

# 2018 FIELD STATION ANNUAL REPORT



UNIVERSITY of WISCONSIN  
**UWMILWAUKEE**

Field Station

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***On the Cover:*** James and Dorathea Levenson enjoyed a visit to the Field Station boardwalk. The Levensons have established a \$250,000 fund to support graduate student fellowships at the UWM Field Station. James Levenson completed his Ph.D. at UWM in 1976, where he studied forested woodlots as biogeographic islands.

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/>.

Director:	James A. Reinartz
Manager/Staff Biologist:	Gretchen A. Meyer
Maintenance:	Ron E. Tagye
Administrative Assistant:	Cynthia K. Boettcher
Field Station Committee:	Peter Dunn, Paul Engevold, Glen Fredlund, Tim Grundl, Gerlinde Höbel, Jeffrey Karron (Chairman), Thomas Schuck, Erica Young

# About Us

## 2018 Highlights

- The James and Doratheia Levenson Endowment for Ecology and Field Biology was established 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) (see the cover).
- UWM gained the UW-Waukesha Field Station after the two institutions merged in 2018. The field station will be called the UWM at Waukesha Field Station, and the merger will lead to greater cooperation between the two field stations.
- Phenology research in Downer Woods became part of an international collaboration working with data collected by VENUS (Vegetation and Environment monitoring on a new MicroSatellite). The UWM part of the project is being led by Alison Donnelly in Geography.
- Field Methods in Conservation, a new semester course taught entirely at the Field Station, was offered for the second time in the Fall semester.
- Jim Reinartz and Gretchen Meyer each taught an on-campus class during the Spring Semester: Plant Systematics and Evolution (Reinartz) and Community Ecology (Meyer).
- 28 research projects in 2018.
- Over 12,700 person-hours of instruction and group use in 2018.

## The UWM Field Station

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

available for research and teaching. The University of Wisconsin-Milwaukee owns approximately 320 acres, most of which were donated by The Nature Conservancy in 1964. Research at the Station has produced 403 scientific publications and 152 theses since 1970.

## Natural Areas at the Field Station

### The Cedarburg Bog State Natural Area

- One of the largest and the most biologically diverse of the wetlands in southern Wisconsin, is accessible to researchers and classes by the Field Station's boardwalk. Shallow and deep lakes, marshes, shrub communities, sedge meadow, hardwood swamp, conifer swamp, and the southernmost string bog in North America are just some of the vegetation types of the Cedarburg Bog. Populations of at least 35 species of higher plants and 19 birds are at or near the southern edge of their range in the Bog. The Bog is part of the national system of Experimental Ecological Reserves established by the National Science Foundation and The Institute of Ecology. A "Guide to the Natural History of the Cedarburg Bog," which serves as a ready introduction and reference source for researchers and educators using the Bog, is available from the Field Station and on our website. In 2015, the DNR purchased 66 acres of land in the Cedarburg Bog from The Bog Golf Course, the first major addition of acreage to the State Natural Area in decades. As of 2016 Emerald Ash Borer has killed essentially all of the mature ash trees in the Bog. Approximately 12% of the trees in the Bog were black ash, accounting for 10% of total tree basal area, and 2% were green ash, 4% of basal area.

### The Cedarburg Beech Woods State

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

have known that Emerald Ash Borer beetles have been present in the woods since 2012 when adults were captured in traps at the Station. Essentially all of the white ash in the upland forest are now dead. White ash made up about 9% of the trees in the forest and 13% of the total basal area of trees. The Cedarburg Beech Woods SNA is likely to experience major changes within the next few years. The beech-maple forest and the Cedarburg Bog are each State Natural Areas, and are classified as National Natural Landmarks by the Department of Interior.

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

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

**Old Agricultural Fields** – Over 100 acres in various stages of succession are available for experimental research. A history of the use and management of the fields over the past 40 years is maintained. Six separate areas in the old fields have been planted with prairie species native to Wisconsin. We conducted controlled burns of three prairie/old-field areas (Burn units 2, 4, and 5) on 15 April 2016 with Field Station staff and volunteers.

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

in 2017 the beetle population appeared to have been reduced and there was more flowering of the purple loosestrife again. Friends of Cedarburg Bog volunteers help Field Station staff with trail maintenance and our efforts to control invasives.

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

## **Research and Teaching Facilities**

### **General Facilities**

- Office/classroom building with meeting rooms, teaching lab, and computer lab.
- A Research Lab constructed in 2004
- Service building – machine & wood shop
- The Farm House for researcher & student housing
- The Researcher House for longer stays by individuals and groups
- Natural areas marked with a permanent grid – Accurately GPS-located in 2005
- Boardwalk to the center of the Cedarburg Bog – Reconstruction completed in 2009
- 14 aquatic mesocosms (200 gallon tanks)

- Several small boats, canoes, and trailers
- Global Positioning System equipment
- Extensive map and aerial photo collection
- Geographic Information System (GIS) for the Field Station area

## Hydrology, Meteorology & Phenology

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

## Animal Ecology & Behavior

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

## Experimental Garden

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

## Plant Ecology

- Herbarium & Plant lists
- Plant identification lab
- Vegetation sampling & surveying equipment

- Fenced deer exclusion plots in various plant communities and habitats

## Outlying Natural Areas

### Neda Mine Bat Hibernaculum State

**Natural Area** - An abandoned iron mine, located on the Niagara Escarpment near Mayville and Horicon, Wisconsin, is among the largest bat hibernacula in the Midwest. Up to 150,000 bats of four species (Little brown bats, Big brown bats, Eastern pipistrelles, and Northern long-eared bats) used the hibernaculum. The hibernaculum has the infrastructure and instrumentation to be a productive facility for research on the behavioral ecology of bats at a major hibernaculum. An infrared beam system provides continuous counts of bat flights through the entrances to the mine and we have monitored bat activity continuously since 2000. 2015 was the first year that the fungus that causes white-nose syndrome in bats was positively detected at the Neda Mine Hibernaculum. The disease was confirmed in the bat population in 2016, and the population of bats in the mine has declined. The mine is also of geological interest; its cliffs provide an excellent exposure of the Niagara Dolomite and the only accessible exposure of the Neda Iron formation.

### Neda Beechwoods State Natural Area -

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

**Benedict Prairie** - Near Kenosha, is a 6-acre tract of virgin prairie along a railroad right of way that has a remarkably diverse flora. A vascular plant species list for Benedict Prairie has been published in the Field Station Bulletin. Woody plants were cut from the prairie and controlled burns were conducted in spring of both 2012 and 2013. More extensive woody plant brush removal was conducted in 2014, and the prairie was burned in the spring of 2015 and again on 14 April 2016.

**Downer Woods Natural Area** - An 11.1 acre fenced woodlot, is an island of forested



natural area in an intensely urbanized setting on the UWM campus. The Field Station assumed management of Downer Woods in 1998. Since that time we have been working very hard to control the garlic mustard, buckthorn, and honeysuckle with funding provided by the University. In 2016 the Field Station obtained a grant from the *Southeastern Wisconsin Invasive Species Consortium* to continue eradication of invasive shrubs and garlic mustard in Downer Woods. We completed that funded control project in 2017, and management work in Downer Woods has entered a new maintenance phase requiring substantially less annual effort.



Groups use Downer Woods on the UWM campus

**UWM Innovation Campus – The UWM Monarch Conservancy** – In the northwestern part of UWM's new Innovation Campus on the old Milwaukee County grounds in Wauwatosa is an area that has been set aside and dedicated as wildlife habitat. The special target conservation goal for this site is butterfly habitat since it has historically been an important roosting area for Monarch butterflies during their fall migration. The Field Station has been assigned the initial management and restoration of that habitat area and has been working with the UWM Foundation and a local volunteer group, *Friends of the Monarch Trail*, to control invasive plants and begin restoring native vegetation on that site.

## Field Station Programs

- 28 active research projects conducted at the Field Station in 2018.
- Including: 3 M.S. theses, 4 Ph.D. and 7 studies by researchers from outside of the University.
- 22 papers published during 2018. Several others are in press.

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

- Vascular plant flora of the Field Station area (including approximately 720 taxa) & excellent herbarium.
- A complete stem map and diameter measurements of all trees in 5.5 acres (2.25 hectares) of the beech-maple woods first censused in 1987.
- Repeated surveys of the entire beech-maple forest at the permanent grid locations.
- A complete, quantitative, survey of the vegetation of the Cedarburg Bog, first conducted in 1991 and repeated in 2006.
- A working map of the Cedarburg Bog basin depth.
- Phenological observations on leaf-out and flowering of standard genotypes of 6 species in a phenological garden, and 25 naturally occurring species at the Station since 2001.
- Long-term weather records from a standard US Weather Service weather station and a Bowen-Ratio energy flux monitoring system. Dr. Mark Schwartz' research relating climatic parameters to seasonal development of plants has contributed to this long-term database.
- Continuous monitoring of bat activity levels at the Neda Mine Bat Hibernaculum since 2000 and of temperatures in the mine since 1997.
- Drs. Peter Dunn and Linda Whittingham have conducted long-term studies on tree swallows and sexual selection.

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

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

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

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

- GIS developed for the Field Station area.

### **Educational Programs**

- Over 12,700 person-hours of instruction and group use in 2018 .

- Nine workshops on topics in natural history.

- A new UWM course, Field Methods in Conservation, taught entirely at the Field Station, was taught in both the Fall 2017 and Fall 2018 semesters.

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

- 2 undergraduate student projects.

- 22 *Friends of the Cedarburg Bog* programs for the general public on a variety of topics.

- The guidebook to the Bog is available to teachers using the boardwalk for instruction.

- Several field ecology exercises developed for

the Field Station are available to instructors.

## **The Friends of the Cedarburg Bog – 2018**

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

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

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

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

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

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

Some of the main highlights and challenges for FOCB in 2018 included:

- FOCB continued the Bog Guardian Program, with supporting funds from the Ozaukee Washington Land Trust and the WI DNR – Citizen Based Monitoring Program. This multi-faceted program is designed to stop the advancement of 5 target invasive

plants that are nearly absent from the Bog area, and that are spread primarily along roadways, before they reach the area. The program also engages neighboring land owners through education and outreach.

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

- FOCB celebrated International Bog Day for the second time in 2018.

- FOCB continued to work on upgrading its web and social media presence.

- The Friends continue to expand and strengthen their educational programming for the general public with 22 educational events and programs in 2018.

- The Friends continued to be the primary

provider of stewardship of the Cedarburg Bog. 2018 was FOCB's fourth year of working on a \$197,000 grant from the EPA to control buckthorn in the Bog. With additional grants from the Natural Resource Foundation of Wisconsin and the DNR, and considering volunteer labor, that project is valued at over a quarter of a million dollars.

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

If you are interested in the Field Station's programs and activities, or you wish to support the preservation of the Cedarburg Bog State Natural Area, please consider joining the Friends group. Contact the Field Station for information on how to become involved, or visit the FOCB website, [www.bogfriends.org](http://www.bogfriends.org).



Friends of the Cedarburg Bog host multiple events at the Field Station. The annual winter hike in January is one of the most popular events.



# Abstracts of Research

## **Wildlife Population Assessment for the Milwaukee Estuary Area of Concern**

Gary S. Casper  
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The goal of this 4-year project is to evaluate the status of selected wildlife populations in Milwaukee and Ozaukee county portions of the Milwaukee River Area of Concern, and make recommendations for addressing Beneficial Use Impairments through habitat restoration projects and monitoring. The project is coordinated with Milwaukee County Parks, participating under sepa-

rate funding. Work included historical data collection, wildlife surveys, landowner outreach, and reporting. Final reports were submitted in 2018 and the senior author continues to participate in technical group meetings to advise on data use. Funded by the Wisconsin DNR and the U.S. Environmental Protection Agency.

## **Wildlife Monitoring in Ozaukee and Washington Counties, Wisconsin**

Gary S. Casper<sup>1</sup> and Katie Weber<sup>2</sup>  
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The Ozaukee Washington Land Trust (OWLT) began wildlife monitoring in 2004 as a means of assessing the success of habitat restorations, and identifying important wildlife resources for OWLT habitat management and acquisition and protection

planning. In 2018 OWLT continued acoustic monitoring at 6 OWLT properties, and we began analysis of 4 years of accumulated acoustic data. Funded by several habitat restoration grants.

## **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 recording systems is now fully implemented in seven National

Parks. In 2018 annual data collection continued and we analyzed and reported on 2017 data. Funded by the National Park Service

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## Wisconsin Herp Atlas

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

Over 600 new county records have been confirmed by the project. The data collected helps to map species distributions, document rare species occurrences, analyze distribution and habitat associations, and plan conservation priorities. In 2007 the Atlas was moved to the UWM Field Station, and currently houses over 73,000 occurrence records for Wisconsin. Record collection and vetting continued in 2018.



Casper et al. performed the first amphibian and reptile inventory of the Stockbridge-Munsee Community reservation in Shawano County, and published five new county records in 2018 in the Wisconsin Herp Atlas, such as this Four-toed Salamander (*Hemidactylium scutatum*)

## Collaborative Native Orchid Conservation and Restoration Project

Melissa Curran  
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North America is home to over 200 species of native orchids. Nearly half of these species are under severe threat due to habitat destruction, and many species are likely to become extinct unless action is taken to

conserve them and their fungal partners. Promoting efforts to conserve habitats and to restore native orchids where populations have declined will be essential to the future of these fascinating plants. Since

2012, a coalition of partners has focused on native orchid conservation by developing a large-scale, collaborative project addressing threats to native orchid species in Wisconsin with an emphasis on trying to understand their recovery and conservation potential. This project relies on shared resources across a network of partners including nonprofits, local municipalities, federal and state agencies, research institutions and private individuals. The project's main objectives are to support regional and national conservation efforts by supplying partner organizations with local genotypes



Seed capsules from Showy Lady's-slipper

for ex situ propagation, seed and fungal banking, and to advance the science of native orchid restoration through experimental outplantings of lab-propagated orchids in native habitats. Project tasks include investigating the biological requirements of several orchid species by collecting baseline data at reference sites where they occur; collecting seed for propagation experiments; collecting seed and root material for regional banking; identification of suitable outplanting sites; implementation of trial outplantings; and monitoring to evaluate the success of the introduced populations.

Several survey events were completed at Cedarburg Bog State Natural Area and the UW-Milwaukee Field Station in 2018 focused on documenting the distribution and abundance of orchid species and collecting information on orchid population associates. Mature seed capsules were collected from

showy lady's-slipper and yellow lady's-slipper for lab propagation trials. With luck, our team will have seedlings available for out-planting starting in 2020. Additional surveys and sample collections will be performed in 2019, specifically targeting species with limited distribution within the Cedarburg Bog. Conservation of native orchids requires a thorough understanding of the ecological requirements of each species, their historic and current distribution, associated pollinators and fungal relationships. Monitoring is needed at sites where orchids occur in abundance to ensure the sites selected for reintroduction match the existing habitat in its vegetation characteristics, soil composition, geology and hydrology; this level of understanding is critically important for ensuring the long-term survival of reintroduced orchids, and Cedarburg Bog will play a significant role as a living laboratory for orchid conservation studies.



Seed capsules from Pink Lady's-slipper

# A Resurvey of a Prairie Restoration Using Small-scale Disturbances Shows Increasing Benefits Over Time

Katrina Degenhardt

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Small-scale disturbances can be used in prairie restorations to create open patches for seeding of native plants. It may take time for native plants to establish, so monitoring over time is necessary. A study using small-scale disturbances to seed native species in an old agricultural field dominated by exotic grasses was carried out at the University of Wisconsin-Milwaukee Field Station in Saukville, WI. Disturbance plots were created by placing coverboards in a 15 X 15 meter grid, removing established vegetation. Each disturbance plot was seeded in 2010 after the coverboards were removed, with either native forbs, native grasses, both native forbs and grasses, or no seeding. Untreated plots to represent the background vegetation were also included. In 2011, the plots were sampled by estimating percent cover for each species rooted within the plots. This survey showed a greater abundance and diversity of native plants in the disturbance plots that were seeded than those that were not. The seeded forb species showed a higher abundance and more successfully repressed the exotic grasses than did the seeded grasses. A follow up survey was conducted in 2018 to determine if the species that had previously established could maintain or increase their population, if seeded species that were not detected would establish, and if the species composition and diversity of the field would change over time. The 2018 survey showed that the seeded species which were found in 2011 generally increased in population, and most of the seeded species which had

not appeared were now present. The abundance of the native grasses dramatically increased, and the population of the exotic grasses decreased especially in the plots seeded with grass only. These results show that small-scale disturbances can be used to establish native plants in abandoned agricultural fields and that benefits increase over time. Undergraduate research project, Dr. Gretchen Meyer, advisor.



A clump of native grass that established in a grass plot



# Chlorophyll Characteristics of a Range of Native and Invasive Shrub Species in a Small Urban Woodland

Alison Donnelly<sup>1</sup>, Chloe Rehberg<sup>1</sup>, Erica Young<sup>2</sup>, Rong Yu<sup>1</sup> and Gretchen Meyer<sup>3</sup>

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The end of the growing season in deciduous forests is characterized by a decrease in photosynthetic activity and an increase in leaf color of shrubs and trees. In recent studies, the timing of satellite-derived leaf color is consistently earlier than direct in situ observations of leaf color change. In order to explore possible reasons for this discrepancy we monitored leaves of a range of native (choke cherry *Prunus virginiana*, wild currant *Ribes americanum*, maple leaf viburnum *Viburnum acerifolium* and nannyberry *Viburnum lentago*) and invasive (buckthorn *Rhamnus cathartica*, honeysuckle *Lonicera spp.* and European privet *Ligustrum vulgare*) shrubs in Downer Woods on the UW-Milwaukee campus during the 2018 autumn season. Twice weekly, we carried out a series of recordings on three leaves of three individual plants of each species. We conducted four activities: (i) direct visual observations of leaf color, (ii) leaf chlorophyll content using a handheld meter (SPAD), (iii) leaf sampling for chlorophyll extraction to validate the SPAD values,

and (iv) chlorophyll fluorescence. Preliminary results suggest that invasive species have a greater amount of leaf chlorophyll as determined by higher SPAD values and stay greener longer than their native counterparts. In the coming months, we hope to quantify the relationship between SPAD values and (i) absolute chlorophyll content and (ii) direct observations of leaf color. Since chlorophyll degradation begins prior to visible symptoms we expect these results may at least in part help explain the discrepancies observed between satellite and in situ observations of leaf color. This work is part of a larger project which has been funded by a UWM RGI grant entitled 'Determining the contribution of the shrub layer to overall forest phenology using in situ observations and remote sensing metrics' which has been presented at the Phenology 2018 conference in Melbourne, Australia and also featured on WUWM (<http://www.wuwm.com/post/uwm-partners-international-space-agencies-study-shrubs#stream/0>).



Chloe Rehberg using a handheld chlorophyll meter to determine leaf chlorophyll content nondestructively



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

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Climate change is altering environmental conditions, thus, understanding the mechanisms influencing the timing of reproduction has taken on new urgency as there is concern that species will not be able to synchronize their reproduction with changing food supplies. In 2018 we completed the 22<sup>nd</sup> 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, precipitation, wind speed and food abundance, influence the timing of breeding and reproductive success. At the Field Station, we measure the abundance of flying insects in a bug trap, collect data from the weather station, and monitor the timing of egg laying, the number of eggs

and the number of nestlings produced in a population of box-nesting tree swallows. A prominent hypothesis predicts that reproductive success is maximized when animals synchronize their reproduction with seasonal peaks in food supply, but the synchrony will be disrupted by climate change. This mismatch hypothesis does not seem to be supported in tree swallows, and many other species. Instead, reproductive success appears to be more closely related to the absolute levels of food, rather than to the timing of food. We thank Gretchen Meyer and Ron Tagye for their assistance, particularly in collecting data. This research was supported by funds from the College of Letters and Science, UWM.

## Fifty Shades of Grey in Treefrogs: Investigating Multimodal Signals in *Hyla versicolor*

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Animal signals are often composed of multiple signal modalities, such as vocal, visual, or tactile components. Research in anuran communication tends to focus on acoustics, despite many frogs also showing conspicuous coloration. In 2018 we explored how visual signals interact with advertisement calls to determine whether Eastern Grey Treefrogs (*Hyla versicolor*) employ multimodal signaling in mate attraction. Eastern Grey Treefrogs exhibit different pigmented traits involved in the color display

and we chose to focus on the grey throats (melanin pigment) and yellow hind legs (carotenoid pigment): melanin is genetically influenced, and carotenoid is environmentally acquired. Additionally, we investigated possible proximate mechanisms underlying these color traits by collecting salivary samples for sex (testosterone) and stress (corticosterone) hormone analyses. Using phenotypic integration matrices, we visualized the interrelationships between visual and acoustic traits to examine the extent



Variation in yellow coloration of treefrog hind legs

that these traits covary either independently (modularity) or jointly (integration). Modularity analyses indicate that call functions as one module and both color displays function as a second module. Additional integration analyses show that call and throat color traits covary jointly, suggesting that these traits may signal a similar message to the same receiver (likely females). By contrast, call and leg color traits do not covary jointly, suggesting different receivers (likely females versus predators). These analyses reveal semi-independence of call and color traits, alluding to potential importance of multi-

modal signals in anuran sexual selection. Hormone analyses are pending, but they will be included in the phenotypic integration matrix once salivary concentrations have been determined. Future research will investigate the behavioral significance of multimodal signals and hormones by investigating *H. versicolor* female responses to various visual traits. Funded by an Animal Behavior Society's Student Research Grant and a Society for the Study of Amphibians and Reptiles' Field Research Grant in Herpetology. M.S. Thesis research, Gerlinde Höbel, Major Advisor.

## **Diverse Microbial Communities Hosted by the Model Carnivorous Pitcher Plant *Sarracenia purpurea*: Analysis of Both Bacterial and Eukaryotic Composition Across Distinct Host Plant Populations**

Jacob Grothjan and Erica Young

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The pitcher plant *Sarracenia purpurea* supplements nutrient acquisition through carnivory, capturing insect prey which are digested by a food web of eukaryotes and bacteria. The food web invertebrates are well studied, and some recent studies have characterized bacteria, but detailed genetic analysis of diversity is lacking. This study aimed to compare eukaryotic and bacterial composition and diversity of pitcher communities within and between populations of host plants in nearby but distinct wetland habitats, and to characterize microbial functions across populations, and compare with other freshwater communities. Pitcher fluid was sampled from Cedarburg and Sapa bogs, and community DNA was extracted while rRNA amplicons were sequenced and data processed for community-level comparisons. Bacterial diversity in the small pitcher volume rivaled that of larger aquatic communities. Between pitcher plant populations, several bacterial families were significantly higher in one population. Predicted pitcher bacterial functions were distinct from other freshwater communities, especially for amino acid metabolism, but most functions were similar across all the pitchers.



Fluid from pitcher plant drawn for analysis

This suggests some bacterial functional redundancy, and that different bacterial composition achieves similar food web processes. Sequencing identified a previously under-appreciated high diversity of ciliates, Acari mites, fungi and flagellates in pitcher communities. Two thirds of eukaryotes were identified as food web inhabitants and a third as prey organisms. Although eukaryotic composition was not significantly different between populations, different species represented core taxonomic groups in different pitchers. Wetland habitat differences may provide distinct taxa available to colonize new pitchers. Eukaryotic composition was more variable than bacterial composition, and there was a poor relationship between bacterial and eukaryotic composition within individual pitchers, suggesting that colonization by eukaryotes may be more stochastic and that bacterial recruitment to pitchers may involve factors other than prey capture and colonization by eukaryotic food web inhabitants. Ph.D. dissertation research, Dr. Erica Young, Major Advisor.



Syringe used to extract fluid from pitcher plants

## Plant-soil Feedbacks Across Resource Gradients

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A major goal in ecology is predicting the outcome of interactions between species. However, achieving this goal has been challenging, because these interactions are notoriously context dependent and can vary over time and space. A first step to understanding this variation is to determine how abiotic factors influence the relative abundance of interacting partners. We asked how the abundance of soil biota (mutualists and pathogens) and herbivores associated with wild bergamot (*Monarda fistulosa*) differ in two climatic regions: low-productive semi-arid grasslands in Montana and high-productive tallgrass prairies in Wisconsin (including Benedict Prairie and the UW-

Milwaukee Field Station). Root colonization by beneficial mycorrhizal fungi (AMF) did not differ between the regions, but colonization by other fungi, which may include pathogens, was greater on plant roots from Wisconsin than on plant roots from Montana. Ongoing and future greenhouse experiments are testing how plant responses to soil biota differ between soil collected from Montana and Wisconsin. Our results indicate that spatial variation in resource availability may influence the outcome of interactions among plants, soil biota and herbivores. Funded by MPG Ranch.

## Plumage Ornaments Signal Male Physiological Quality in Common Yellowthroats

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Elaborate ornaments are thought to honestly signal quality to potential mates. These ornaments may signal a variety of physiological processes that affect health and fitness. I examined the relationship between ornaments and physiological quality in a bird, the common yellowthroat (*Geothlypis trichas*). Male common yellowthroats have two plumage ornaments, a black (eumelanin-based) mask and a yellow (carotenoid-based) bib. Males with larger masks are preferred by females for both extra-pair and social mates. I found that both the mask and the bib of male common yellowthroats honestly signal their ability to resist oxidative stress. Males with larger masks and more colorful bibs also produce a greater amount of corticosterone,

a hormone that releases stored energy and induces adaptive behavioral changes, during a short-term stress response. This suggests that these ornaments signal how well males cope with stressful situations. In contrast, neither the mask or the bib signal the infection intensity of haemosporidian parasites across males in the population. However, haemosporidian infection intensity was not related to overwinter survival or body mass, suggesting that these parasites may not be very costly. Together, these results suggest that both melanin- and carotenoid-based plumage ornaments honestly signal male physiological quality in common yellowthroats. PhD. dissertation research, Dr. Peter Dunn, Major Advisor

## Salamander Cover Board Survey

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As part of a larger inventory project of amphibians at the UWFS property (my lab already has call and visual surveys of anurans in place), we placed cover board arrays in several locations at the Field Station forest. The short-term goal is to reassess presence of species at the Field Station, for which data has not been collected since the last published report in 2007 (Casper 2007), and to provide a comparative data set about salamander abundance to be compared with the effectiveness of conservation dogs

also training at the site. Since deployment of the boards in late summer 2017, we have captured Blue-spotted salamanders and Eastern Newts under the boards (as well as Wood Frogs and Spring Peepers). We are adding to the data set to eventually be able to extract seasonal patterns cover board-use, as well as examining whether certain board sizes are accepted more frequently than others.

# White-nose Syndrome Dynamics in Large Colonies of *M. lucifugus*

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White-nose syndrome (WNS) has caused massive mortality in bat populations across the eastern United States and is continuing to spread across North America. The disease is caused by the pathogen *Pseudogymnoascus destructans* (Pd), which first invaded into Wisconsin in the winter of 2013/14. Despite the devastating population impacts suffered by bats across this region several colonies of bats still persist post-WNS invasion. However, the mechanisms allowing some colonies to persist while others are extirpated remain unknown. Our research seeks to understand the mechanisms underlying population persistence, which can help determine the most effective management strategies that may yield the greatest benefit for each population and species. Our data from hibernacula across the northeastern U.S. suggest that density influences population declines of some species but not others, whereas in the Midwestern U.S., all species experience density-dependent declines (e.g. smaller declines in smaller populations). Species with density-dependent declines should be more likely to persist with WNS because transmission

should decrease as populations become smaller. In order to assess whether density is important in bat population persistence, it is essential to study a large range of bat colony sizes of multiple species. Our studies of the large bat population at the Neda Mine field station will complement existing work on smaller colonies in Wisconsin and allow us to draw stronger comparisons to large bat colonies in the Northeast. This research will aid also enable us to track the health and potential slow recovery of bat populations in Neda Mine. Funded by the U.S. Fish and Wildlife Service.



A little brown bat in Neda Mine. It is covered with condensed water, which happens in the more humid sites like Neda.

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

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A major unsolved question in biology is why plant populations often maintain a mixture of two reproductive strategies. Long standing genetic theories predict that the extreme form of inbreeding known as self-fertilization should rarely co-exist with outcrossing. Yet

this dual strategy is surprisingly common in nature, suggesting that existing theory does not adequately explain the maintenance of mixed mating. This project tests the hypothesis that ecological interactions among plant species help maintain dual strategies.



When plant species flower together and share pollinators, pollen is often wasted on flowers of other species, reducing the benefits of cross-pollination. We are testing this hypothesis through a combination of field studies of pollinator behavior, measurement of floral traits, and molecular genetic lab studies of parentage.

Most studies of plant mating systems quantify selfing rates for entire populations, using multilocus estimation models. However,

natural selection operates on individuals, and we know surprisingly little about how floral traits influence individual selfing rates. Through the use of unambiguous paternity analysis (100% exclusion), we are determining whether selfing rates and male fertility of individual plants are consistent within clonal lines, and whether they correlated with heritable floral traits. Funded by the National Science Foundation.

## Warning Colors in Gray Treefrogs: Aposematism or Deimatic Displays?

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As part of a larger research agenda investigating variability and color change in Gray Treefrogs, this particular project focuses on the yellow thigh color of Gray Treefrogs. Aposematic or warning colors are used by toxic or defended animals to warn potential predators that they are dangerous, noxious or otherwise unprofitable. On the other hand, generally undefended animals may use deimatic or startle displays to scare off or momentarily distract predators, thus giving them the chance to escape. Unlike aposematic behaviors, which are mostly static and permanently 'switched on', the startling visual cue in deimatic displays is only revealed when necessary. Eastern Gray

Treefrogs (*Hyla versicolor*) are generally camouflaged, but show conspicuous yellow coloration in their armpits, groin and legs. They also produce noxious skin secretions that can cause discomfort in the eyes (at least for humans). We tested two hypotheses about the function of the yellow color patches in Eastern Gray Treefrogs (Deimatic displays vs aposematic coloration). Because the yellow patches are not permanently displayed, but only visible when the frogs are disturbed (i.e., "switched-on" during escape locomotion), we suggest a deimatic display function.

## Breeding Bird Survey at the Cedarburg Bog in 2018

John O'Donnell

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The fourth year of the Wisconsin Breeding Bird Atlas II (WBBII) has now been completed with only one year left (2019) on the five year State-wide breeding bird survey project. Given the special significance of the Cedarburg Bog designation as an "Important Bird Area" within the State of Wisconsin, the Bog and the Upland Woods

have been determined to be an area of special conservation significance - meaning that special efforts were made to thoroughly census the breeding bird population within the Cedarburg Bog complex. These efforts have paid off with nearly 80 confirmations of breeding species and 28 more species as "probable" breeders.

New additions in 2018 to the “confirmed breeding species” list in the Cedarburg Bog are: Chimney Swift, White-throated Sparrow, Indigo Bunting, and Red-shouldered Hawk. Historically, Red-shouldered Hawks were reliable breeders in the Bog; however, they disappeared at least 20 years ago. In 2018 they were observed in and around the Cedarburg Bog all through the spring and summer and by mid-summer they were confirmed as once again breeding - possibly in two different locations. This is likely the first time in 20+ years that Red-shouldered Hawks have nested in Ozaukee County. On the “probable breeder list” in the Bog are Ring-necked Pheasant, Canada Warbler, and Sora. These species will hopefully yet be confirmed as breeders in 2019.



Red-shouldered Hawk



Canada Warbler



White Throated Sparrow



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

John O'Donnell

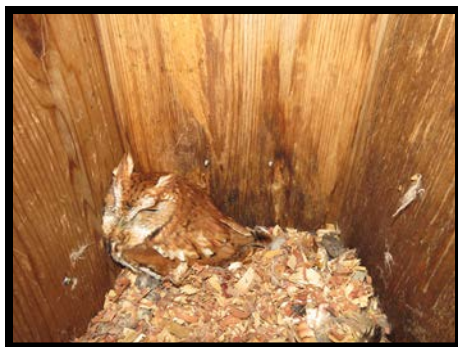
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Installation of nesting boxes for cavity-nesting ducks and owls was initiated in 2012 with four wood duck nest boxes and four nest boxes for small owls, e.g., eastern screech and northern saw-whet owls. By the close of 2018, 26 duck nest boxes were being actively monitored and maintained in and around the Cedarburg Bog. The boxes are equipped with predator guards. Some of the duck boxes are on trees, but most are on 10' poles driven down into the ground or into the substrate of a pond or lake. Fourteen of the duck boxes are under the direct supervision of the Friends of the Cedarburg Bog (FOCB), and 12 of the duck boxes have been installed by and/or maintained by private landowners on their own property in conjunction with the FOCB Duck Nest project.

Two of the original small owl nest boxes on DNR bog property have been "decommissioned" due to continual problems with squirrels being able to circumvent the predator guards. In their place, two large nest boxes for Barred Owls were constructed and hung in large trees -- one on DNR property within the Bog and one on private property within the Bog. All four of these owl boxes are being maintained and monitored by the Friends of the Cedarburg Bog.

In 2018, egg laying occurred in 18 of the 26 duck boxes indicating 69% overall usage; however, only 34% of the boxes gave evidence of successful duck fledging. One explanation for this is "egg dumping" -- a descriptive term referring to the phenomenon of hens laying eggs in an empty box or in the nest of another hen's box without incubating the eggs laid. Other explanations for nest failures include the spate of cold winter-like conditions which occurred late last spring and/or the presence of predators such as Cooper's hawks. The most

successful nest boxes were those over water. Hooded Mergansers utilized two "over water" nest boxes with one successful nest producing eight ducklings. The other 16 duck nest boxes were utilized by Wood Ducks.



Screech Owl in Nest Box

Once again, there was no evidence of owls using any of the boxes for nesting. It may be that there is a plethora of natural tree cavities suitable for owl nesting in which case the FOCB owl nest boxes face formidable competition. However, the small owls were not averse to using the boxes for roosting. Based on pellet evidence, the two small owl boxes on DNR land were actively used as winter roosts by saw-whet owls. An eastern screech owl using a wood duck box on private property near the bog as a roost was quite startled when his/her abode was opened for maintenance! In sum, the small owls have consistently used the boxes for roosting; however, to date they clearly prefer tree cavities over the boxes for nesting. For three years now, barred owls have yet to show any interest in the large owl boxes constructed for them.

# 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 ther-

mally 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 al-

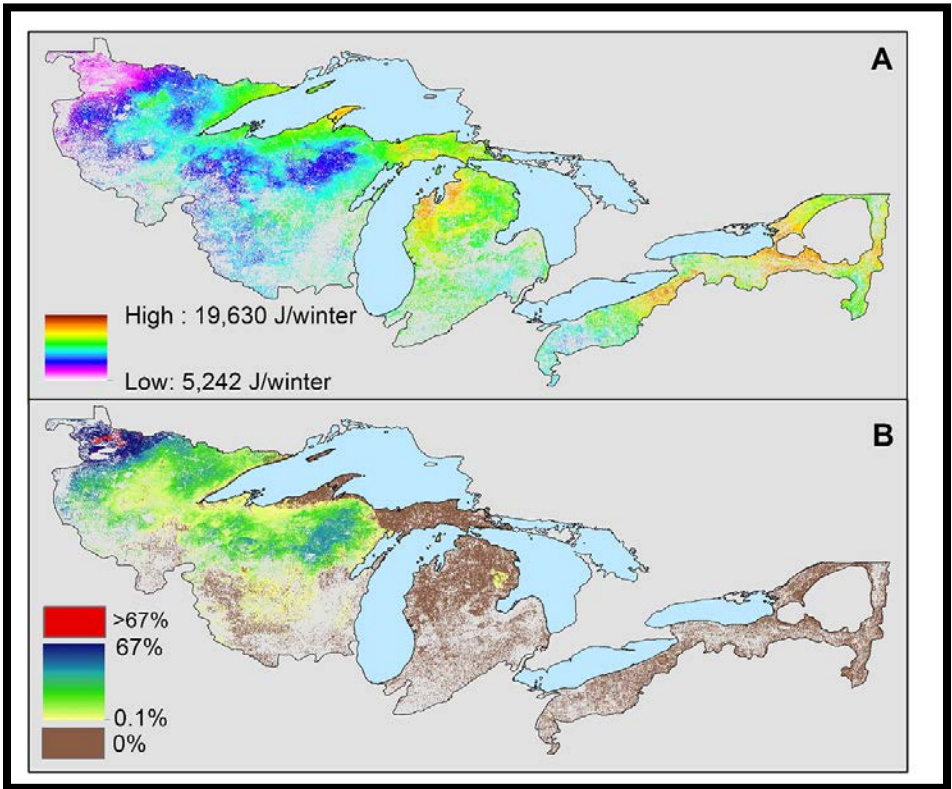


Figure 1. A) Simulated energy requirements of wood frogs wintering in shallow soil across the midwestern United States under recent average weather conditions. Energy requirements must be met by burning stored fat or carbohydrate reserves. B) Simulated peak ice content (percent of body water frozen) reached by wintering wood frogs under recent average weather conditions. Wood frogs are freeze-tolerant but cannot survive temperatures that cause greater than approximately 67% of their body water to freeze.

low 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 validate a mechanistic model of soil temperature based on winter weather conditions and forest type. We used this model, combined with a model of animal heat-mass balance, to simulate the winter physiology of wood frogs, a freeze-tolerant species which hibernates in the subnivium,

across the midwestern United States. Under average winter weather conditions of the past decade (2007-2016), we found that winter energy requirements for wood frogs were highest in lake effect snow regions, where well-insulated soil and moderate air temperatures kept wood frog metabolic rates high over a long snow season (Fig. 1A). In contrast, wood frogs were more likely to reach lethally low temperatures in northwest Minnesota, where cold air temperatures and shallow snow led to cold soil (Fig. 1B). As our next step, we will model wood frog physiology under future climate conditions to predict climate change effects on future wood frog survival. Funded by the National Science Foundation.

## Common Elements in the Development and Function of Vertebrate and Insect Communication Systems

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We are using laser vibrometry and vibrational playback experiments to study the nature of the communication system of *Enchenopa* treehoppers. These are insects that communicate with vibrational signals that have a complex hierarchical structure. Male signals have two elements (a pure-tone “whine” followed by pulses); individual signals are grouped into signal bouts, and bouts into series. Females have strong mate preferences for particular features in male signals.

Recent surprising discoveries include a process of social ontogeny, wherein interactions with other individuals early in life shape the development of signals and preferences - previously documented in humans, some other primates, whales and some birds, this is the first example from an invertebrate. Another such feature is combinatorial signal processing, with rules regarding the combinations of signal elements that are acceptable to receivers. Funded by the Research Growth Initiative (UWM).



Rafa Rodríguez in the field



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## Variation in Throat Pigmentation and its Influence in Mating Success in Eastern Gray Treefrogs

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As part of a larger research agenda investigating variability and color change in gray treefrogs, this particular project focuses on the throat color of gray treefrogs. Over the breeding season (May/July) we took pictures of the throat and belly area of males and females collected at Byers Pond for our behavioral studies. There are currently 3 parts of this study, in different stages of completion: (1) To examine year-round variation in throat color, we have deployed PVC refugia in the woods around the forest to try and obtain color data from

frogs outside the breeding season. Data accumulation is slow, and no results can be reported yet. (2) The project examining sex differences in throat coloration is completed and submitted for publication. Males and females differ in their throat color (males have darker throats) and the darkness of male throat coloration increases as the breeding season progresses. (3) The project examining whether throat color is involved in mate choice is still in progress. Undergraduate research project, Dr. Gerlinde Höbel, advisor.

## 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.

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## Influence of Natural and Anthropogenic Light Levels on Female Preferences in Eastern Gray Treefrogs (*Hyla versicolor*)

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While the influence of environmental variables, particularly temperature and rainfall, on the breeding behavior of amphibians is widely recognized, relatively few studies have addressed how the moon affects amphibian behavior. Yet, the lunar cycle provides several rhythmic temporal cues that animals could use to time important group events such as spawning, and the substantial changes in light levels associated with the different moon phases may also affect the behavior of nocturnal frogs. Using seven years of field observation data, we tested for lunar effects on the reproductive activity of male and female Eastern gray treefrogs (*Hyla versicolor*). We found that chorusing and breeding activity was statistically more likely to occur around the first quarter of the moon and during intermediately bright nights, but that reproductive activity also occurred during various other times during the lunar cycle. We discuss these findings in relation to the two main hypotheses of lunar effects on animals: predator avoidance and temporal synchronization of breeding.

Nocturnal light levels vary throughout the course of the lunar cycle, being darkest during the new moon and brightest during the full moon. Many nocturnal animals change their behavior in response to this natural variation in moonlight intensity. Frequently, these behavioral changes can be attributed to the way in which moonlight affects the ability of predators to spot potential prey. Mate sampling females may expose themselves to predators, making mate choice a behavior likely influenced by moonlight. Because mate choice is an important cause of sexual selection, understanding the causes of variation in mate choice decisions can yield a better understanding of the strength and direction of sexual selection under natural conditions. We predicted that female

Eastern gray treefrogs (*Hyla versicolor*) would prefer longer calls (i.e., more attractive males) and/or be choosier, under darker conditions, because cover of darkness may aid in predator evasion. However, light treatment did not affect how females responded to variation in call duration, nor did it affect female choosiness or aspects of their approach behavior. This suggests that in gray treefrogs, variation in light levels associated with the changing phases of the moon does not alter the sexual selection regime on male call traits.

Human activities are drastically changing the amount of artificial light entering natural habitats. Because light pollution alters the sensory environment, it may interfere with behaviors ranging from prey detection and vigilance to mate choice. Here we test the hypothesis that anthropogenic light pollution affects the mate choice behavior of female Eastern gray treefrogs (*Hyla versicolor*). We tested this hypothesis under two experimental light treatments that simulate the light pollution created by streetlights (i.e., expansion of lit areas and increased light intensity), and the light pollution created by headlights of passing vehicles (i.e., rapid fluctuations between bright and dark conditions). The hypothesis predicts that females tested under conditions simulating light pollution will show behavioral changes geared towards mitigating detection by predators, such as relaxed preferences, decreased choosiness for the normally preferred call, and differences in approach behavior (either more directional, faster, or stealthier movements, or no approach at all). Contrary to our prediction, we found that light pollution did not affect mate choice behavior in gray treefrogs, and should therefore neither interfere with population persistence nor affect the sexual selection regimes on male call

traits of this species. However, we caution that this result does not imply that anthropogenic light pollution is of no concern for amphibian conservation, because behavioral responses to variation in nocturnal light levels (both in the natural as well as

anthropogenically enhanced range) seem to be highly species-specific in anurans. We encourage additional studies to help gauge the vulnerability of anurans to anthropogenic light pollution. M.S. Thesis research, Dr. Gerlinde Höbel, Major Advisor.

## **Individual Variation in Multivariate Signal Assessment in *Hyla versicolor* Females**

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Female choice is a widely researched topic of sexual selection. Biologists have characterized both the variation in male mating displays and shape of female preferences for such behaviors across a variety of taxa. In the wild, choosers must assess displays that vary for multiple traits, however, much of what is known about preference stems from female responses to univariate scenarios. While there is value in measuring how females assess synthetically-controlled advertisement traits separately, their response to more authentic multivariate options is critical to understanding patterns of mate choice. Here we test the expression of female preference by Eastern gray treefrogs in a two-choice scenario involving bivariate call manipulation. The rate and duration of males' calls are strongly inversely proportional, generating an abundance of "mixed attractiveness" among neighboring displays (e.g. one male frequently produces a com-

paratively shorter but faster call). By exploiting this call trade-off, we use a repeated-trial design that forces females to prioritize one trait over the other. We found that duty cycle is widely required for discrimination, with the majority of females failing to show a consistent preference. Among those that demonstrated repeatable preference, there was significant support for prioritization of call duration, as well as an indication that other individuals prioritize rate. On average, these females chose a stimulus significantly faster than inconsistent females, indicating "confused" sampling behavior among less discriminant individuals. These findings provide new insights on the cognition of multivariate assessment and the efficacy of female choice in driving signal evolution. M.S. Thesis research, Gerlinde Höbel, Major Advisor.

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

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

logical responses between predators and prey can result in cascading asynchronous phenological change within food webs and alter ecosystem dynamics.

By studying the phenology of life events throughout the annual cycles of organisms, researchers are able to better understand

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

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

This will be accomplished by adding contemporary data to and filling gaps in long-term phenological datasets from a myriad of sources. Historic bird banding data

recorded by Dr. Chuck Weise at the UWM Field Station during the late 1960s through the early 1990s will be analyzed for trends in aspects of bird breeding phenology such as the timing of brood patch development in passerine females. Findings will be compared to contemporary bird banding data from current and ongoing research projects in Ozaukee and Milwaukee counties.

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

## Effects of Different Bumble Bee Species on Reproductive Success, Facilitated Selfing, and Mate Diversity in Monkey-flower

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Over the last decade there have been startling changes in the abundance and diversity of bumble bee populations, including significant decline of many species both in North America and Europe. Several species often coexist within a population and it is not known whether these species provide equivalent pollination services for native flowering plants. To address this question we quantified seed set, pollen deposition, outcrossing rate and mate diversity of *Mimulus ringens* flowers following individual

visits by *Bombus impatiens* and *Bombus vagans*. The mean number of seeds produced per fruit following single visits by *B. vagans* was significantly higher than from visits by *B. impatiens* (ANOVA;  $P < .02$ ). *B. vagans* also deposited significantly more pollen on plant stigmas per visit. Outcrossing rates within fruits did not differ between visits by these two species. However, the correlation of paternity among offspring within fruits visited by *B. vagans* was higher than fruits visited by *B. impatiens*. This

suggests that pollen deposited by these two species contain a different number of pollen donors. Morphology among these species is relatively similar, except for tongue length. Perhaps tongue size influences bee behavior within the flower and subsequent plant reproduction. The results of this study suggest that bumble bee species may have

unequal contributions to some aspects of plant reproduction. Therefore local plant reproduction may be affected by changes in pollinator composition as well as changes in pollinator abundance. Ph.D. dissertation research, Dr. Jeffrey Karron, Major Advisor.

## Bat Activity Surveillance and Monitoring at Neda Mine Hibernaculum

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White-Nose Syndrome (WNS) has spread to 33 states and seven Canadian provinces. The fungus, *Pseudogymnoascus destructans* (Pd), that causes the syndrome has been found in three other states (MS, TX and WY). This deadly disease has and continues to cause massive bat mortality in North America. WNS was confirmed in Wisconsin on March 28th, 2014. As of May 2018, all visited sites in Wisconsin have been confirmed infected with either Pd or WNS. Closely monitoring WNS-affected bat populations is essential to better understand identify and protect surviving populations.

The bat population of Neda Mine has been inspected (either by internal or external methods) annually for the past eight hibernation seasons and continues to be inspected. Neda mine was confirmed Pd infected in April of 2015 and the proceeding hibernation season (2016), the Wisconsin Bat Program (WBP) received many public reports from nearby areas that observed

aberrant winter bat behavior, almost all reports resulting in the collection of dead bat carcasses. WBP did not receive any public reports of bat activity in or around Neda mine during the winter of 2017 or 2018.

WBP only inspected the mine through external methods in the 2017-2018 season and was limited to one trapping session. The goal was to trap a sample of bats late in the pre-hibernation period to 1) understand fall weight gain cycle, 2) collect standard measurements (weight; forearm length; species; sex) and 3) reproductive activity.

WBP harp-trapped at one mine entrance for one evening during fall swarm. Twelve bats were captured in September (2018), all little brown bats (*Myotis lucifugus*) (9 male, 3 female). Of the bats captured that evening, four were aged as juveniles (3 male, 1 female) and eight as adults (6 male, 2 females). All adult males displayed signs of being reproductively active.



## Identification of Microorganisms From Soil at UWM Field Station

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Different media were used to isolate microorganisms from soils collected from the rhizosphere. The bacterial colonies of different types or colors were picked and the single colonies were further purified by streaking them on the agar plates. To identify the bacteria isolated in the soils, the chromosomal DNA of each bacterium was isolated and the 16S rDNA was amplified through PCR and sequenced. Different

bacteria such as *Lysobacter*, *Pseudomonas*, *Duganella*, *Brevibacillus*, and *Rhizobium* spp. were identified in this study. The compounds produced from the bacteria were extracted and their biological activities were evaluated. Funded by the United States Department of Agriculture, National Science Foundation, and T3 Bioscience LLC.



Leather-leaf (*Chamaedaphne calyculata*)

# Recent Publications and Theses

## — Recent Publications Resulting from Field Station Projects —

- Anton, T. G., T. F. Beauvais and G. S. Casper.** 2014. Geographic distribution: *Clonophis kirtlandii* (Kirtland's Snake), USA: Illinois: De Kalb County. *Herpetological Review* 45(3):465.
- Beck, J. B., J. C. Semple, J. M. Brull, S. L. Lance, M. M. Phillips, S. B. Hoot and G. A. Meyer.** 2014. Genus-wide microsatellite primers for the goldenrods (*Solidago*; Asteraceae). *Applications in Plant Sciences* 2 (4): 1300093. doi:10.3732/apps.1300093.
- Beck, J.B., C.J. Ferguson, M. H. Mayfield and J. Shaw.** 2014. Reduced genetic variation in populations of black cherry (*Prunus serotina* subsp. *serotina*, Rosaceae) at its western range limit in Kansas. *Northeastern Naturalist* 21(3):472-478.
- Casper, G.S.** 2014. Geographic distribution: *Diadophis punctatus edwardsii* (Northern Ring-necked Snake), USA: Minnesota: Cook County. *Herpetological Review* 45(1):94.
- Bradley D. W., R. G. Clark, P. O. Dunn, A. J. Laughlin, C. M. Taylor, C. Vleck, L. A. Whittingham, D. W. Winkler and D.R. Norris.** 2014. Trans-Gulf of Mexico loop migration of tree swallows revealed by solar geolocation. *Current Zoology* 60:653-659.
- Fowler-Finn, K. D., N. Al-Wathiqui, D. Cruz, M. Al-Wathiqui and R. L. Rodríguez.** 2014. Male *Enchenopa* treehoppers (Hemiptera: Membracidae) vary mate-searching behavior but not signaling behavior in response to spider silk. *Naturwissenschaften* 101:211-220.
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- Höbel G. and T. Barta.** 2014. Adaptive plasticity in calling site selection in gray treefrogs (*Hyla versicolor*). *Behaviour* 151:741-754.
- Reichert, M., H. Galante and G. Höbel.** 2014. Female grey treefrogs, *Hyla versicolor*, are responsive to visual stimuli but unselective of stimulus characteristics. *Journal of Experimental Biology* 217:3254-3262.
- Rebar, D. and R. L. Rodriguez.** 2014. Trees to treehoppers: genetic variation in host plants contributes to variation in the mating signals of a plantfeeding insect. *Ecology Letters* 17: 203-210.
- Rebar, D. and R. L. Rodriguez.** 2014. Genetic variation in host plants influences the mate preferences of a plant-feeding insect. *American Naturalist* 184: 489-499.
- Thomas, J. J. and G. Höbel.** 2014. *Hyla versicolor* (Eastern Gray Treefrog). *Lacrima Spot*. *Herpetological Review* 45(1): 112.
- Whittingham, L. A. and Dunn, P. O.** 2014. Extra-pair mating and sexual selection on male traits across populations. *The Wilson Journal of Ornithology* 126:9-18.
- Casper, G. S.** 2015. New county distribution records for amphibians and reptiles in Wisconsin. *Herpetological Review* 46(4):582-586.
- Casper, G. S., J. B. LeClere and J. C. Gillingham.** 2015. *Natural History Notes. Thamnophis sirtalis* (Common Gartersnake). Diet/scavenging. *Herpetological Review* 46(4):653-654.
- Casper, G. S., R. D. Rutherford and T. G. Anton.** 2015. Baseline distribution records for amphibians and reptiles in the Upper Peninsula of Michigan. *Herpetological Review* 46(3):391-406.
- Fowler-Finn, K. D., J. T. Kilmer, A. C. Hallett and R. L. Rodríguez.** 2015. Variation in signal-preference genetic correlations in *Enchenopa* treehoppers (Hemiptera: Membracidae). *Ecology and Evolution* 5: 2774-2786.
- Hileman, E. T., J. M. Kapfer, T. C. Muehlfeld and J. H. Giovanni.** 2015. Recouping lost information when mark-recapture data are pooled: a case study of milksnakes (*Lampropeltis triangulum*) in the upper Midwestern United States. *Journal of Herpetology* 49: 428-436.
- Liu, L., L. Liang, M. D. Schwartz, A. Donnelly, Z. Wang, C. B. Schaaf and L. Liu.** 2015. Evaluating the potential of MODIS satellite data to track temporal dynamics of autumn phenology in a temperature mixed forest. *Remote Sensing of Environment* 160: 156-165.
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methanogenic environments. *Microbiology* 161:1189–1197.

**Meyer, G. A.** 2015. Playing the field. *Science* 348: 938.

**Rebar, D. and R. L. Rodríguez.** 2015. Insect mating signal and mate preference phenotypes covary among host plant genotypes. *Evolution* 69: 602–610.

**Reichert, M. S. and G. Hoebel.** 2015. Modality interactions alter the shape of acoustic mate preference functions in gray treefrogs. *Evolution* 69: 2384–2398.

**Rodríguez, R. L., M. Araya-Salas, D. A. Gray, M. S. Reichert, L. B. Symes, M. R. Wilkins, R. J. Safran and G. Höbel.** 2015. How acoustic signals scale with body size: common trends across diverse taxa. *Behavioral Ecology* 26: 168–177.

**Rosenfield, R. N., W. E. Stout, M. D. Giovanni, N. H. Levine, J. A. Cava, M. G. Hardin and T. G. Haynes.** 2015. Does breeding population trajectory and age of nesting females influence disparate nestling sex ratios in two populations of Cooper's Hawks? *Ecology and Evolution* 5: 4037–4048.

**Rosenfield, R. N., S. A. Sonsthagen, W. E. Stout and S. L. Talbot.** 2015. High frequency of extra-pair paternity in an urban population of Cooper's Hawks. *Journal of Field Ornithology* 86:144–152.

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**Whittingham, L.A., C.R. Freeman-Gallant, C.C. Taff and P.O. Dunn.** 2015. Different ornaments signal male health and MHC variation in two populations of a warbler. *Molecular Ecology* 24: 1584–1595.

**Berg, J. A., G. A. Meyer and E. B. Young.** 2016. Propagule pressure and environmental conditions interact to determine establishment success of an invasive plant species, glossy buckthorn (*Frangula alnus*), across five different wetland habitat types. *Biological Invasions* 18(5): 1363–1373.

**Casper, G. S.** 2016. Geographic Distribution: *Necturus maculosus* (Mudpuppy). USA: Wisconsin: Washington Co. *Herpetological Review* 47(3): 417.

**Casper, G. S.** 2016. Geographic Distribution: *Hyla versicolor* (Gray Treefrog). USA: Wisconsin: Milwaukee Co. *Herpetological Review* 47(3): 419.

**Casper, G. S. and Matthew Schmidt.** 2016. Geographic Distribution: *Lithobates catesbeianus* (American Bullfrog). USA: Wisconsin: Green Lake Co. *Herpetological Review* 47(3): 420.

**Casper, G. S. and R. D. Rutherford.** 2016. Geographic Distribution: *Opheodrys vernalis* (Smooth Greensnake). USA: Wisconsin: Menominee Co. *Herpetological Review* 47(3): 428.

**Casper, G. S. and P. Kleinhenz.** 2016. Geographic Distribution. *Tropidoclonion lineatum* (Lined Snake). USA: Wisconsin: Dane Co. *Herpetological Review* 47(3): 429.

**Henschen, A. E., L. A. Whittingham and P. O. Dunn.** 2016. Oxidative stress is related to both melanin- and carotenoid-based ornaments in the common yellowthroat. *Functional Ecology* 30(5): 749–758.

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**Whittingham, L. A. and P. O. Dunn.** 2016. Experimental evidence that brighter males

sire more extra-pair young in tree swallows. *Molecular Ecology* 25 (15): 3706-3715.

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**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.

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**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.

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**Reichert, M.S. and G. Höbel.** 2017. Frequency channel-dependent selectivity for

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**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.

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

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**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

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Evolution 8: 2146-2159.

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**Graham, L.E., M.T. Trest, S. Will-Wolf, N.S. Mücke, L.M. Atonio, M.J. Piotrowski and J.J. Knack. 2018.** Microscopic and metagenomic analyses of *Peltigera ponojensis* (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.

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**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.

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## Recent Theses

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

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

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

**Servi, Jason S. 2016.** Natural selection by insect pollinators and seed predators on floral head traits of *Helianthus grosseserratus*

(Sawtooth Sunflower). M.S. Thesis.

**Joynt, Emily K. 2017.** Factors controlling diffusive CO<sub>2</sub> 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.



# Cooperation with Other Groups and Agencies

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

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

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

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

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

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

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

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

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

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

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

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

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

# 2018 Natural History Workshops

This is a series of intensive workshops on specialized topics which provide a continuing education opportunity and a meeting place for biologists. Nine workshop topics were offered in 2018.

Workshop	Instructor	Date
Ecology and Physiology of Plants in Winter	James Reinartz	January 5 & 6
Introduction to Bird Song	William Mueller	February 6 - March 27
Field Herpetology: Identification of Wisconsin Amphibians and Reptiles	Josh Kapfer	June 1 & 2
Sedges: Identification and Ecology	Anton Reznicek	June 15 & 16
Vegetation of Wisconsin	James Reinartz	June 18 - 23
Ecological Geology	Roger Kuhns	July 16 - 20
Introduction to Lichens	Suzanne Joneson	July 27 & 28
Plant-Insect Interactions: Ecology and Evolution	Gretchen Meyer and Robert Clare	August 3 & 4
Invasive Plant Management Techniques	James Reinartz	September 29



Jim Reinartz demonstrating spraying in the Invasive Plant Management Techniques Class

# Semester Classes

Semester classes taught for UWM by Field Station staff. Field Methods in Conservation is taught entirely at the Field Station, while the other two classes were taught on campus.

Term	Class	Instructor
Spring 2018	Biosci 407, Plant Systematics and Evolution.	James Reinartz
Spring 2018	Biosci 458, Community Ecology	Gretchen Meyer
Fall 2018	Biosci/CES 451, Field Methods in Conservation	James Reinartz & Gretchen Meyer



The 2018 Ecological Geology class visited a quarry



Jim Reinartz teaching about trees in the Field Methods class



# Class and Group Use

## Winter - Spring 2018

## Number of Student Hours

Ecology and Physiology of Plants in Winter Workshop . . . . .	310
Introduction to Bird Song Workshop . . . . .	180
Winter Ecology Hike and Friends Chili Dinner . . . . .	520
Friends of Cedarburg Bog - Mammals . . . . .	80
Friends of Cedarburg Bog - Owl-prowl hike . . . . .	30
Friends of Cedarburg Bog - Wood ducks . . . . .	20
Friends of Cedarburg Bog - Glacial geology . . . . .	30
Friends of Cedarburg Bog - Woodcocks and Frogs . . . . .	60
Friends of Cedarburg Bog - Bog Guardians . . . . .	10
Friends of Cedarburg Bog - Frogs and Maybe Woodcocks . . . . .	10
Friends of Cedarburg Bog - Spring in the Bog . . . . .	40
Friends of Cedarburg Bog - Spring Migrant Bird Walk . . . . .	20
Friends of Cedarburg Bog - Ethnobotany . . . . .	40
Friends of Cedarburg Bog - Bird walk . . . . .	20
Friends of Cedarburg Bog - meetings . . . . .	210
Marian University - Outdoor Adventure Club . . . . .	240
Escuela Verde - Bog tour . . . . .	20
Schlitz Audubon - Bog tour . . . . .	200
Shorewood High School - Watershed Wisdom . . . . .	210
Wisconsin Phenological Society - Annual Meeting . . . . .	20
Natural Resources Foundation - Birding . . . . .	20
Schlitz Audubon - Bog tour . . . . .	240
UWM - Geography 120 - Our Physical Environment . . . . .	100
UWM - BioSci 310 - General Ecology (Downer Woods) . . . . .	1,500
<b>TOTAL . . . . .</b>	<b>4,140</b>

## Summer 2018

Field Herpetology Workshop . . . . .	320
Sedges: Identification and Ecology Workshop . . . . .	320
Vegetation of Wisconsin Workshop . . . . .	1,240
Ecological Geology Workshop . . . . .	480
Introduction to Lichens Workshop . . . . .	310
Plant-Insect Interactions Workshop . . . . .	310
Friends of Cedarburg Bog - Birding the North End of the Bog . . . . .	10
Friends of Cedarburg Bog - Birding Mud Lake by Kayak . . . . .	80
Friends of Cedarburg Bog - Summer in the Bog . . . . .	20
Friends of Cedarburg Bog - International Bog Day . . . . .	40
Friends of Cedarburg Bog - Reptiles and Amphibians . . . . .	40
Friends of Cedarburg Bog - Butterflies and Dragonflies . . . . .	20
Friends of Cedarburg Bog - meetings . . . . .	60
Riveredge Nature Center - Bog tour . . . . .	40
WI DNR Forest Health Team - Field Station tour . . . . .	20
Natural Resources Foundation - Ethnobotany . . . . .	120
Elm Brook Garden Club - Bog tour . . . . .	20



Summer 2018

Number of Student Hours

Natural Resources Foundation - Ethnobotany . . . . .	120
Osher Lifelong Learning - Bog tour . . . . .	30
<b>TOTAL . . . . .</b>	<b>3,600</b>

Fall Winter 2018

Invasive Plant Management Techniques Worksop . . . . .	160
Friends of Cedarburg Bog/UWM BioSci - Annual Picnic. . . . .	240
Friends of Cedarburg Bog - Ferns. . . . .	10
Friends of Cedarburg Bog - Gifts from the Glacier . . . . .	40
Friends of Cedarburg Bog - Owl Prowl . . . . .	20
Friends of Cedarburg Bog - meetings . . . . .	70
Wild Ones - Bog tour . . . . .	20
St John's Lutheran School - Bog tour . . . . .	60
Alverno College - Ecology class . . . . .	60
University of Illinois-Chicago - Ecology field trip . . . . .	750
Cedarburg High School - Honors Biology class . . . . .	290
Urban Ecology Center – Naturalist's choice field trip . . . . .	40
Riveredge Nature Center - Christmas bird count . . . . .	10
UWM - BioSci/CES 451 - Field Methods in Conservation. . . . .	1,300
UWM - BioSci 310 - General Ecology (Downer Woods) . . . . .	1,500
UWM - Geography 120 - Our Physical Environment. . . . .	100
UWM - Geography 475 - Geography of Soil (Downer Woods) . . . . .	80
UWM - Geosciences 463 - Physical Hydrogeology. . . . .	100
UWM - Geology Club field trip (Neda Mine) . . . . .	50
UWM - Geography Department picnic . . . . .	90
<b>TOTAL . . . . .</b>	<b>4,990</b>

TOTAL 2018 Class & Group Use Hours. . . . .

12,720



The Friends of the Cedarburg Bog Fall picnic included a wagon ride behind tractor driven by Jim Reinartz

# Meteorological Data for 2018

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

## Temperature

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

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

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

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

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

## Degree Days

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

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

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

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

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

## Relative Humidity

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

## Number of Days

**Precipitation** of 0.25 mm or more

### Temperature-Maximum

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

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

### Temperature-Minimum

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

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

## Mean Pressure (mbars)

Mean of all 30-min means in the month.

## Precipitation (mm)

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

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

## Wind

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

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

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

**Temperature (C°)**

	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	OCT	NOV <sup>1</sup>	DEC <sup>2</sup>
Average Daily Maximum	-1.4	0.0	4.4	7.7	22.3	23.7	26.8	26.8	22.4	13.8	2.3	2.7
Average Daily Minimum	-10.0	-9.8	-4.9	-3.2	10.3	13.6	15.1	15.6	11.5	4.4	-3.5	-4.2
Daily Average	-5.5	-4.8	-0.3	2.5	16.4	18.7	21.4	21.1	16.8	9.1	-0.5	-0.9
Highest (Date)	12.0 (11)	15.7 (27)	13.1 (18)	26.2 (30)	33.9 (27)	34.1 (29)	32.1 (1)	32.4 (4)	31.5 (17)	29.1 (3)	9.7 (4)	9.6 (27)
Lowest (Date)	-23.8 (1)	-24.8 (5)	-9.5 (8)	-9.7 (7)	2.1 (11)	4.4 (6)	8.6 (7)	10.8 (31)	1.7 (29)	-4.6 (18)	-11.5 (14)	-11.6 (7)

**Degree Days**

Sum at 5°	2.0	3.8	0.0	31.4	354.3	410.8	507.4	500.2	353.8	135.2	5.2	0.0
Sum at 10°	0.0	0.0	0.0	6.0	209.3	260.8	352.4	345.2	207.4	53.0	0.0	0.0

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

Mean	0.08	0.09	0.18	0.21	0.24	0.24	0.27	0.21	0.16	0.10	0.06	NA <sup>3</sup>
Maximum	0.54	0.67	0.85	0.98	1.00	1.03	1.03	1.02	0.92	0.71	0.54	NA

**Relative Humidity (%)**

Hour 00-06 mean	80.6	79.6	82.4	78.9	82.1	88.6	91.2	92.5	92.2	84.8	83.0	87.7
Hour 06-12 mean	76.4	73.4	66.4	59.1	66.6	72.4	67.1	74.7	76.4	75.3	77.2	83.9
Hour 12-18 mean	65.7	62.5	52.9	51.3	56.1	65.1	59.9	63.9	68.9	64.4	68.8	76.3
Hour 18-24 mean	77.5	76.2	76.7	67.4	73.7	80.3	80.5	86.9	89.9	79.9	77.9	85.7

**Number of Days**

Precip. 0.25mm or more	9	12	5	10	14	13	10	11	12	13	9	7
Max Temp 32° and above	0	0	0	0	1	3	1	1	0	0	0	0
Max Temp 0° and below	16	13	3	3	0	0	0	0	0	0	10	8
Min Temp 0° and below	29	25	31	25	0	0	0	0	0	10	22	23
Min Temp -18° and below	7	5	0	0	0	0	0	0	0	0	0	0

**Pressure (mbars)**

Mean	1019.59	1019.67	1018.83	1016.96	1014.78	1014.21	1017.91	1015.79	1019.43	1016.38	1017.12	1014.86
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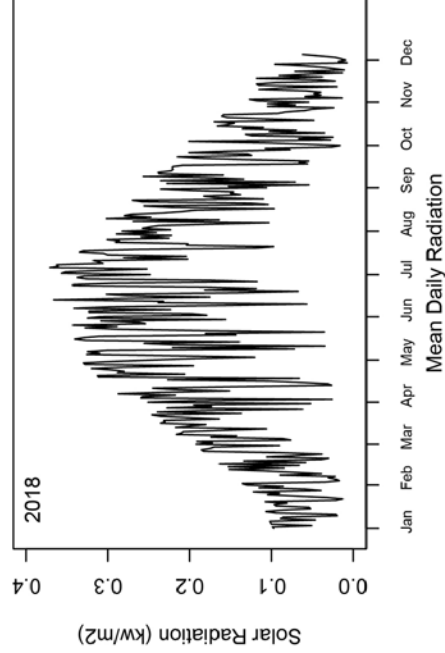
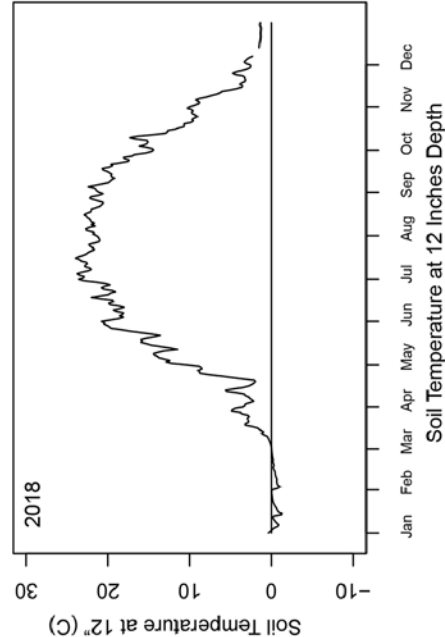
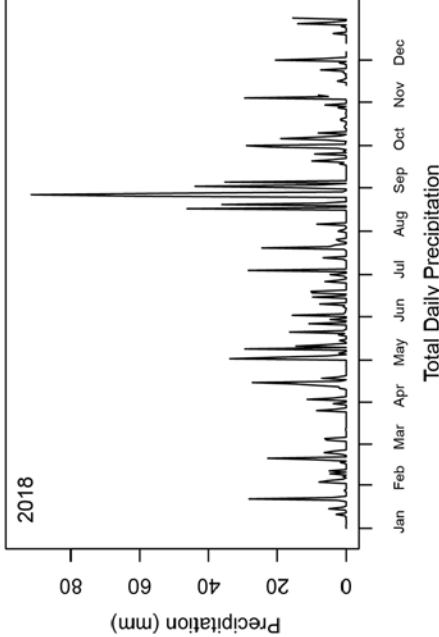
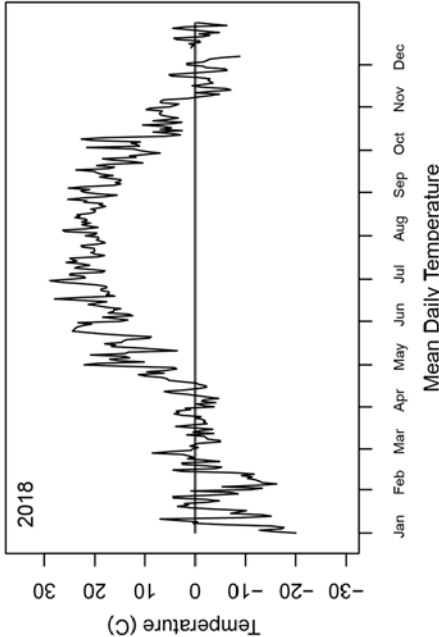
**Precipitation (mm)**

Total	45.1	70.4	27.6	80.4	149.9	65.6	79.2	309.0	152.7	85.2	57.4	67.1
Greatest (24 hrs) (Date)	28.2 (22)	22.8 (20)	8.6 (26)	27.2 (15)	33.8 (2)	15.7 (2)	28.5 (4)	91.6 (27)	43.8 (2)	29.0 (1)	29.6 (4)	20.5 (1)

**Wind**

Mean Speed (m/s)	1.8	1.7	1.7	1.8	1.3	1.3	1.2	1.0	1.0	1.4	1.6	1.3
Maximum Speed (m/s)	4.7	5.6	5.2	5.4	4.9	3.9	4.9	4.2	4.5	5.1	6.2	5.6

<sup>1</sup>Rain data are missing for 11/7-11/12. <sup>2</sup>Data are missing for 12/8 - 12/12 and partially missing for 12/6. <sup>3</sup>Pyranometer was removed for calibration on 12/6.





## Field Station

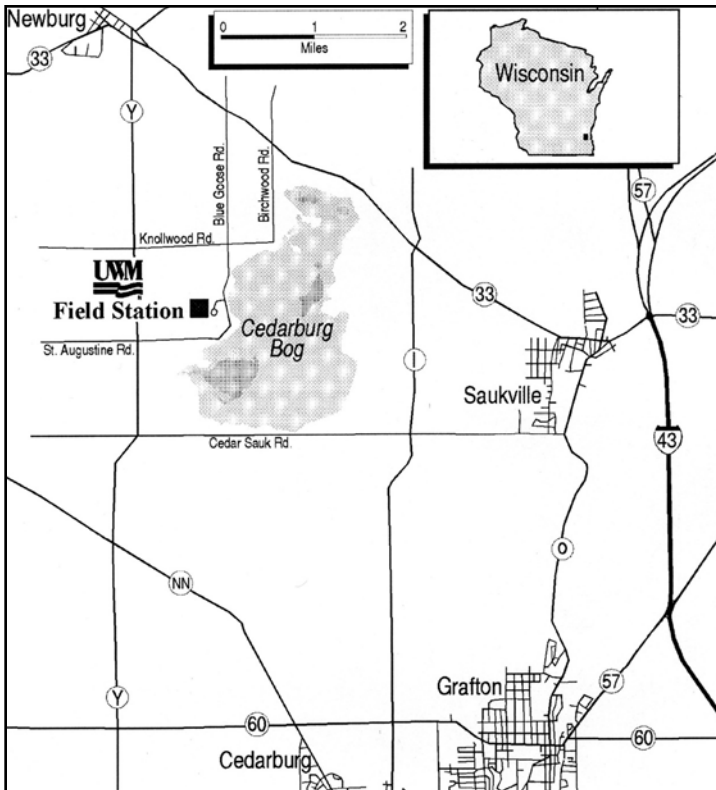
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