2021-2022

RESEARCH + MANAGEMENT REPORT

Reptile, Amphibian, and Invertebrate Conservation & Management

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2021-22 RESEARCH & MANAGEMENT REPORT

Maine Department of Inland Fisheries and Wildlife protects and manages Maine's fish and wildlife and their habitats, promotes Maine's outdoor heritage, and safely connects people with nature through responsible recreation, sport, and science.

Reptile, Amphibian, and Invertebrate Conservation & Management

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Spring salamander cover photo by Trevor Persons

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REPTILE, AMPHIBIAN, AND INVERTEBRATE CONSERVATION AND MANAGEMENT

Program Overview

Maine is home to 18 species of frogs and salamanders (amphibians), 18 species of turtles and snakes (reptiles), and over 15,000 species of terrestrial and freshwater invertebrates, from beetles and butterflies to mayflies and mussels. The Reptile, Amphibian and Invertebrate (RAI) Group is challenged with coordinating research and conservation priorities for this diverse suite of organisms, more than 100 of which are currently state listed as Endangered, Threatened, or Special Concern.

Some rare invertebrates, such as the Katahdin arctic butterfly and Roaring Brook mayfly, are state or regional endemics – found nowhere else in the world but in Maine or a small area of the Northeast. Other species, including the cobblestone tiger beetle and the short-tailed swallowtail butterfly, have only recently been discovered in Maine by our biologists. The RAI Group works to ensure that these and many other lesser known, but ecologically important, species remain a part of Maine's rich ecosystem.

The RAI Group is one of the Department's few units devoted entirely to nongame and endangered species work, and is therefore dependent on dedicated, non-General Fund sources of revenue, such as the Loon License Plate and Chickadee Check-off. Thank you for your support of both these critical funding sources, thus helping our Department meet its legislative mandate "to conserve, by according such protection as is necessary..., all species of fish or wildlife found in the State, as well as the ecosystems upon which they depend" (107th Maine Legislature, 1975).

Black racer photo by Derek Yorks

Wood turtle photo by Derek Yorks

Black swallowtail photo by Kent McFarland

Meet the Reptile, Amphibian, and Invertebrate Group

Phillip deMaynadier, Ph.D., Wildlife Biologist and Group Leader

Phillip supervises RAI Group activities, provides expertise on issues related to reptiles, amphibians, and invertebrates, and advises more broadly on endangered and nongame species policy. Some of his recent projects include: facilitating updates to the state's endangered and threatened species list; supervising MDIFW's program for protecting high-value vernal pools; co-coordinating state atlasing efforts for butterflies, dragonflies, amphibians, and reptiles; and advising landowners and land trusts on best management practices for conserving at-risk species. Phillip is also a Graduate Faculty member at the University of Maine's Department of Wildlife, Fisheries, and Conservation Biology and a Research Scientist in the Colby College Biology Department.

Beth Swartz, Wildlife Biologist

Beth is the Department's lead biologist on a wide range of invertebrate taxa. Her recent efforts have been devoted to assessment and conservation of Clayton's copper butterfly, brook floater and other freshwater mussels, rare mayflies, and bumble bees. Beth is currently coordinating a statewide atlasing effort for bumble bees and targeted surveys for the rusty patched bumble bee, which was federally listed as an Endangered species in 2017. Beth also helps coordinate the Department's vernal pool conservation efforts and plays a lead role in environmental review of large energy project proposals statewide.

Derek Yorks, Wildlife Biologist

Derek is the Department's lead biologist on reptile and amphibian issues, coordinating research and conservation efforts on several priority rare species. Derek is currently assessing the distribution, status, and management needs of Maine's black racers, Blanding's turtles, spotted turtles, and wood turtles, and is coordinating Maine's efforts on these species with those of several working groups across the Northeast. Derek is also studying and developing recommendations on how to mitigate the impacts of roadways on Maine's reptiles and amphibians.

SEASONAL STAFF AND PROFESSIONAL COOPERATORS

The RAI Group could not address such a diverse suite of taxa without the expert assistance of the following professionals in 2021-2022:

Dr. Catherine Bevier
Kalyn Bickerman-Martens
Dr. Steve Burian
Dr. Ron Butler
Dr. Aram Calhoun
John Calhoun
Dr. Matthew Chatfield
Sequoia Dixson
Charlene Donahue
Dr. Frank Drummond
Sarah Haggerty
Victoria Hughes
Dr. Malcolm Hunter
Dr. Mike Jones
Dr. Michael Kinnison
John Klymko
Gregory LeClair
Derek Moore
Ethan Nedeau
Trevor Persons
Bryan Pfeiffer
Dr. Leif Richardson
Karen Robbins
Dr. Patrick Roberts
Marcia Siebenmann
Lisa St. Hilaire
Dr. Herb Wilson
Mark Ward
Dr. Liz Willey
Dr. Bruce Young

AMPHIBIANS AND REPTILES

By eastern U.S. standards, Maine is a large and climatically diverse state. Thus, while North American reptiles and amphibians (herpetofauna) are richest and most diverse at southern latitudes, Maine's relatively moderate southern and coastal climate permits many species to reach their northeastern range limit here. Only one species, the mink frog, reaches the southern edge of its range in Maine (and northern New Hampshire and Vermont).

Maine provides some of the most extensive and intact remaining habitat for the 36 known herpetofauna species it hosts. Of our 18 amphibians and 18 reptiles, one is extirpated (timber rattlesnake) and two introduced (mudpuppy salamander and red-eared slider turtle). Some are of regional and national conservation concern, and about ⅓ are listed as Species of Greatest Conservation Need (SGCN) in Maine's 2015 State Wildlife Action Plan. Some of MDIFW's recent survey, research, and conservation projects directed at these and other priority herpetofauna are highlighted below.

Partners in Amphibian and Reptile Conservation (PARC)

Derek Yorks and Phillip deMaynadier

MDIFW continues to cooperate with Partners in Amphibian and Reptile Conservation (PARC). Modeled partly after the successful Partners in Flight (PIF) bird conservation program, PARC forges partnerships between diverse public and private organizations to stem worldwide amphibian and reptile population declines.

MDIFW regularly attends PARC's northeastern chapter meetings, including the most recent 2022 annual meeting in West Virginia. Some of Northeast PARC's projects to date include: drafting model state herpetofauna regulations; compiling a list of regional species of conservation concern; publishing management recommendations for important habitats; developing fact sheets on emerging amphibian and reptile diseases; designing guidelines for identifying Priority Amphibian and Reptile Conservation Areas (PARCAs); developing best management practices for turtle road crossing structures; and coordinating northeastern working groups for priority species such as the wood turtle, Blanding's turtle, and spotted turtle, and for priority habitats like vernal pools.

For more information on this or other national PARC conservation efforts, visit the PARC website at **parcplace.org**

This work is supported by the federal (USFWS) State Wildlife Grants program, state revenues from the Loon Conservation Plate and Chickadee Check-off Funds.

Maine Amphibian and Reptile Atlas Project (MARAP)

Derek Yorks and Phillip deMaynadier

1ST, 2ND, AND FORTHCOMING 3RD BOOK EDITIONS (1992, 1999, 2024)

In 1986, MDIFW, in cooperation with Maine Audubon and the University of Maine, launched the Maine Amphibian and Reptile Atlas Project (MARAP). Over a four-year period, 250+ volunteers across the state recorded roughly 1,200 amphibian and reptile observations. This first step culminated in the 1992 publication of the book, The Amphibians and Reptiles of Maine, the first edition of which sold out within two years.

By 1998, new data had been compiled and there was increasing demand for updated information on the state's herpetofauna. Editors Malcolm Hunter, Jr., Aram Calhoun, and Mark McCollough revised a second edition, incorporating information from 1,300 new records into updated range maps and species narratives, and adding color photographs.

Still generating data after 37 years, MARAP is Maine's longest-running community science project. With more than 16,000 records currently logged into MDIFW's electronic database (more than six times the number included in the 1998 book!), a new team of editors (M. Hunter, A. Calhoun, T. Persons, P. deMaynadier, and D. Yorks) has embarked on a third edition of The Amphibians and Reptiles of Maine for publication with University of Maine Press. The updated work will be written for a diverse audience of scientists, naturalists, and curious members of the public. In so doing, the new book will help advance both of MARAP's longstanding goals: 1) to raise public awareness of and concern for these under-appreciated vertebrate groups, and 2) to improve our scientific knowledge of Maine's herpetofauna.

CONTINUING DATA COLLECTION

Since the most recent atlas's publication, MDIFW has continued to collect data and maintain a comprehensive database on the distribution of Maine's 35 extant amphibian and reptile species (33 native and two exotic). As of spring 2022, 1,700+ volunteers had logged over 16,000 records, nearly all of which were carefully vetted and digitally curated by Trevor Persons, a consulting herpetologist. Read on to learn how you can contribute to this ongoing atlasing effort.

INSIGHTS

The MARAP project has continuously improved our understanding of Maine's reptile and amphibian biogeography. For example, we now know that reptile species richness sharply decreases northward, while amphibian richness is fairly even across the state. MARAP findings have also helped to inform specific species' conservation status assignments (e.g., Endangered, Threatened, Special Concern, SGCN), survey and research priorities, and on-the-ground conservation efforts.

During the 2021-2022 field seasons, MDIFW made additional efforts to advance MARAP by filling distribution gaps, exploring the limits of species distribution within the state, and investigating novel occurrences in need of verification. Our field surveys yielded many new and notable township occurrences, including:

- The first documentation of **Northern dusky salamanders** in Washington County and confirmation that they are distributed throughout easternmost Maine
- Confirmation of **pickerel frog** northwest of Fort Kent in the St. John drainage bordering New Brunswick, where the species range is disjunct from the rest of Maine
- A 25% increase in vouchered townships for **four-toed salamanders**, including a new northernmost record near Baxter State Park
- A western mountain occurrence of **blue-spotted salamander** at >2,300 feet – the highest-documented elevation in Maine and possibly range-wide.

Because of their regional significance, many of these records have been submitted for publication in a scientific journal.

There is still much to learn about the distribution and ecology of Maine's herpetofauna, and you can help! Members of the public can share photo observations in two ways:

1. Submit reptile and amphibian observations online on MDIFW's Maine Amphibian and Reptiles Atlas Project website: **mefishwildlife.com/atlas (Figure 1).**
2. Use the popular iNaturalist app. Within the platform, just look for the project, *Maine Amphibian and Reptile Atlas Project*. All Maine amphibian and reptile observations added to iNaturalist are automatically added to this project.

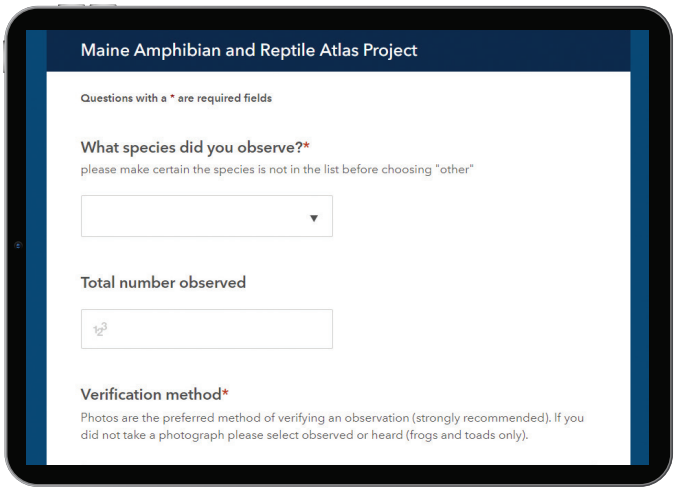


FIGURE 1. SCREEN CAPTURE OF MARAP DATA ENTRY PORTAL

This work is supported by the federal (USFWS) State Wildlife Grants program, state revenues from the Loon Conservation Plate and Chickadee Check-off Funds, and volunteer assistance.

How can you help?

Please submit observations of any of the six state-listed species below to: **derek.yorks@maine.gov or (207) 941-4475**

Blanding's turtle (Endangered) photo by Derek Yorks

Black racer (Endangered) photo by Derek Yorks

Spotted turtle (Threatened) photo by Derek Yorks

Wood turtle (Special Concern) photo by Derek Yorks

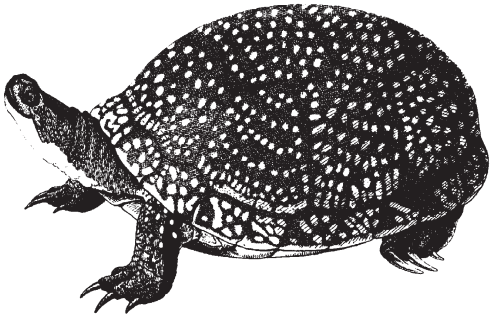
Ribbon snake (Special Concern) photo by Trevor Persons

Northern spring salamander (Special Concern) photo by Trevor Persons

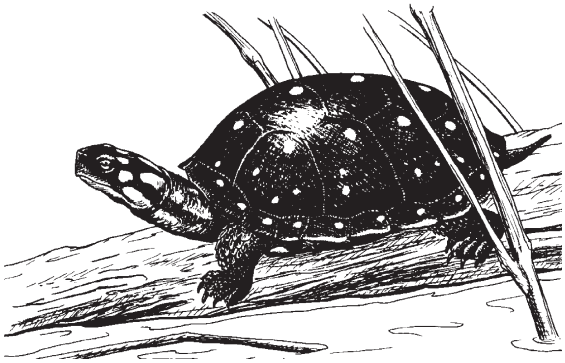
Blanding's and Spotted Turtles

Derek Yorks

For over 30 years, MDIFW has researched the distribution and status of Blanding's (Endangered) and spotted (Threatened) turtles in Maine. Blanding's turtles are seven to 10 inches long with a yellow throat and light-colored flecking on a helmet-shaped shell. They are found primarily in York County and areas south and southwest of Portland. Spotted turtles are five to six inches long with yellow spots on the head, tail, and legs and a slightly domed, yellow-spotted black shell. They are found in southern Maine and the mid-coast area east to Penobscot Bay. Both species are semi-aquatic, preferring small, shallow wetlands including swamps, marshes, and vernal pools. Undeveloped upland forests, fields, and other habitats surrounding these wetlands provide habitat for nesting, aestivating (a period of summer inactivity), and migratory movements between seasonally occupied wetlands.



Blanding's Turtle drawing by Abigail Rorer



Spotted Turtle drawing by Mark McCollough

SURVIVAL CHALLENGES

Despite the attention these turtle species have received, habitat loss and fragmentation continue to threaten them in Maine. And as human population and development expand in southern and coastal areas, road mortality becomes an ever-increasing threat. The turtle's shell has provided sufficient protection from predators for millions of years but is no match for a car tire.

Both Blanding's and spotted turtles are long-lived animals that take a minimum of seven (spotted) to 14 (Blanding's) years to reach reproductive age. This delayed maturity, coupled with low hatching success, places increased importance on adult survivorship. Like most turtle species, Blanding's and spotted turtles have evolved a life history strategy dependent upon on a slow but steady reproductive output paired with long adult lifespans. Population analyses of Blanding's turtles indicate that as little as 2 to 3% additive annual mortality of adults is unsustainable. In other words, losing just a few breeding adult turtles in a population each year to roadkill, or other causes such as illegal collection, can drive local populations to extinction.

CONSERVATION EFFORTS

MDIFW is currently involved in multiple conservation projects benefiting Blanding's and spotted turtles in Maine:

1. **Conservation of Blanding's Turtle in the Northeast:** MDIFW and partner agencies in four northeastern states were awarded a U.S. Fish and Wildlife Service Competitive State Wildlife Grant to implement collaborative conservation measures for Blanding's turtles.

   This is the second such award northeastern states have been given for Blanding's turtle conservation, and our renewed effort focuses on implementing on-the-ground conservation actions and standardized population assessments that we identified in the *2014 Conservation Plan for Blanding's turtles in the northeastern United States*.

   Next steps toward maintaining and enhancing functional Blanding's turtle populations include improving and monitoring the use of nesting habitat, working to reduce road mortality, studying the population and demographics at priority sites, and reaching out to landowners and land trusts hosting high-value populations.

Blanding's turtle photo by Derek Yorks

2. **Cautionary Road Signage Project (Turtle Xing):** A cooperative study by the University of Maine and MDIFW identified high-density, rare turtle areas with road-crossing hotspots. With the assistance of the Maine Department of Transportation (MDOT), The Nature Conservancy, and local towns, we installed signs in strategic locations in York County warning motorists to watch for rare turtles on the roadway. The signs are permanent, but they fold closed so that they may be deployed seasonally, coinciding with the spring and summer period when overland turtle movements are greatest. This reduces sign fatigue by local commuters, increasing the signs' impact. Now in its 17th year, this project was one of the first of its kind among northeastern states.

3. **Maine's First Turtle Passage System:** In southern Maine, where road densities and traffic volumes are significant, road mortality is a serious threat to rare turtles and other wildlife.

   One particular stretch of highway – a segment of Route 236 in Eliot – stands out as the state's deadliest known road segment for Blanding's turtles, with seven mortalities documented since 2013. During that same time, other at-risk species mortalities documented at the site include spotted turtle (Threatened) and New England cottontail (Endangered).

   In 2019, we constructed a half-mile exclusionary barrier on both sides of the road where it bisects diverse freshwater wetlands. Then in the spring of 2021, we built a large concrete box culvert that is now tied into the barrier fencing.

   This effort to reduce Blanding's turtle mortality and permit safe wildlife passage under Route 236 was a cooperative endeavor between MDIFW and Maine MDOT. The Maine Turnpike Authority (MTA) and USFWS provided additional financial support.

   Technical challenges have hampered efforts to monitor turtles' use of the culvert, but we consider the project to be an overall success. Road mortality surveys along the fenced segment have documented that just a handful of painted turtles managed to travel beyond the end of the fence and were killed while attempting to cross the roadway.

4. **Improving Nesting Habitat for Blanding's Turtles:** Most modern-day Blanding's turtle nesting sites are created by human disturbance; and without periodic management, these bare gravel, sand, or soil areas are eventually overcome with vegetation that is too thick to permit successful reproduction.

   MDIFW, in partnership with local land trusts, private landowners, and the U.S. Forest Service, is working to monitor (using time-lapse cameras to document nesting females), and in some cases create or enhance nesting habitat at several of Maine's Blanding's turtle sites.

   This ongoing habitat-focused management effort will improve long-term viability of Maine's regionally important Blanding's turtle populations and reduce the need for nesting females to travel outside core or interior areas of sites. Nesting area management may also enhance nest success and hatchling survival by directing females away from marginal nesting habitats like backyards, active gravel pits, roadsides, and agricultural lands, where eggs and hatchlings are more susceptible to severe disturbance and human-subsidized predators, such as raccoons and skunks.

5. **Spotted Turtle Conservation in the Eastern U.S:** In 2017, MDIFW, along with eight other eastern states, was awarded a U.S. Fish and Wildlife Service Competitive State Wildlife Grant to assess spotted turtle populations and develop an adaptive conservation plan. The State-Threatened spotted turtle reaches the northeastern terminus of its range in the Atlantic Coastal Plain of Maine and is identified as a Species of Greatest Conservation Need (SGCN) in all 21 states in which it occurs. While at the outset of this grant the spotted turtle's distribution in York County was well understood, seemingly isolated populations have since been confirmed in another four counties as far north as central and mid-coast Maine, adding significantly to our knowledge of the species' distribution rangewide.

   Under this grant, MDIFW broadened its spotted turtle population assessments, making a special effort to gather baseline data at sites supporting the species throughout its statewide range. We also focused considerable sampling effort on poorly understood areas outside of York County, which helped us to identify new spotted turtle populations ranging from seemingly small to rather substantial and of statewide importance.

   These efforts in Maine, and from other participating states throughout the species' range, culminated in 2022 with the publication of the **Status Assessment and Conservation Plan for the Spotted Turtle in the Eastern United States (Figure 2).**

FIGURE 2. THE NEWLY PUBLISHED SPOTTED TURTLE STATUS ASSESSMENT AND CONSERVATION PLAN.

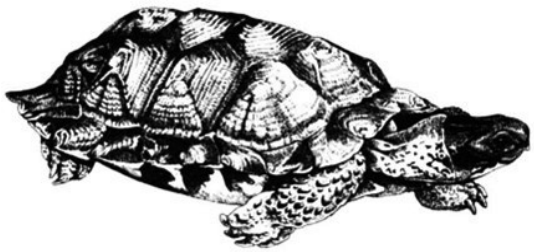
This work is supported by the federal (USFWS) State Wildlife Grants program, the Maine Department of Transportation, The Nature Conservancy, the Maine Outdoor Heritage Fund, state revenues from the Loon Conservation Plate and Chickadee Check-off Funds, and volunteer assistance.

Regional Wood Turtle Conservation

Derek Yorks

The wood turtle, listed as Special Concern, is one of Maine's rarest and most vulnerable turtles. This medium sized (five to eight inches) species with a distinct sculpted shell and orange coloration on its neck and legs can survive for 60 years or more.

For much of the year, wood turtles are found in slow to moderate moving clear-water streams with predominantly sand or gravel substrates. During late spring and summer, they use the surrounding uplands including forests, floodplains, meadows, and hayfields. From late fall to early spring, they hibernate underwater in sheltered areas of rivers, including deeper pools, under riverbanks, or beneath woody debris. No other Maine turtle species makes such extensive use of both aquatic and terrestrial habitats.



Drawing by Abigail Rorer

Widespread concern about the wood turtle's status prompted the 2009 establishment of the Northeast Wood Turtle Working Group (NEWTWG) through the Northeast Partners for Amphibian and Reptile Conservation (NEPARC). This group, consisting of agency biologists, agency representatives, land managers, and others from 13 states and the District of Columbia, has collaborated on several major initiatives. In 2014, MDIFW and seven other state wildlife agencies active in NEWTWG were awarded a federal Competitive State Wildlife Grant (CSWG) entitled *Conservation Planning and Implementation for the Wood Turtle (Glyptemys insculpta) and Associated Riparian Species of Greatest Conservation Need from Maine to Virginia*. This project was active from 2014-2017, during which time MDIFW biologists conducted standardized field surveys and participated in a regional, data-driven, scientific process for delineating the state's best wood turtle populations. The results of this effort included identification of a wood turtle Conservation Area Network (CAN) and publication of a ***Conservation Plan for the Wood Turtle in the Northeastern United States***. This study was the most comprehensive to date on the wood turtle in the Northeast, and it helped to establish a conservation baseline for this vulnerable and beautiful denizen of Maine's wild rivers and forests.

In 2021, a second CSWG entitled *Regional Conservation for Wood Turtles and Related Emydine Turtles* was awarded to Maine and many of the same states that participated in the first CSWG. This new grant has enabled northeastern states and their partners to continue gathering baseline data on wood turtle populations and engage in conservation actions outlined in the first CSWG's conservation plan. In Maine, this new effort has primarily focused on gathering baseline data on populations across the state so that they may be identified, tracked, and conserved.

During the spring and fall seasons of 2022, MDIFW staff and seasonal field technicians conducted standardized surveys for wood turtles at sites around the state. Over the course of the 2022 field season, and to a limited extent during 2021, MDIFW conducted 113 standardized surveys at 21 sites including 46 unique 1-km segments (many sites contain more than one survey segment). Biologists made 185 wood turtle captures representing 157 individual animals. Work on this project will continue through 2023 with another season of sampling, conservation planning, and a symposium on the conservation of wood turtles and related Emydine turtles to be held in Pennsylvania in July.

In 2022, a new book, ***Biology and Conservation of the Wood Turtle,*** was published by the Northeast Association of Fish and Wildlife Agencies **(Figure 3)**. This publication is dedicated to the evolution, ecology, biology, spatial ecology, habitat needs, and conservation of the wood turtle. MDIFW biologists and other specialists from 13 state fish and wildlife agencies and non-governmental conservation groups contributed to this impressive body of work. Supported in part through regional State Wildlife Grants, this semi-technical and richly illustrated 235-page publication will be of interest primarily to natural resource professionals and land managers.

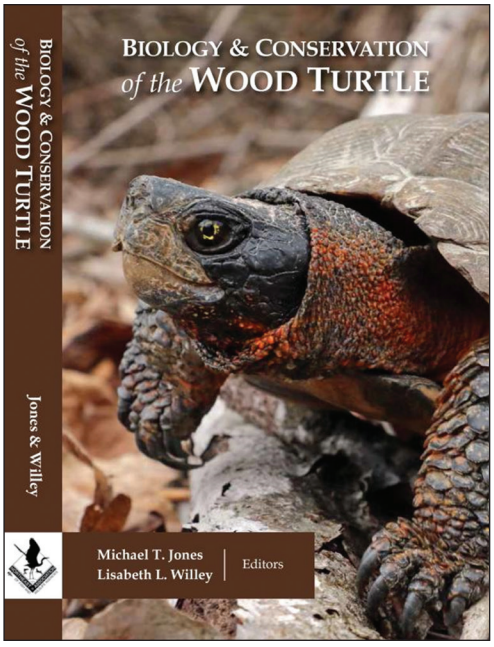


FIGURE 3. RECENTLY PUBLISHED WOOD TURTLE BOOK, INCLUDING CONTRIBUTIONS FROM MAINE.

Northern Black Racers

Derek Yorks

Adult northern black racer photo by Derek Yorks

Neonate northern black racer. As hatchlings, and for their first year, they have a blotched pattern that will soon fade to the characteristic black of adults. photo by Derek Yorks

HABITATS AND STATUS IN MAINE

In northern New England, black racers are habitat specialists and are most commonly found in shrublands and sunny open woodlands with predominantly sandy soils. They are diet generalists that prey upon rodents, frogs, birds, and even other snakes. The northern black racer is found from southern Maine to northern Alabama, Georgia, and South Carolina. In many areas of its range, it is abundant and is one of the most commonly encountered snake species. Despite its prevalence elsewhere, the Northern black racer is listed as a Species of Greatest Conservation Need (SGCN) in all six New England states and is state Endangered in Maine. The black racer reaches its northern range limit in Maine where it is at risk of extirpation due to rarity, habitat loss, and habitat fragmentation. Currently, Maine racer populations appear to be restricted to interior York County and southern Oxford County, where there are only about 12 modern, documented sites.

POPULATION MONITORING

In the spring of 2016, MDIFW biologists initiated a multi-year project seeking to confirm and document new or poorly known occurrences, study habitat use, and to establish a monitoring program at sites where black racer populations occur. In the first three years of this effort (2016-2018), we tracked 25 individual racers using VHF radio transmitters. In 2017, we added a monitoring program that assessed populations with repeated transect surveys, and we continued these surveys in 2018. An analysis of the data we collected during this period estimated that populations at three of Maine's best-known racer sites range from 29.1 (95% CI =17.4-70.5) to 182.1 (95% CI =124.3-297.9). This indicates that even Maine's very best sites support relatively small populations.

The radio-telemetry study, which began in 2016, continued through 2021 and will resume in 2023. During the six years from 2016 to 2021, we used VHF radio transmitters to track a total of 53 racers. We have now conducted telemetry at five sites, tracking anywhere from six to 14 individuals each year. Data gathered on occupancy, abundance, and habitat use of northern black racers will guide future conservation of this rare reptile.

A secondary component of the telemetry work has focused on monitoring racer habitat use prior to the construction of a commercial grid-scale solar development in Sanford. In 2021, we conducted our first season of post-construction monitoring to evaluate the effects of this development on racer habitat use. During this first season, we tracked 12 racers and observed almost no snake use beneath the solar panel arrays. We plan to keep monitoring habitat use at this site in 2023 and beyond.

NEW POPULATION DISCOVERED IN SOUTHERN OXFORD COUNTY

Also in 2021, we confirmed the existence of a black racer population for the first time in Oxford County, which is likely the northern extent of the species' statewide range. We equipped two racers at this outlying site with radio transmitters in the spring to learn more about their movements and habitat use. Unfortunately, we lost track of both snakes relatively early in the season. MDIFW's work on racers during the 2022 season was limited to a few surveys in a new area of this site, where we were fortunate to document a neonate racer early in the fall. We plan to return to this promising site again in 2023 and track a larger number of individuals.

This work is supported by the federal (USFWS) State Wildlife Grants program, state revenues from the Loon Conservation Plate and Chickadee Check-off Funds.

Common mudpuppy
photo by Trevor Persons

The Introduced Mudpuppy

Phillip deMaynadier

The mudpuppy is Maine's largest salamander and only non-native (exotic) amphibian species. Entirely aquatic in all life stages, this giant salamander (up to 14 inches) is found in lakes and streams throughout eastern North America, ranging from the Great Lakes region, south to the Gulf states, and approaching its native northeastern range in New York and Vermont.

Throughout much of its range, the mudpuppy is considered a species of conservation concern, but it is an introduced species in several New England states, including Rhode Island, Massachusetts, New Hampshire, and Maine.

Accidentally introduced into the Belgrade Lakes, Kennebec County, in 1939, current documentation suggests the mudpuppy may have spread to 16 waterbodies (11 confirmed) across three major central Maine watersheds. This exotic salamander represents a potential management risk, where it could have negative interactions with economically important fisheries and several aquatic Species of Greatest Conservation Need (SGCN) identified in Maine's 2015 Wildlife Action Plan.

There is no clear evidence that the mudpuppy has negatively affected Maine's aquatic communities; however, its ecological interactions as both predator and prey are largely unstudied. Anecdotally, anglers have expressed concerns that it interferes with fishing gear, is a possible fish larvae predator, and could be competing with game fish for food resources. Indeed, mudpuppies do have a broad diet that can include fish eggs, small fish, aquatic insects, mollusks, crayfish, and other amphibians. All of these taxa include SGCN species in Maine, some of which overlap the mudpuppy's potential range. More study is needed to assess the mudpuppy's current range and its ecological effects on Maine's local aquatic communities.

MUDPUPPY STUDY

In the winter of 2017-2018, MDIFW and cooperators initiated a new study on the mudpuppy with the following objectives:

1. **Document distribution and relative abundance using standardized field trapping techniques.**
2. **Conduct a diet and disease risk analysis to assess potential impacts on aquatic ecosystems.**
3. **Increase public and angler awareness of mudpuppies and potential risks of new waterbody introductions.**

eDNA SAMPLING

This project will inform novel mudpuppy environmental DNA (eDNA) detection protocols in development at the University of Maine (Dr. Michael Kinnison and Vaughn Holmes) by providing a confirmed baseline of occupied mudpuppy waterbodies and their relative abundance. eDNA consists of cellular DNA products shed from organisms into their environment, and has recently emerged as a sensitive and potentially cost-effective alternative to traditional survey methods for amphibians, fish, and other taxa. Given the challenge of mudpuppy detection and management, the prospect of combining eDNA sampling with traditional direct observation and trapping methods presents an exciting opportunity to determine and validate species occupancy estimates.

IMPROVED TRAPPING TECHNIQUE

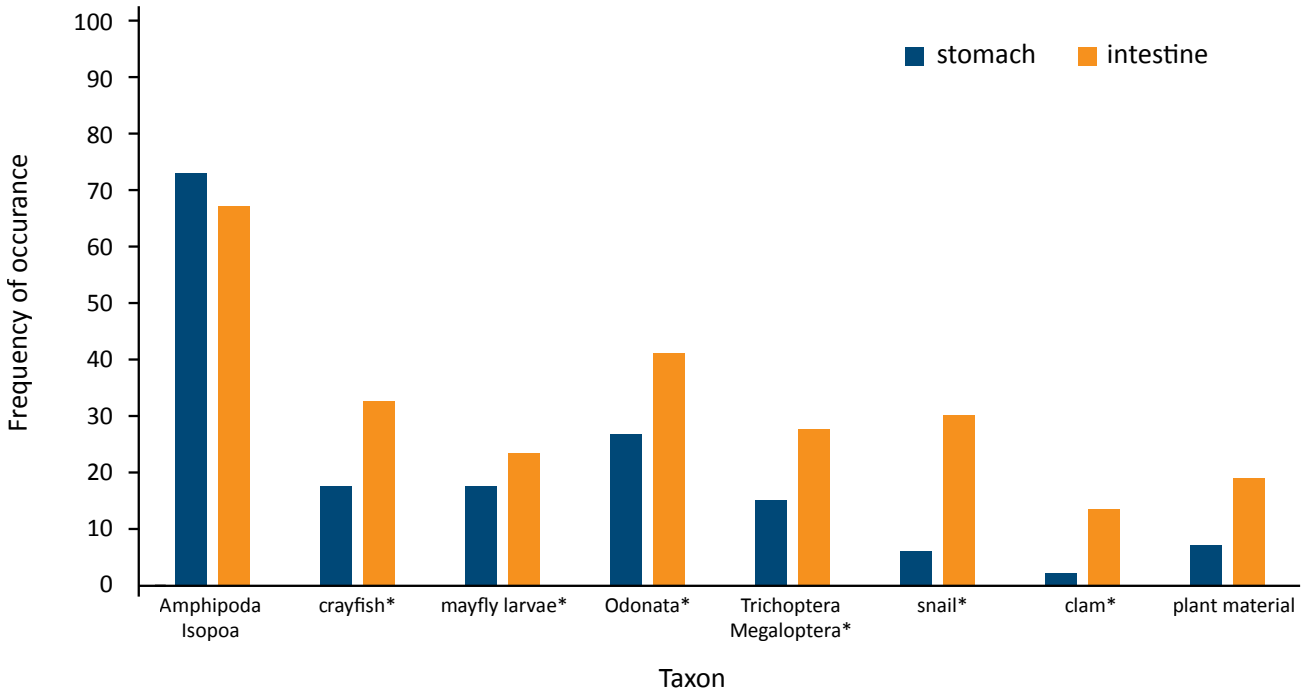
Following a review of previous capture techniques, we developed a methodology for trapping mudpuppies through the ice using modified, baited minnow traps. Using this technique, we captured 356 mudpuppies during the winters of 2017, 2018, and 2019, confirming presence in seven waterbodies: Salmon Lake (Belgrade/Oakland), North Pond (Smithfield/ Rome), Long Pond (Livermore), Messalonskee Lake (Belgrade/Oakland), Togus Pond (Augusta), Long Pond (Belgrade/Mount Vernon), and Great Pond (Belgrade/ Rome). Our capture rate of 0.488 animals per trap night compares favorably to that of other mudpuppy studies using similar methodology from within the species' native range, where capture rates range from 0.028 (Vermont) to 0.69 (Ontario). Notably, capture rates on Long Pond (Belgrade/Mount Vernon) equaled 1.45 animals per trap night (139 animals over 5 days), a rate exceeding that of any reports from elsewhere in the species range!

GUT CONTENT EXAMINATIONS

A Colby College laboratory (Dr. Cathy Bevier) has dissected 300 mudpuppies to examine digestive tract contents. As a generalist predator, the mudpuppy consumes a wide range of prey. In Maine, it was found to consume seven major taxa: crayfish (Decapoda), mayflies (Ephemeroptera), amphipods (Amphipoda), damselflies and dragonflies (Odonata), alderflies (Megaloptera), snails (Gastropoda), clams (Bivalvia), as well as plant matter **(Figure 4)**. By far the most frequent food items were amphipods (scuds), found in 73% of mudpuppy stomachs and 67% of intestines. Incidental items included remains of a rubber fish lure, pebbles, fish lenses, two worms, two cranefly larvae, and an unidentified beetle. The presence of fishhooks in the stomachs of three mudpuppies suggests interference with fishing gear.

This work is supported by the federal (USFWS) State Wildlife Grants program, state revenues from the Loon Conservation Plate and Chickadee Check-off Funds, Colby College, and the University of Maine Orono.

FIGURE 4. FREQUENCY OF OCCURRENCE OF FOOD ITEMS IN STOMACHS (N = 194) AND INTESTINES (N = 281) OF MUDPUPPIES SAMPLED IN 2017 AND 2018. TAXA FOLLOWED BY AN ASTERISK INCLUDE AT LEAST ONE SPECIES OF CONSERVATION CONCERN (SGCN) IN MAINE.



INVERTEBRATES

As they do globally, invertebrates dominate Maine's biota, both in richness and biomass. In fact, Maine's non-marine invertebrates are conservatively estimated to exceed 15,000 species, or nearly 98% of the state's animal species diversity. Like many other states, Maine's legal definition of "wildlife" (any species of the animal kingdom) includes vertebrates and invertebrates, thus challenging MDIFW and conservation partners with a tremendous breadth and volume of species to protect and manage. One of the ways MDIFW triages its limited staff and program resources toward invertebrate conservation and management is to focus on better-studied species and groups with well-documented patterns of decline or imperilment. Maine lists 132 non-marine invertebrates as Species of Greatest Conservation Need (SGCN) in the 2015 State Wildlife Action Plan, and some examples of recent survey, research, and conservation projects for these and other priority invertebrates are highlighted below.

Bumble Bees

Beth Swartz

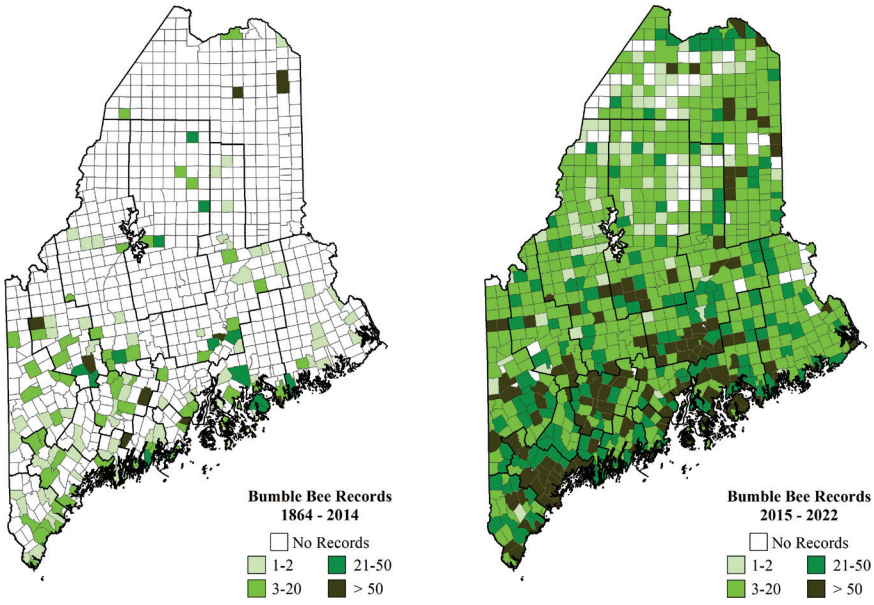
Bumble bees are one of our most valuable pollinators of flowering plants. Many spring wildflowers, as well as important Maine crops like apples, blueberries, cranberries, and tomatoes, thrive on bumble bees' early spring emergence and "buzz pollination" method. Unfortunately, over the past 25 years, several species of North American bumble bees have all but disappeared, and others have significantly declined. Habitat loss, pesticides, intensive agricultural practices, diseases, and parasites introduced with commercially raised bumble bees, and climate change all may play a role. For the past several years, MDIFW has been collecting data to assess the diversity, distribution, and conservation status of Maine's bumble bee fauna. Read on to see what we've learned, and be sure to check out "Pollinator Habitat" on page 24 for information on how you can help Maine's bumble bees and other pollinators.

THE MAINE BUMBLE BEE ATLAS: KEEPING TRACK OF NATIVE POLLINATORS

In 2015, MDIFW and the University of Maine initiated the Maine Bumble Bee Atlas (MBBA). This multi-year statewide survey enlisted the help of volunteer community scientists from all over Maine to collect data on what species are present, where they occur, what habitats they use, and how abundant they are.

During the project's six seasons, more than 200 volunteers conducted surveys at more than 2,500 sites statewide and contributed more than 27,000 new Maine bumble bee records! Their efforts have greatly increased what we know about Maine's bumble bees **(Figure 5).** Since the project ended in 2020, MDIFW has been steadily entering MBBA data into a database that documents what species are found in Maine, where they occur, and what habitats and forage plants they use. The data has already been extremely valuable in helping MDIFW determine which species appear to be rare or declining vs. stable or increasing.

FIGURE 5. MAINE BUMBLE BEE RECORDS BEFORE AND AFTER THE MAINE BUMBLE BEE ATLAS PROJECT.



As a result of MBBA, we've learned that 15 of the 17 species historically known to occur in Maine **(Table 1)** are still present – which is positive news, considering that some of these species have disappeared in other parts of their range. One example is the yellow-banded bumble bee, which has experienced rangewide declines but is now rebounding in northern New England. MBBA volunteers found this species every year of the project, in a wide range of habitats spanning more than 350 Maine townships.

While MBBA data indicate that most of Maine's bumble bee species are still relatively abundant and widely distributed on the landscape, several species stand out as either inherently rare or significantly less common compared to historical records **(Table 1)**. Two species were found at only one or two locations, and two others were not found at all and may now be extirpated from the state. Continue reading to learn more about Maine's rarest bumble bees.

For more information about the Maine Bumble Bee Atlas, visit the project website at **mainebumblebeeatlas.umf.maine.edu.** You can also follow the project on Facebook at **facebook.com/MaineBumblebeeAtlas.**

TABLE 1. BUMBLE BEES OF MAINE.

COMMON NAME	SCIENTIFIC NAME	STATE STATUS	SRANK
Rusty Patched Bumble Bee	*Bombus affinis*	SC	SH
Yellow-banded Bumble Bee	*Bombus terricola*		S3
Brown-belted Bumble Bee	*Bombus griseocollis*		S4S5
Red-belted Bumble Bee	*Bombus rufocinctus*		S3S4
Ashton's Cuckoo Bumble Bee	*Bombus ashtoni*	PE	S1
Lemon Cuckoo Bumble Bee	*Bombus citrinus*	SC	S3
Flavid Cuckoo Bumble Bee	*Bombus flavidus*		S3S4
Indiscriminate Cuckoo Bumble Bee	*Bombus insularis*	SC	S1
Two-spotted Bumble Bee	*Bombus bimaculatus*		S5
Common Eastern Bumble Bee	*Bombus impatiens*		S5
Confusing Bumble Bee	*Bombus perplexus*		S5
Sanderson's Bumble Bee	*Bombus sandersoni*		S4S5
Tri-colored Bumble Bee	*Bombus ternarius*		S5
Half-black Bumble Bee	*Bombus vagans*		S5
Northern Amber Bumble Bee	*Bombus borealis*		S4S5
Yellow Bumble Bee	*Bombus fervidus*	SC	S2
American Bumble Bee	*Bombus pensylvanicus*		SX

State Status: *SC = Special Concern, PE = Proposed Endangered*

SRANK *is a state conservation status rank assigned to a species using NatureServe (natureserve.org) ranking criteria. S1 = Critically Imperiled, S2 = Imperiled, S3 = Vulnerable, S4 = Apparently Secure, S5 = Secure, SX = Presumed Extirpated, SH = Historical/Possibly Extirpated.*

ON THE HUNT FOR MAINE'S RAREST BUMBLE BEE SPECIES

Two species that historically occurred in Maine but were not found during the MBBA project are the American bumble bee and rusty patched bumble bee.

The **American bumble bee** is known from just a few records and has not been reported in Maine since 1951. While still relatively common elsewhere, this species appears to have always been very rare in Maine and is now believed to be long extirpated from the state.

Conversely, the **rusty patched bumble bee** once occurred across most of the state, with records regularly reported from the late 1800s to the mid-1990s. But since then, only two observations have been documented — both in the mid-coast region and not since 2009. Unfortunately, the rusty patched bumble bee has experienced a 90% population decline and reduction in range throughout North America, and in March 2017 became the first bumble bee to be protected by the U.S. Endangered Species Act. Beginning in 2019, with funding from the U.S. Fish & Wildlife Service, MDIFW has been conducting targeted annual surveys in the vicinity of the most recent occurrences, as well as in adjacent areas of southern and southwestern Maine. So far, despite four seasons of surveys at more than 200 sites, not a single rusty patched bumble bee has been found.

One of the most exciting MBBA finds came in 2017, when a volunteer collected an **Ashton's cuckoo bumble bee** in northern Aroostook County. Once widespread across the state, this species is now one of the rarest bumble bees in North America and had not been recorded in Maine since 1996. Except for several observations in Alaska and Canada, where the species is listed as Endangered, our single occurrence is one of the only known recent records in the species' former range. Because Ashton's cuckoo bumble bee is an obligate nest parasite of both the rusty patched bumble bee and yellow-banded bumble bee, its decline is likely attributable in part to the rangewide declines experienced by these once common species.

Rusty patched bumble bee photo by Johanna James-Heinz

Ashton's cuckoo bumble bee photo by USGS Bee Inventory and Monitoring Lab

Due to its extreme rarity, Ashton's cuckoo bumble bee was proposed for listing as Endangered under the Maine Endangered Species Act in 2022. Although three more individuals were found at the same location in 2018 and 2019, surveys conducted in 2022 were unsuccessful. MDIFW will continue searching in 2023, especially along the New Brunswick border where a few new occurrences were recently documented. If not already too late, one hope is that the rising numbers of yellow-banded bumble bees across Maine and other northern regions might support a gradual recovery of this critically imperiled species.

MBBA surveys also indicated that two other cuckoo bumble bee species are rare in Maine. The **indiscriminate cuckoo bumble bee**, which was previously known from just a handful of records and apparently never common in Maine, was documented at just two locations – also in northern Aroostook County. Historically more common and widespread, the **lemon cuckoo bumble bee** was only found in 17 different townships, most in Aroostook County and a few in western Maine. MDIFW listed both these species as Special Concern in 2022.

Not uncommon in historical collections, the **yellow bumble bee** has become alarmingly rare in Maine over the past decade. Despite six seasons of MBBA followed by targeted MDIFW surveys for rare species, only nine occurrences have been documented statewide since 2015. Known to be experiencing a long-term, steady decline in other parts of its range, particularly in the Northeast, the yellow bumble bee was listed as Special Concern in 2022. If its downward trend continues, it could qualify for state-Threatened status.

MDIFW will continue to look for these extremely rare species in hopes of finding additional populations. You can help by carefully observing the bumble bees you see and documenting any possible sightings with close-up, in-focus photographs. Then submit your photos to iNaturalist (**inaturalist.org**), which MDIFW will monitor for confirmed reports. For more information and tips on how to identify the rusty patched and other rare bumble bee species, please visit the Maine Bumble Bee Atlas website (**mainebumblebeeatlas.umf.maine.edu**).

This work is supported by the federal (USFWS) State Wildlife Grants and Endangered Species Section 6 grants programs, state revenues from the Loon Conservation Plate and Chickadee Check-off Funds, and volunteer assistance from community scientists.

Damselflies and Dragonflies

Phillip deMaynadier

Insects in the order Odonata, damselflies and dragonflies are diverse and ecologically important members of Maine's wildlife community. Over 1/3 of North America's Odonate fauna — 160 species — have been documented in Maine. In fact, northeastern North America is considered a regional hotspot for damselfly diversity, hosting several species of global conservation concern.

TRACKING THE ELUSIVE RINGED BOGHAUNTER DRAGONFLY

Listed as a State Threatened species and a Species of Greatest Conservation Need in Maine's 2015 Wildlife Action Plan, the ringed boghaunter is globally rare and regionally restricted to the northeastern and upper midwestern U.S., where fewer than 60 populations have been documented. This species was a former candidate for federal listing and is considered "vulnerable" by the International Union for the Conservation of Nature.

Ringed boghaunter basking on a red maple trunk, South Berwick, Maine photo by Mark Ward

MDIFW biologists discovered Maine's first ringed boghaunter in 1995. Since then, extensive fieldwork (>725 field surveys of >325 wetlands over 26 years) has only yielded 16 confirmed and probable breeding populations, all restricted to York and Oxford Counties. One of the challenges of boghaunter detection is the short (less than one month) spring field season when winged adults are active near their natal wetlands. To help extend field study opportunities, MDIFW is cooperating with the University of Maine's School of Biology and Ecology (Dr. Erin Grey and Christiana Teye) to explore the use of environmental DNA (eDNA) as a novel survey technique. eDNA consists of cellular DNA products shed from organisms into their environment, and has recently emerged as a sensitive and cost-effective alternative to traditional survey methods for cryptic species. Currently, this research is focused on identifying boghaunter genetic markers, which if successful, could help us identify the shed larval skins (exuviae) they leave behind on aquatic vegetation upon transformation to adults. These exuviae are often more detectable than the far-flying adults and can persist for weeks or months, significantly extending the survey season.

In some cases, boghaunter dragonflies share their habitat with other species of conservation concern, including Blanding's turtles (State Endangered), spotted turtles (State Threatened), and Eastern ribbon snakes (State Special Concern). Significant in its own right, the ringed boghaunter is also an indicator of healthy pocket swamp and vernal pool ecosystems – habitats threatened by development in southern Maine. As with other vulnerable elements of Maine's biological diversity, identifying, characterizing, and mapping populations of the ringed boghaunter is an important first step toward forging species conservation strategies and partnerships with landowners, land trusts, towns, and others.

New England bluet photo by Bryan Pfeiffer

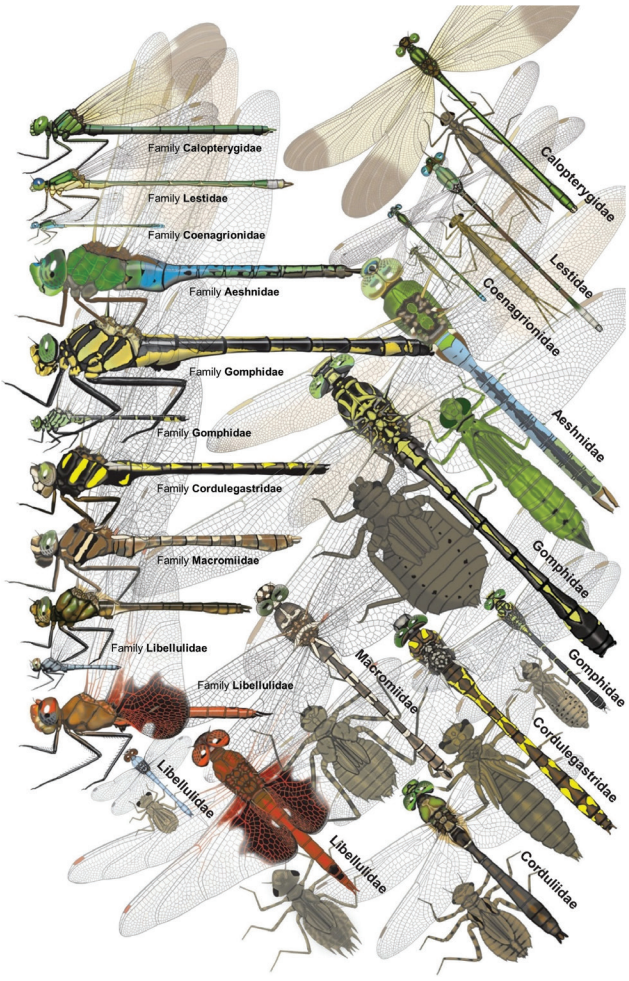
AN ATLAS OF THE DAMSELFLIES AND DRAGONFLIES OF THE ACADIAN REGION

In 1998, MDIFW received a grant from the Maine Outdoor Heritage Fund to initiate the Maine Damselfly and Dragonfly Survey (MDDS). One of North America's first state-sponsored dragonfly atlasing projects, the MDDS engaged trained community scientists to improve the Department's knowledge of statewide Odonata distribution and abundance. In addition to engaging nearly 250 Maine naturalists and raising public awareness of invertebrate conservation, the MDDS helped MDIFW more accurately assess the status of several at-risk species including the ringed boghaunter and boreal snaketail (both State Threatened), and 18 additional species of State Special Concern.

With the field survey component of the MDDS completed, the next phase is to compile and summarize the results by way of: a) a comprehensive database of all Odonate records of Maine and the Maritime Provinces (completed), b) a reference collection of Museum-curated specimens and digitally-archived photo vouchers of all 160+ species, c) a

website summarizing the distribution and status of Maine's Odonata, and d) a book planned for publication by Cornell University Press in 2025. The publication (co-authored by P. Brunelle, R. Butler, J. Klymko, P. deMaynadier, and D. McAlpine) is intended for scientists and curious naturalists alike, and will include detailed species distribution maps, keys to larvae and adults, 160 color species accounts, and an emphasis on species status and conservation needs. The book will be generously annotated with detailed color schematics of the region's Odonata **(Figure 6)** by the first author, the late Paul Brunelle, an accomplished graphic design artist.

FIGURE 6. ADULTS AND LARVAE (SCALED TO SIZE) OF REPRESENTATIVE ODONATA FAMILIES AND GENERA OF THE ACADIAN REGION. DRAWINGS BY PAUL M. BRUNELLE.



This work is supported by the federal (USFWS) State Wildlife Grants program, state revenues from the Loon Conservation Plate and Chickadee Check-off Funds and volunteer assistance from community scientists.

Butterflies

Phillip deMaynadier

With over 120 species and subspecies, butterflies are a colorful and conspicuous component of Maine's biological diversity. They also play important ecological roles, both as wildflower pollinators and as prey to larger species, from dragonflies to birds. Despite growing concern for butterflies and other pollinating insects, Maine has, until recently, only had a rudimentary knowledge of the group.

MAINE BUTTERFLY SURVEY

Launched in 2007, the Maine Butterfly Survey (MBS) was a statewide atlasing effort designed to fill information gaps on distribution, flight seasons, and habitat relationships for one of the state's most popular insects. Following in the tradition of previously state-sponsored wildlife surveys, MBS data was contributed by both professional biologists and community scientists.

There is increasing scientific and public concern about the status of butterflies, bumble bees, and other pollinating insects. Of special note is the high proportion of Maine butterflies considered Extirpated, Endangered, Threatened, or Special Concern. Additionally, about 20% of the state's butterflies are currently recognized as Species of Greatest Conservation Need (SGCN) in Maine's 2015 Wildlife Action Plan because of perceived rarity and habitat specialization. Statewide survey effort could demonstrate that some of these species are more abundant than formerly believed, while others may merit increased conservation attention. By marshalling the efforts of volunteers and professionals, this multi-year atlas was designed to advance our knowledge on the status and trends of the state's butterfly fauna.

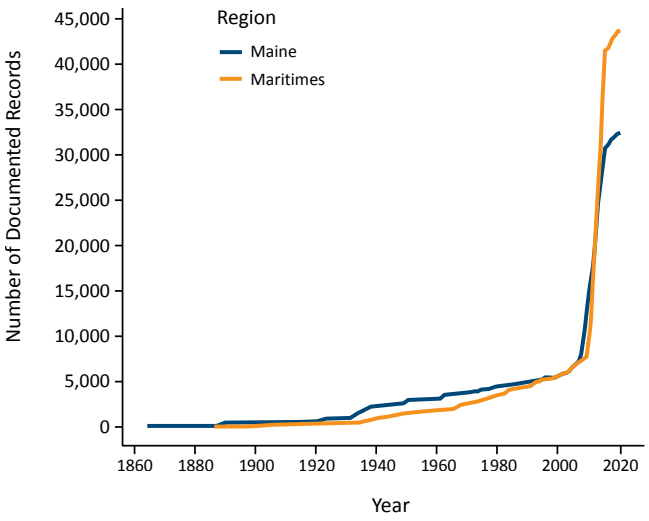
Pink-edged sulphur photo by Bryan Pfeiffer

White admiral photo by Bryan Pfeiffer

The volunteer atlasing component of the MBS project was launched in 2007 and completed its 10th field season in 2016. More than 25,000 new observations were contributed, representing a >270% increase in records over project baseline. Since then, we have limited new data submissions to unusual species and new county records.

Placed in the context of Maine's historical butterfly study over the past century **(Figure 7)**, the MBS contributions are striking. Many of these records provide novel information to our understanding of butterfly distribution and abundance, including >240 new county records, 12 new state records, one new U.S. national record (Short-tailed Swallowtail), and dozens of newly recorded SGCN butterflies.

FIGURE 7. CUMULATIVE INCREASE IN BUTTERFLY RECORDS IN MAINE AND THE MARITIMES INDICATING THE RECENT DRAMATIC INCREASES ASSOCIATED WITH BOTH COMMUNITY SCIENCE PROJECTS.



Public outreach goals for the project met expectations, with more than 300 volunteers attending MBS training workshops at Colby College, over half of whom contributed photo and/or specimen voucher records. More than 10 media articles were published on the project, and the website (**mbs.umf.maine.edu**) has attracted more than 50,000 worldwide visits.

NEW ACADIAN BUTTERFLY PUBLICATION

In 2016, we began working with the Atlantic Canada Conservation Data Centre (John Klymko) to combine data from their recently completed Maritime Butterfly Atlas with that of the MBS project. A key product of this collaboration is a new book entitled *Butterflies of Maine and the Canadian Maritime Provinces,* available from Cornell University Press in the fall of 2023 **(Figure 8)**. Other atlas and book collaborators include UMaine Farmington (Ron Butler), Colby College (Herb Wilson), and the Florida Museum of Natural History (John Calhoun).

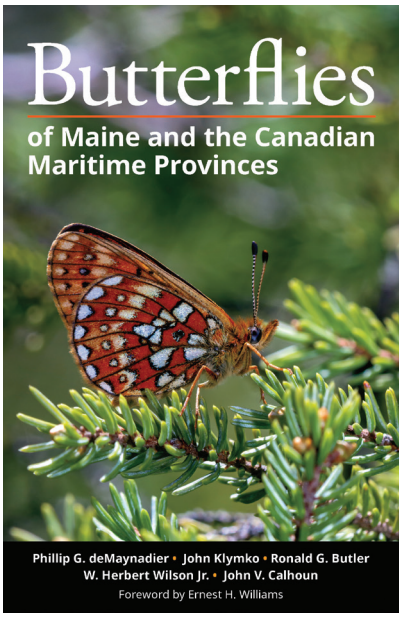


FIGURE 8. RECENTLY COMPLETED BOOK ON THE BUTTERFLIES OF THE ACADIAN REGION, WITH CONTRIBUTIONS BY MAINE COMMUNITY SCIENTISTS.

We hope that this contribution will both summarize the state of Acadian region butterfly knowledge for scientists and introduce new members of the public to the fascinating world of butterflies and other invertebrates.

In addition to the publication, other recently completed MBS project deliverables include: a finalized electronic database of over 38,000 records, an updated MBS website, revised state butterfly rarity ranks (NatureServe S-ranks and state ETSC status), and a curated reference collection at the Maine State Museum.

The work is supported by the federal (USFWS) State Wildlife Grants program, The Nature Conservancy, the Maine Outdoor Heritage Fund, state revenues from the Loon Conservation Plate and Chickadee Check-off Funds, and volunteer assistance.

Flowerflies (Hoverflies)

Phillip deMaynadier

Reports of insect decline are widespread in the scientific and popular press, raising concerns that critical ecosystem functions such as pollination, decomposition, and food web provisioning are at risk of unravelling. Yet we still do not know the status of entire groups of insects, or why they might be declining. One such group that is known to be important for pollination in the Northeast is flower flies, also known as hover flies (order: Diptera; family: Syrphidae). With approximately 900 species in North America, these flies are among the most colorful and conspicuous insects found around flowers. Flower flies occur in a diverse range of moist northeastern habitats, from salt marshes to old-growth forests, and they play important ecological roles during different phases of their life cycle. As adults forage for nectar and pollen they pollinate many plant species including crops such as cranberries. And unlike young bees, who are fed by their mothers or colonies, flower fly larvae forage for themselves and typically serve as decomposers or predators of aphids and related insects.

Until now, MDIFW has not worked on flower flies, due to a lack of awareness of their importance and to limited capacity and expertise. This recently changed when, with assistance from NatureServe, Maine and a few other northeastern states began developing state flower fly checklists followed by assessments of their rarity and risk status. To support this effort, NatureServe contracted John Klymko from the Atlantic Canada Conservation Data Centre to develop a list of Maine flower flies based on confirmed records gleaned from the literature, museum collections, online community science forums (e.g., iNaturalist, BugGuide), and recent surveys. Upon completion of this contract, Klymko delivered an electronic database of more than 3,500 Maine flower fly records and a checklist of 214 species including completed S-ranks per NatureServe methodology.

Oblique-banded pond fly photo by Ron Butler

Bald-faced hornet fly photo by Ron Butler

NatureServe is a North American network of scientists and institutions whose mission is to track the status and trends of at-risk species and habitats based on standardized, science-based methodologies. Core to this practice is the assignment of conservation status ranks indicating the threat of extinction or extirpation a species or subspecies faces at the global, national, and subnational (e.g., states and provinces) levels, using G-ranks, N-ranks, and S-ranks, respectively. **NatureServe status ranks** take into consideration factors of rarity, threats, and population trends, and can be defined as follows:

- **X:** Presumed extinct (G-rank) or extirpated (N-rank and S-rank).
- **H:** Possibly extinct — known from only historical occurrences but still hope of rediscovery.
- **1:** Critically imperiled — At very high risk of extinction or extirpation.
- **2:** Imperiled — At high risk of extinction or extirpation.
- **3:** Vulnerable — At moderate risk of extinction or extirpation.
- **4:** Apparently secure — At fairly low risk of extinction or extirpation.
- **5:** Secure — At very low risk of extinction or extirpation.
- **U:** Unrankable — Unrankable due to lack of information about status or trends.
- **NR:** Unranked — Rank not yet assessed.
- **NA:** Not applicable — The species is not a suitable target for conservation activities. Examples include nonnative species, rare colonists, and vagrants.

While we do not have enough records or life history information on most of Maine's flower flies to develop informed ranks (making them State Unrankable, or SU), eight species were flagged as taxa of potential conservation concern. These included *Chrysogaster inflatifrons (SH), Eristalis brousii (SX), Sericomyia slossonae (S1S3), Volucella evecta (S1S3), Volucella facialis (S1S3), Parasyrphus tarsatus (S1), Platycheirus modestus (SH), and Sphaerophoria pyrrhina (SX).* These S-ranks are now available to the public via the NatureServe Explorer online database (**explorer.natureserve.org**). With this new information on a previously under-studied taxon, MDIFW is better prepared to consider adding at-risk flower flies to the state's SGCN list during the 2025 State Wildlife Action Plan update, thereby leveraging SWG funds for increased survey, research, and conservation of this ecologically important group.

The work is supported by the federal (USFWS) State Wildlife Grants program, state revenues from the Loon Conservation Plate and Chickadee Check-off Funds, NatureServe, and the Sarah K. de Coizart Perpetual Charitable Trust.

Mayflies

Beth Swartz

Mayflies, or "shadflies" as they are often called, are a diverse group of insects with over 170 species found in Maine. Some species inhabit lakes and ponds, but most live in the flowing waters of streams and rivers. Belonging to the Order Ephemeroptera – named for the short lifespan of the winged adults – mayflies spend nearly their entire lives underwater, where they play a significant role in the food webs of aquatic ecosystems. The often-abundant nymphs are major algae consumers and plant material decomposers, and they provide a high-quality food source for many stream predators. Anglers know that a good mayfly stream is likely a good trout and salmon stream, too – and the most popular flies tied by fly-fishers are modeled after the different life stages of the mayfly.

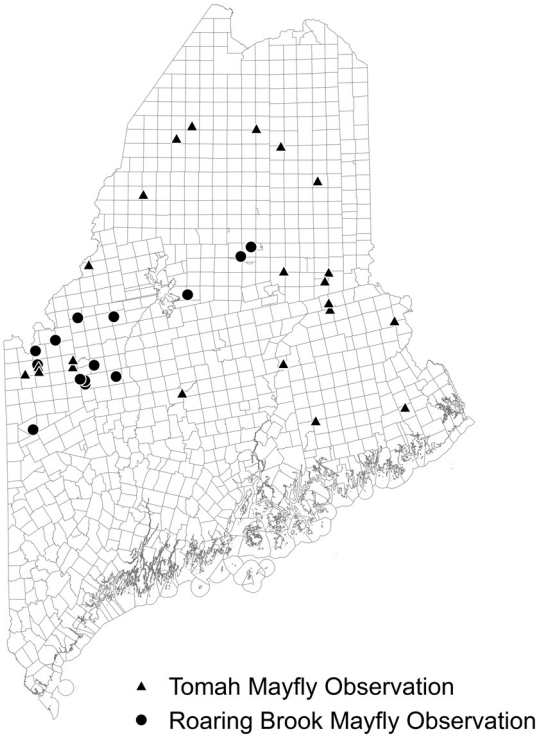
MAYFLY CONSERVATION

Most, but not all, of Maine's mayfly species are common and widespread. Of the rarer mayfly species, Maine lists Roaring Brook and tomah mayflies as Threatened, and both are identified as Priority 1 Species of Greatest Conservation Need (SGCN) in Maine's 2015 Wildlife Action Plan.

The **Roaring Brook mayfly** is among the rarest mayflies in the world. For many years, it was only known from a single adult specimen collected on Mt. Katahdin in 1939, until MDIFW confirmed in 2003 that the species was still present there. Since then, MDIFW has surveyed more than 170 streams and documented 15 where the mayfly occurs, all in the mountains of north central and western Maine **(Figure 9).**

Roaring Brook mayfly photo by Don Chandler

FIGURE 9. DISTRIBUTION OF ROARING BROOK MAYFLY AND TOMAH MAYFLY IN MAINE.



Tomah mayfly ©Dwight Kuhn

Researchers outside of Maine have also collected specimens in recent years: one in the Green Mountains of Vermont and several in the White Mountains of New Hampshire. While we now know the Roaring Brook mayfly is not confined just to Mt. Katahdin, it does appear to be New England's only endemic mayfly, restricted to cold, undisturbed, high-elevation streams of the northern Appalachian Mountain Range. To learn more about this unique habitat and the Roaring Brook mayfly's ability to survive its harsh conditions, be sure to read "Montane Headwater Streams" on page 29.

Like the Roaring Brook mayfly, **Brown's comb minnow mayfly** is also a high-elevation, headwater stream specialist. To date, it has been recorded at just seven streams in Maine — five in Baxter State Park and two in the western mountains. Its only other global records are from similar habitats in Vermont and the White Mountains of New Hampshire, as well a single record from Quebec. Of the 170 streams that MDIFW surveyed for Roaring Brook mayfly, we only found Brown's comb minnow mayfly in two. The Roaring Brook and Brown's comb minnow mayflies may be equally rare, but we can't be certain yet. Because the minnow mayfly emerges in early spring, it may be under-sampled. For now it is listed as Special Concern, but to adequately assess its status in Maine, we will need to do more targeted survey work.

The **Tomah mayfly,** once thought to be extinct, was rediscovered in Tomah Stream (Washington County) in 1978 and has since been documented at 21 sites across northern, eastern, and central Maine **(Figure 9)** and at least one site in New York. Unlike other mayfly species, the Tomah mayfly is carnivorous as a nymph, preying largely upon other mayfly larvae. To complete its life cycle, this species depends on highly productive seasonally flooded sedge meadows along large streams or rivers. Although sedge meadows are not uncommon in Maine, the Tomah mayfly is only known to inhabit a limited number of sites.

To protect Maine's state-listed mayflies, MDIFW regularly provides management guidelines for development projects and forest harvest activities that may impact their stream habitats. In 2020 and 2021, this included working with several ski resort expansion projects to avoid and minimize their impacts on potential Roaring Brook mayfly streams. The best management practices that we recommended focused on conserving forested riparian buffers, implementing Stream Smart road and trail crossings, and protecting water quality.

This work is supported by the federal (USFWS) State Wildlife Grants program, state revenues from the Loon Conservation Plate and Chickadee Check-off Funds.

Tiger Beetles

Derek Yorks

Tiger beetles are a large group of predatory beetles belonging to the subfamily Cicindelinae within the family Carabidae (ground beetles). They are known for their incredible running speed (relative to their size) and their aggressive predatory behaviors. They have large eyes, long legs, and prominent mandibles. Maine's 14 known tiger beetle species live in a variety of habitats, but most are associated with bare or sparsely vegetated ground that may be composed of sand, gravel, cobble, or mud depending upon the species. Even their larvae are fierce predators, living in burrows where they lie in wait to ambush invertebrate prey that pass over them.

KEEPING TRACK OF RARE TIGERS

Most of Maine's tiger beetle species are widespread and common in their respective habitats. However, Maine lists one as Endangered, one as Threatened, and one as Special Concern. The State Endangered **cobblestone tiger beetle** is identified as a Priority 1 Species of Greatest Conservation Need (SGCN) in Maine's 2015 Wildlife Action Plan and the State Threatened **marginated tiger beetle** and State Special Concern **White Mountain tiger beetle** are identified as Priority 2 SGCN.

Cobblestone tiger beetle photo by Jonathan Mays

The cobblestone tiger beetle, first discovered in Maine in 2009, is considered a 'Globally Imperiled' (G2) species by NatureServe and is deemed 'Critically Imperiled' (S1) in most jurisdictions throughout its range including New Brunswick, Maine, New Hampshire, Vermont, New York, Pennsylvania, New Jersey, West Virginia, Indiana, Kentucky, and Alabama. It is 'Presumed Extirpated' in Mississippi.

This unique insect is rare primarily because it is a habitat specialist confined to sparsely vegetated cobble bars (usually associated with islands) in free-flowing rivers of a very specific hydrology. This distinct habitat is maintained by high flows in the early spring that produce the preferred cobble substrate and limit organic sediment build-up. Statewide surveys to document potential new cobblestone tiger beetle populations were conducted in 2010 and more recently in 2019 and 2020, but failed to locate the species anywhere other than its original site of discovery in Somerset County. MDIFW will continue to search for this endangered beetle, but the list of remaining unsurveyed sites with suitable habitat is short, and it is quite possible that the future of the cobblestone tiger beetle in Maine depends on our efforts to conserve the habitat integrity of a single small watershed in the western foothills.

UPCOMING TIGER BEETLE STUDY

The newly state-Threatened marginated tiger beetle is a saltmarsh habitat specialist. Within this ecosystem, it primarily inhabits the back dune-marsh ecotone where unvegetated sand lies between the salt marsh's high tide line and the barrier beach's backdune. This species is rare throughout New England; and in Maine, its distribution is very limited and its habitat is increasingly threatened by development and climate change-caused sea level rise. In 2023, MDIFW plans to assess the status of the few known marginated tiger beetle populations. We will also survey for potential new populations in areas of suitable habitat while keeping track of relative abundance and potential habitat threats.

This work is supported by the federal (USFWS) State Wildlife Grants program, state revenues from the Loon Conservation Plate and Chickadee Check-off Funds.

Freshwater Mussels

Beth Swartz

Freshwater mussels are largely sedentary, bottom-dwelling invertebrates found in most of Maine's lakes, ponds, rivers, and streams. They provide a vital service to aquatic environments by filtering suspended particles such as algae and bacteria from the water – keeping it clean for humans, too. Because they spend their entire lives (decades!) in one place constantly filtering large volumes of water, freshwater mussels are valuable indicators of water quality and aquatic ecosystem health. They are also one of the most imperiled groups of animals in the country. Of the nearly 300 species native to the U.S., more than a third have vanished or are in danger of extinction, and over 75% are listed as Endangered, Threatened, or Special Concern at the state level. These dramatic declines have resulted primarily from habitat loss and degradation caused by pollution, dams, invasive species, riparian development, and channelization and sedimentation of once clean, free-flowing rivers and streams.

Maine is home to 10 species of freshwater mussels **(Table 2)**, three of which are listed as Threatened under the Maine Endangered Species Act: the brook floater, yellow lampmussel, and tidewater mucket. For more than three decades, MDIFW's conservation actions have helped protect these rare species and their habitat. Examples include surveying for new occurrences, assessing statuses of known populations, identifying potential threats and conservation needs, helping to remove and relocate mussels from harm's way during construction projects, and working with partners on new monitoring techniques and regional conservation programs. Read on to learn more about MDIFW's work with rare mussels in 2021 and 2022.

TABLE 2. FRESHWATER MUSSELS OF MAINE.

COMMON NAME	SCIENTIFIC NAME	STATE LISTING
Eastern Pearlshell	*Margaritifera margaritifera*	
Eastern Elliptio	*Elliptio complanata*	
Triangle Floater	*Alasmidonta undulata*	
Brook Floater	*Alasmidonta varicosa*	THREATENED
Eastern Floater	*Pyganodon cataracta*	
Alewife Floater	*Utterbackiana implicata*	
Creeper	*Strophitus undulatus*	
Yellow Lampmussel	*Lampsilis cariosa*	THREATENED
Eastern Lampmussel	*Lampsilis radiata*	
Tidewater Mucket	*Atlanticoncha ochracea*	THREATENED

ASSESSING BROOK FLOATER STATUS IN THE PISCATAQUIS RIVER

The **brook floater** is found only in clean, relatively undeveloped, undammed rivers and streams with intact forested riparian buffers. Because of its exacting habitat requirements, this species has declined throughout its range and is listed as Endangered or Threatened in nearly every state where it occurs.

In Maine, its stronghold lies in streams and rivers of the Penobscot River watershed, but it also inhabits several other river systems across the state. In 2020, a new brook floater occurrence (one individual) was discovered in the Piscataquis River — a tributary of the Penobscot. In 2021, MDIFW contracted Ethan Nedeau (Biodrawversity, LLC) to assess the status of the brook floater in the river. Ethan was able to find eight animals of various ages at seven sites from Milo to Guilford, indicating that a small population is present in the river. During the survey, he also found a strong population of yellow lampmussels and one tidewater mucket.

Brook floater photo by Ethan Nedeau

ASSESSING TIDEWATER MUCKET STATUS IN COLD STREAM POND AND THE LOWER ANDROSCOGGIN RIVER

Like the brook floater, the **tidewater mucket** has declined throughout much of its Atlantic Coast range. Unlike the brook floater, it lives in lakes and ponds as well as rivers and streams. Contrary to its name, this mussel has been found far from tidal waters in Maine but never outside the Penobscot, Kennebec, and St. George River watersheds. One of the oldest Maine tidewater mucket records is from Cold Stream Pond in Enfield, where it was first reported in 1947. Subsequent surveys by The Nature Conservancy in 1984 and MDIFW in 1995, 1996, and 2006 failed to reconfirm the species' presence in the pond. Undeterred, MDIFW sent Ethan Nedeau back to Cold Stream Pond in 2022. Within 45 minutes, he located several live muckets – marking the first time the species had been found in the pond in 75 years!

Another old record — an empty shell found in 1995 where the mouth of the Androscoggin River meets Merrymeeting Bay — has long been a mystery to MDIFW. While tidewater muckets had previously been documented about 14 miles upriver in the Kennebec, live animals had never been found downstream, nor had the species ever been reported from the Androscoggin or any of its tributaries. Consequently, it was thought the shell had probably drifted downstream from the Kennebec River. In 2022, MDIFW contracted Ethan Nedeau to survey the greater Merrymeeting Bay area, including the lower Androscoggin River, lower Kennebec River, and the Muddy River, a tributary of the lower Kennebec. He visited 13 sites and found live muckets at every location! This discovery of an Androscoggin River population was the first time the species had been found outside the three previously known watersheds. What we do not know yet is if the mucket occurs further up the Androscoggin or if it is restricted to the area below the first dam in Brunswick.

RECOVERY AND RELOCATIONS

To keep Maine's freshwater mussel fauna intact, it's important that we minimize impacts on listed species during projects that alter aquatic habitat or directly affect the bottom substrate. MDIFW frequently provides recommendations and coordinates pre-project surveys and relocations when listed species might be present, including for bridge repairs and replacements, dam removals, impoundment drawdowns, dredge projects, shoreline stabilization, boat launch construction, and underwater pipeline crossings. For example, MDIFW worked with Maine Dept. of Transportation in 2021 to survey the Penobscot River where the Rte. 2 bridge in Old Town is scheduled for replacement. Within the project footprint, biologists found 86 yellow lampmussels, five tidewater muckets, and one brook floater. We moved them all, along with some more common mussel species, a short distance upriver where they would be safe from construction activities.

Tidewater mucket photo by Ethan Nedeau

Yellow lampmussel photo by Ethan Nedeau

OUTREACH AND PARTNERSHIPS

Because Maine hosts some of the best remaining brook floater, yellow lampmussel, and tidewater mucket populations and habitats, we play a key role in their rangewide conservation. Throughout 2021 and 2022, MDIFW provided technical support and expertise to a variety of state and regional rare freshwater mussel conservation efforts. In partnership with Maine DOT and the University of Maine, we collected DNA samples from all ten of our mussel species to support development of eDNA markers for detecting species presence from water samples. We also collected DNA samples from two different **yellow lampmussel** populations, which we provided to the U.S. Fish & Wildlife Service for its research on this rare mussel's genetic diversity across its range. New yellow lampmussel initiatives included MDIFW serving on a technical Working Group to develop a rangewide assessment and conservation program, and cooperating with the University of Maine to investigate methods for assessing habitat and identifying potential survey and restoration locations.

MDIFW also worked with Ethan Nedeau to develop a brochure/poster that highlights **Maine's freshwater mussel fauna,** the Department's conservation efforts, and how you can help. This is available for download at **mefishwildlife.com/mussels** and a printed version will be published by spring 2023. We also developed similar outreach panels for two watersheds where listed mussels occur. These will be placed at public access sites to teach visitors about Maine's freshwater mussels and how they can support their conservation.

This work is supported by the federal (USFWS) State Wildlife Grants program, state revenues from the Loon Conservation Plate and Chickadee Check-off Funds.

SPECIAL HABITATS FOR REPTILES, AMPHIBIANS, AND INVERTEBRATES

Per the Maine Legislature, it is the state's policy (and MDIFW's responsibility) to conserve and manage all species of inland fish and wildlife. We take this mandate seriously, but we're also aware of the challenge it presents, considering wildlife is further defined by the state to include thousands of species of native birds, mammals, fish, reptiles, amphibians, and invertebrates.

The Department uses a fine-scale, hands-on approach to the conservation and management of a relatively small number of these species, mainly those managed as harvestable fish and game and those endangered or threatened by extinction. However, the state does not have the capacity to manage all fish and wildlife resources on an individual species-by-species basis. Biologists recognize that a more efficient and lasting approach for sustaining the majority of wildlife requires working at coarser scales, by identifying and conserving diverse high-value habitats and natural communities. Doing so not only provides a safety net for our most vulnerable habitat-specialized species, but also helps maintain healthy populations of all Maine wildlife. Below, we highlight some especially valuable habitats for reptiles, amphibians, and nonmarine invertebrates.

Pollinator Habitat

Beth Swartz

Maine is home to a wide diversity of native insect pollinators, including many species of butterflies and moths (Lepidoptera), bees (Hymenoptera), beetles (Coleoptera), and flies (Diptera). The ecosystem services that these wild pollinators provide to natural communities and human societies is immeasurable. Without them, many wildflowers, shrubs, and trees, as well as fruits and vegetables, would not get pollinated, including important Maine crops like apples and blueberries.

Over the past few decades, several native Maine pollinators, including the monarch butterfly, rusty patched bumble bee, and hourglass drone fly have experienced significant declines throughout their ranges. Factors including habitat loss, disease, pesticides, competition from introduced species, and climate change have put these and other insect pollinators in danger of extirpation.

photo by Kelly Boland

Monarch butterfly photo by Bryan Pfeiffer

HOW YOU CAN HELP

We can all help reverse the decline by protecting pollinator habitats. Here are a few ways to do so:

Invite Summer Monarchs – Providing summer habitat for monarch butterflies is as simple as allowing native milkweeds, the sole host plants for their caterpillars and a valuable nectar source, to grow and flourish. Many other beneficial insects in Maine also feed at milkweed flowers.

Create a Bumble Bee Haven – Bumble bees are habitat generalists, but they require an abundance and diversity of flowering plants that offer food from early spring to late fall. You can help by including an assortment of preferred pollinator flowers among your plantings during every part of the growing season.

Embrace Your Wild Side – Some of the best habitats for pollinators are "weedy" unmowed fields and roadsides, which generally benefit from full sun and are rich in pollinator favorites like clovers, milkweeds, goldenrods, vetches, dogbanes, asters, thistles, fireweed, lupines, and raspberries. You can replicate this at home by allowing a portion of your lawn to grow tall until late fall, or by creating an unmowed border around the edge of your property. In early spring, waiting two to three weeks between mowings will allow clovers, violets, creeping groundcovers, and dandelions to bloom - providing pollinators with some of their first available nectar and pollen sources of the season.

Plant a Pollinator Garden – Many common garden plants are especially attractive to butterflies, bumble bees, and other insect pollinators. Examples of favorites that provide high quality nectar and pollen include bee balm, butterfly-weed, sunflower, coneflower, thyme, mint, rhododendron, blueberry, and rose, but there are many more from which to choose. Use native species as often as possible and remember to include host plants for caterpillars.

Minimize Reliance on Pesticides – Be selective when using herbicides. Controlling flowering plants that pollinators feed on reduces their food resources. Always follow label directions carefully when using insecticides. Because insecticides are designed to control insects, improper use may harm bees and other insect pollinators. Even products approved for use by organic growers or homemade mixtures can be toxic to pollinators. Avoid treating plants that are actively flowering with any pesticide, natural or synthetic, since they may be visited by beneficial pollinators. Integrated pest management techniques can help you minimize the need for control. The Maine IPM council's GotPests website, **www.gotpests.org**, can help.

For more information, visit the Xerces Society at **xerces.org/pollinator-conservation**.

Vernal Pools

Phillip deMaynadier

Vernal pools are small, forested wetlands that come in many shapes, sizes, and settings. In the spring, their depressions fill with water from snowmelt and rain, and by late summer, they become partly or completely dry.

Isolated from streams, these habitats provide wildlife with a rich, highly valuable fish-free food base fed by surrounding organic forest matter. They also provide a nearly predator-free haven for a diversity of specialized amphibians (salamanders, frogs, and toads) and aquatic invertebrates (over 500 species in New England) that lack the physical and chemical defenses to reproduce in more fishy environs. Some of Maine's better-known vernal pool indicator species, including spotted salamanders, blue-spotted salamanders, wood frogs, and fairy shrimp, breed almost exclusively in vernal pools.

Still, just as deer wintering areas and waterfowl and wading bird wetlands host more than just deer and ducks, vernal pools provide habitat for more than a few specialized frogs and salamanders. Over half of Maine's amphibian and reptile species frequent vernal pool habitats during their life cycles, as do more familiar species like black ducks, great blue herons, flycatchers, hawks, deer, moose, fox, mink, bats, and other small mammals. Some forest herbivores are drawn to vernal pools because they serve as spring oases, offering up the season's first herbaceous forage. And forest predators are attracted to vernal pools because of the abundance of amphibian prey on the surrounding forest floor. In some forests, the collective weight (or "biomass") of these unseen spring amphibian sentinels has been estimated to exceed that of all birds and mammals combined! Indeed, their sheer abundance and palatability has many biologists and sportsmen convinced that the terrestrial wanderings of pool-breeding frogs and salamanders play a powerful role in the local ecology of Maine's woodlands.

Additionally, among Maine's dozens of wetland community types, few host as many rare and endangered species as do vernal pools, which provide sustenance and shelter to the Blanding's turtle (Endangered), spotted turtle (Threatened), ribbon snake (Special Concern), ringed boghaunter dragonfly (Threatened), as well as rare plants including the featherfoil (Threatened) and sweet pepperbush (Special Concern). Some of these species could face extinction in Maine without the distribution of high-value vernal pools throughout their range.

Blue-spotted salamander photo by Jonathan Mays

Vernal pool photo by Phillip deMaynadier

DEFINING AND PROTECTING SIGNIFICANT VERNAL POOLS

In 2006, MDIFW and the Maine Department of Environmental Protection (MDEP) developed a definition of Significant Vernal Pools — a Significant Wildlife Habitat under the state's Natural Resource Protection Act (NRPA) — which was approved by the 120th Maine Legislature.

By definition, a vernal pool is considered significant if a State Endangered or Threatened species is present or there is evidence of exceptional breeding abundance by specialized amphibian indicator species.

In collaboration with MDEP, MDIFW has reviewed over 4,430 vernal pools to date, and approximately 20-25% of them meet standards for potential regulatory significance under NRPA. This use of science-based and legislatively approved criteria for defining a high value (significant) subset of Maine's vernal pools helps MDIFW biologists prioritize those with the greatest wildlife habitat values.

ONGOING EFFORTS AND HOW TO HELP

MDIFW and MDEP cooperate with the Maine Department of Conservation (DOC), municipalities, and landowners to conserve vernal pools. Workshops on vernal pool biology and conservation have been held throughout the state for landowners, land trusts, and land managers, and several publications are available offering voluntary techniques for protecting vernal pools and their wildlife. One such publication, *The Maine Citizen's Guide to Locating and Documenting Vernal Pools*, provides a comprehensive introduction to recognizing and monitoring vernal pools, including color photographs of the indicator species. Also available are two complementary guidebooks for protecting vernal pool habitat during timber management (*Forestry Habitat Management Guidelines for Vernal Pool Wildlife*) and development (*Conserving Pool-breeding Amphibians in Residential and Commercial Developments in the Northeastern United States*). All of the guides can be obtained by contacting the Maine Audubon Society at 207-781-2330.

Pitch Pine Woodlands and Barrens

Phillip deMaynadier

Pitch pine woodlands and barrens are lightly forested upland areas with dry, acidic, and often sandy soils. Pitch pine, red pine, scrub oak, blueberry, huckleberry, and/or bluestem grasses are commonly among the sparse vegetation of this unique natural community.

Once viewed as unproductive wastelands, Maine's few remaining pine woodlands and barrens are now recognized as areas of exceptional wildlife value, providing habitat for a variety of highly specialized plants and animals that feed on the specialized barrens vegetation. These unique habitats are especially rich in rare butterflies and moths, such as Edwards' hairstreak (Endangered), sleepy duskywing (Threatened), cobweb skipper (Special Concern), and barrens buck moth (Special Concern). Other rare species associated with Maine's barrens include black racers (Endangered), grasshopper sparrows (Endangered), upland sandpipers (Threatened), northern blazing star (Threatened), and many other rare plants.

Pitch pine woodlands photo by Phillip deMaynadier

Sleepy duskywing photo by Bryan Pfeiffer

Dry woodlands and barrens often require periodic fire to prevent succession to a more common, closed-canopy white pine-oak ecosystem; however, fire is a natural disturbance that is now short-circuited by habitat fragmentation and active fire suppression. Both MDIFW and The Nature Conservancy make an effort to manage barren habitats that are in conservation ownership by implementing prescribed burns and mechanical harvesting as tools for conserving the ecosystem's unique vegetation structure and composition. It is estimated that over half of the state's original pine barren acreage has been lost to residential development, agriculture, and gravel mining, and what remains intact (mainly in the towns of Kennebunk, Wells, Waterboro, Sanford, Shapleigh, Hollis, and Fryeburg) is now tracked as a rare natural community by the Maine Natural Areas Program (MNAP, **maine.gov/dacf/mnap**).

Freshwater Marshes and Shrub Swamps

Derek Yorks

Freshwater marshes and shrub swamps are open, vegetated, shallow wetlands that contain water most of the time. They vary in size and appearance, but are all characterized as sun-soaked places with standing water, abundant vegetation, and high biological production. Many of Maine's amphibians, reptiles, and invertebrates depend on these wetlands for some or all of their life cycle.

WILDLIFE HUBS FOR MAYFLIES, MINK FROGS, AND MOOSE

Across Maine's forest-dominated landscape, marshes and shrub swamps serve as focal points for a wide diversity of wildlife.

The mixture of lush herbaceous vegetation found above and below the water surface provides amphibians with shelter from predators, plus food in the form of invertebrate prey or the vegetation itself. Frogs, including leopard frogs (Special Concern), pickerel frogs, green frogs, bull frogs, mink frogs, gray tree frogs, and spring peepers breed and often live here year-round. Many reptile species, including spotted turtles (Threatened), Blanding's turtles (Endangered), painted turtles, ribbon snakes (Special Concern), garter snakes, and northern water snakes, thrive here too. And these habitats are also hugely important to many invertebrate groups, perhaps most conspicuously dragonflies and damselflies, as well as waterfowl, wading birds, beaver, muskrat, and moose.

Blanding's turtle photo by Derek Yorks

CRITICAL HABITAT FOR BLANDING'S TURTLE

Thanks to a Competitive State Wildlife Grant (U.S. Fish and Wildlife Service), MDIFW has recently been able to conduct assessment and planning efforts focused on Blanding's turtles in Maine.

While Blanding's turtles are known to use a number and variety of wetlands, even in a single season, they are not found in just any wetland type. High-value marshes and shrub swamps are often at the core of their home ranges, generally serving as overwintering and late summer feeding areas.

As Maine biologists continue to collect and analyze data from this project, we expect to learn more about what specific characteristics of marshes and shrub swamps are critical for the survival of this and other priority wildlife species.

Shrub swamp photo by Phillip deMaynadier

Montane Headwater Streams

Beth Swartz & Phillip deMaynadier

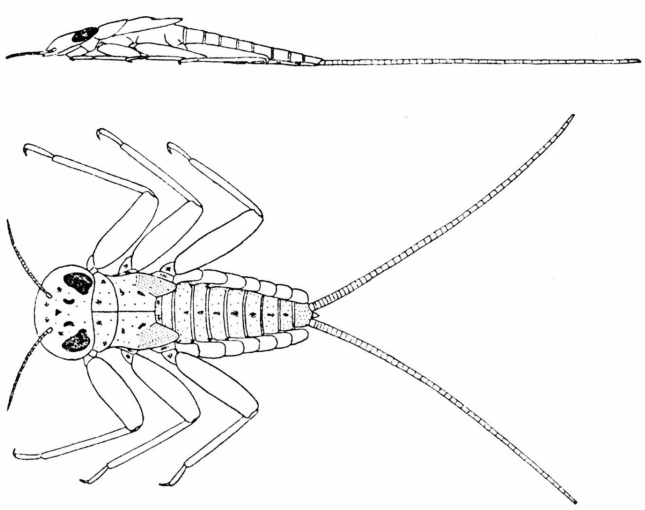
"To protect your rivers, protect your mountains."
— Emperor Yu of China, 1600 B.C.E.

A montane headwater stream often begins its journey as an underground trickle. Fed by groundwater and swelled by melting snow and seasonal rains, it tumbles down steep mountain slopes in a cascade of steps and pools, gradually widening as it descends to lower elevations where it will join with other headwaters. Some too small to show up on a map, Maine's high-elevation headwater streams are the birthplaces of our state's rich network of streams, rivers, lakes, ponds, and productive wetlands.

Scoured by ice in winter and flash floods in spring and fall, and often nearly bone dry in summer, montane streams are highly dynamic ecosystems where life can be difficult for an aquatic organism. But these harsh conditions provide refuge for a unique community of animals well-adapted to survive in such a habitat. Some species of aquatic insects have evolved to thrive in montane headwater streams, benefiting from the absence of fish and other large predators. The dense, over-hanging forest canopy keeps water temperatures cool, slows evaporation, and contributes an annual pulse of decomposing leaves and woody material upon which many insect larvae feed. Mayflies, stoneflies, caddisflies, dragonflies, and damselflies are just some of the insect taxa whose aquatic larval stage often depends on headwater stream habitat.

One of over 170 species of mayflies in Maine, the state-Threatened Roaring Brook mayfly is a high-elevation, headwater stream specialist. It requires the cold, highly oxygenated water of fast-flowing, heavily shaded mountain streams. With its body flattened dorsally, the Roaring Brook mayfly nymph is perfectly adapted for a life spent clinging to the underside of rocks and boulders, undaunted by a rushing torrent above and sheltered in cool pockets of water below when summer flows slow.

Also well-adapted to inhabit mountain streams are some



The flattened body shape of the Roaring Brook mayfly nymph allows it to cling to rocks in swiftly flowing headwater streams.

Artwork from The Ecology of Running Waters, Hynes, H. B. N. 1970. University of Toronto Press.

of Maine's amphibians, including the northern spring salamander, northern dusky salamander, and two-lined salamander. The spring salamander, a species of Special Concern, is Maine's largest native salamander (measuring up to 8" in length) and replaces fish as the top predator in some headwater settings. Like the Roaring Brook mayfly, it is dependent on cold, highly oxygenated, forested streams found at higher elevations. Its robust body and vertically flattened, keel-like tail permit it to swim effortlessly in swift water. And its streamlined shape is perfect for hiding and hunting among submerged rocks and boulders or in underground crevices beneath the streambed.

Montane headwater streams are among the most sensitive

Northern spring salamander photo by Phillip deMaynadier

aquatic ecosystems to disturbance and fragmentation. Their small size, shallow depth, and close connection to the surrounding forest make them especially vulnerable to impacts from human activities, such as poorly planned road crossings, transmission line rights-of-way, housing and recreational developments, and some riparian forestry practices. Despite their ecological value to downstream watersheds and importance to some of Maine's rarest species, small headwater streams are often underappreciated and overlooked in conservation efforts.

To protect state-listed species like the Roaring Brook mayfly and northern spring salamander, MDIFW has developed management recommendations for development and forestry activities taking place near high-elevation headwater stream habitats. These best management practices focus on protecting water quality, conserving forested riparian buffers, and implementing *Stream Smart* road and trail crossings.

Headwater stream photo by Phillip deMaynadier

New RAI Group Reports and Publications (2020-2022)

Much of the RAI Group's non-field-oriented work unfolds through meetings, zoom calls, email exchanges, and webinars. Nonetheless, Department biologists occasionally find time to put pen to paper (or finger to keyboard) to formally document some of their hard-won field findings. These scientific musings can take many forms, from internal technical reports, to peer-reviewed journal articles and book chapters. Frequently, these products emerge from collaborative projects undertaken with outside experts and conservation partners. The following is a list of scientific reports and publications that came to fruition during the period of 2020-2022. All are available from MDIFW upon request.

Technical Reports

Bevier, C., P. deMaynadier, and D. Moore. 2022. **Assessing Potential Ecological Impacts of Introduced Mudpuppies *(Necturus maculosus)* to Maine Waters**. Technical report to the Maine Department of Inland Fisheries and Wildlife, Augusta, ME.

Butler, R.G., H. Mealy, E. Kelly, A. St. Pierre, L. Wadleigh, and P.G. deMaynadier. 2020. **Status, Distribution, and Conservation Planning for Endemic Damselflies of the Northeast: Maine.** Technical report submitted to the Maine Department of Inland Fisheries and Wildlife, Bangor, ME.

deMaynadier, P., B. Swartz, and D. Yorks. 2022. **Herpetofauna and Invertebrate Species of Greatest Conservation Need (SGCN): Research, Status Investigations, and Conservation**. Annual report submitted to U.S. Fish and Wildlife Service for performance under State Wildlife Grant T-6-R-4.

DuClos, B., P. deMaynadier, F. Drummond. 2021. **Roadside rights-of-way as pollinator habitat: a literature review.** Final Report to the Maine Department of Transportation. Augusta, ME.

Hunt, P., V. Brown, R. Butler, P. deMaynadier, L. Harper, L. Saucier, R. Somes, and E. White. 2020. **A Conservation Plan for the Endemic Damselflies of the Northeast.** Technical report submitted to the Sarah K. de Coizart Perpetual Charitable Trust. 20 pp.

Sterrett,S.C., A.H. Roy, P. Hazelton, B. Swartz, E. Nedeau, J. Carmignani, and A. Skorupa. 2022. **Standard Operating Protocol for Mark and Recapture Monitoring of Brook Floater in Streams**. U.S. Department of Interior, Fish and Wildlife Service, Cooperator Science Series FWS/CSS-142-2022, Washington, D. C.

Ward, M. and B. Swartz. 2020. **Surveys for the Rusty Patched Bumble Bee *(Bombus affinis)* in Lincoln and Sagadahoc Counties, Maine.** Technical report to the Maine Department of Inland Fisheries and Wildlife, Augusta, ME.

Ward, M. and B. Swartz. 2021. **Surveys for the Rusty Patched Bumble Bee *(Bombus affinis)* in mid-coast Maine.** Technical report to the Maine Department of Inland Fisheries and Wildlife, Augusta, ME.

Ward, M. and B. Swartz. 2022. **Surveys for the Rusty Patched Bumble Bee *(Bombus affinis)* in Maine**. Technical report to the Maine Department of Inland Fisheries and Wildlife, Augusta, ME.

Ward, M. and P. deMaynadier. 2023. **Hessel's Hairstreak *(Callophrys hesseli)* in Maine: 2022 Survey Results** Technical report to the Maine Department of Inland Fisheries and Wildlife, Augusta, ME.

Ward, M. and P. deMaynadier. 2021. **Survey Results for the Ringed Boghaunter *(Williamsonia lintneri)* in Southern Maine.** Technical report to the Maine Department of Inland Fisheries and Wildlife, Augusta, ME.

Ward, M. and P. deMaynadier. 2022. **Survey Results for the Ringed Boghaunter *(Williamsonia lintneri)* in Southern Maine.** Technical report to the Maine Department of Inland Fisheries and Wildlife, Augusta, ME.

Scientific Publications

deMaynadier, P.G. In Press (2023). **Reflections on the Common Green Darner Dragonfly.** In Calhoun, A., M.L. Hunter, Jr., and K. Redford (editors). Our Maine: Exploring its Natural Heritage. Down East Books.

deMaynadier, P.G., J. Klymko, R. Butler, H. Wilson, and J. Calhoun. In Press (2023). **Butterflies of Maine and the Canadian Maritime Provinces.** Cornell University Press, Ithaca, NY.

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