple woods	33
Friends of the Cedarburg Bog – Ferns	10
Friends of the Cedarburg Bog - How Trees Grow	30
Friends of the Cedarburg Bog – Mushrooms	45
Friends of the Cedarburg Bog - Owl Prowls	40
Friends of the Cedarburg Bog - Committee meeting	10
Friends of the Cedarburg Bog - Stewardship work days	82
Milwaukee School of Engineering - Physical Hydrogeology	15
Riveredge Nature Center - Christmas bird count	6
Schlitz Audubon - Cedarburg Bog tour	56
Schlitz Audubon - Master Naturalist class	100
St John's Lutheran Church - Cedarburg Bog tour	18
St John's Lutheran School - Cedarburg Bog tour	27
Urban Ecology Center - Ecology group outing	90
UWM - BioSci/CES 451 - Field Methods in Conservation	1400
UWM - CES 471 - Practicum in Nat. Res. Management field trips	32
UWM - Geosciences 463 - Physical Hydrogeology	108

UWM - Focus Photography Club - Spooky Photoshoot	90
UWM Conservation Club - Downer Woods cleanup	15
TOTAL	**2338**
TOTAL 2021 In-Person Use Hours	**3182**

Online use (synchronous)	**Number of Person Hours**
Friends of the Cedarburg Bog - Annual winter hike	42
Friends of the Cedarburg Bog – Meetings	79
UWM - Identifying Raptors in Fall Migration workshop	60
UWM - Introduction to Bird Song workshop	252
UWM - Making Your Own Nature Film workshop	240
TOTAL	673
TOTAL 2021 Class & Group Use Hours.	**3823**

Students in the Plant-Insect workshop netting for butterflies and other insects. Photo by Kim Kisiolek.

Meteorological Data for 2021

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.

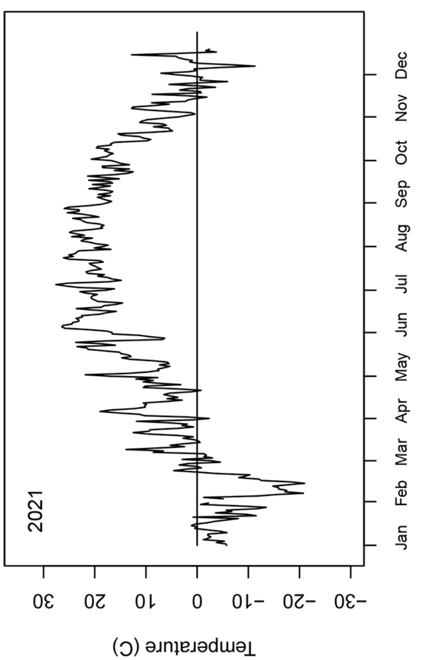
Maximum Speed (m/s): Highest mean wind speed during a 30-min period.

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.

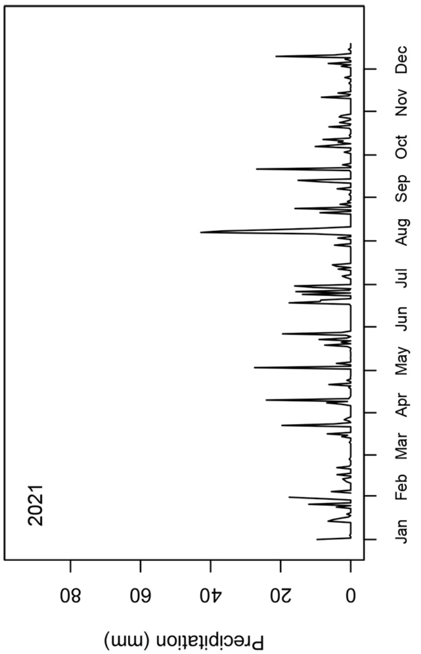
Meteorological Data for 2021

	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	OCT	NOV	DEC[2]
Temperature (C°)												
Average Daily Maximum	-1.1	-4.8	8.5	13.2	19.0	26.4	26.3	27.5	23.2	17.6	7.5	NA
Average Daily Minimum	-8.3	-14.0	-2.2	3.0	7.2	14.6	15.1	15.9	11.0	8.7	-2.3	NA
Daily Average	-4.3	-9.1	3.6	7.8	13.3	20.9	20.9	21.7	17.2	13.0	2.8	NA
Highest (Date)	4.1 (15)	10.6 (27)	18.1 (30)	25.9 (6)	30.5 (1)	33.1 (5)	32.2 (26)	31.6 (28)	28.9 (17)	26.7 (2)	19.3 (7)	NA
Lowest (Date)	-20.0 (28)	-24.6 (7)	-13.6 (2)	-6.6 (1)	-1.5 (12)	6.6 (22)	9.7 (9)	10.4 (2)	6.7 (24)	-1.5 (24)	-9.9 (26)	NA
Degree Days												
Sum at 5°	0.0	0.0	45.4	112.2	256.2	476.5	492.9	516.7	367.0	249.4	33.4	NA
Sum at 10°	0.0	0.0	8.2	29.3	134.9	326.5	337.9	361.7	217.0	123.0	5.4	NA
Radiation (kW/m^2)												
Mean	NA[1]	NA	0.16	0.19	0.23	0.26	0.24	0.22	0.17	0.09	0.08	0.05
Maximum	NA	NA	0.81	0.97	1.04	1.01	1.00	0.98	0.82	0.69	0.57	0.42
Relative Humidity (%)												
Hour 00-06 mean	88.3	80.5	77.6	78.8	82.3	84.1	89.2	91.0	88.3	89.5	75.5	NA
Hour 06-12 mean	86.0	73.6	65.8	65.5	62.2	66.1	71.1	73.3	71.4	80.0	69.8	NA
Hour 12-18 mean	79.2	60.6	53.2	54.9	53.1	56.6	60.5	62.0	57.6	69.3	55.6	NA
Hour 18-24 mean	85.8	73.8	70.9	72.8	72.6	74.2	81.2	83.8	83.5	85.7	68.0	NA
Number of Days												
Precip. 0.25mm or more	11	8	9	8	10	9	6	10	7	14	5	NA
Max Temp 32° and above	0	0	0	0	0	1	1	0	0	0	0	NA
Max Temp 0° and below	20	16	1	0	0	0	0	0	0	0	1	NA
Min Temp 0° and below	31	25	22	9	3	0	0	0	0	3	22	NA
Min Temp -18° and below	3	11	0	0	0	0	0	0	0	0	0	NA
Pressure (mbars)												
Mean	1016.80	1018.81	1019.33	1013.18	1019.52	1013.81	1017.13	1016.41	1015.27	1014.17	1016.78	NA
Precipitation (mm)												
Total	68.1	19.4	38.3	43.2	76.4	91.6	21.3	152.7	57.7	49.0	14.9	NA
Greatest (24 hrs) (Date)	17.5 (31)	5.5 (4)	19.6 (23)	24.1 (10)	27.4 (3)	17.6 (18)	5.2 (15)	42.8 (7)	26.8 (21)	10.1 (7)	8.4 (11)	NA
Wind												
Mean Speed (m/s)	1.4	1.9	2.0	1.6	1.5	1.2	1.0	1.0	1.0	1.1	1.7	1.6
Maximum Speed (m/s)	5.6	5.3	6.1	5.8	4.8	5.6	3.5	3.9	3.8	4.7	5.6	5.9

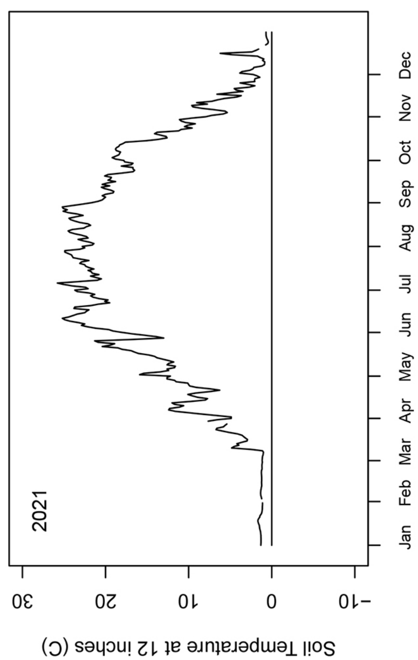
1 - The pyranometer was removed for calibration in Jan. and Feb.
2 - Data for temperature, relative humidity, barometric pressure, and precipitation are missing for the last third of December.



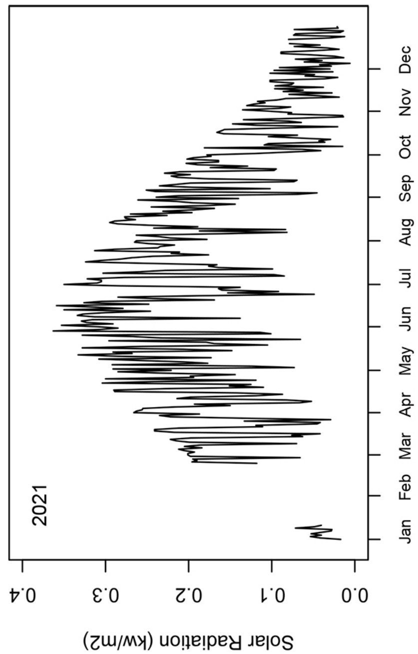
Mean Daily Temperature



Total Daily Precipitation



Soil Temperature at 12 Inches Depth



Mean Daily Radiation

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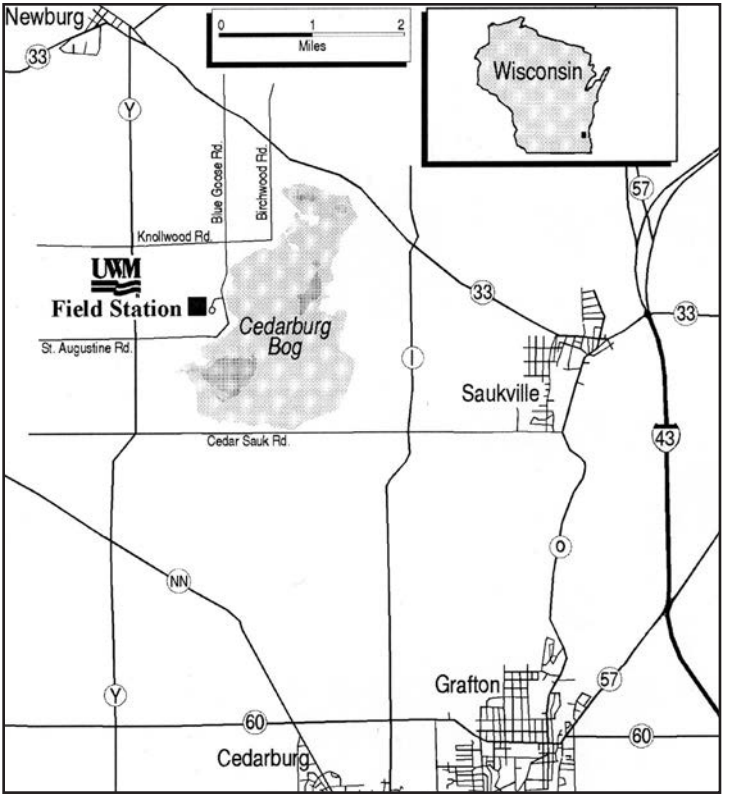

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