

Chapter 5

Species of Greatest Conservation Need

2015

Vermont's Species of Greatest Conservation Need.....	1
Conserving Vermont's Amphibians & Reptiles.....	4
Conserving Vermont's Birds.....	10
Conserving Vermont's Fishes	18
Conserving Vermont's Invertebrates.....	26
Conserving Vermont's Mammals	37
Conserving Vermont's Plants	46

5. Vermont's Species of Greatest Conservation Need

Vermonters love their wildlife. And wildlife love Vermont. During the past century, many wildlife species once rare or missing from the state have returned in larger numbers. The resurgence of Vermont's forests is a significant reason. From a low of 40% forest cover in the 1840s the state is now nearly 80% forested. However, more trees are not the whole story. Restoring wildlife to the state also required the hard work and dedication of scientists, wildlife and habitat managers, sportsmen, and other conservationists. Signature species such as deer, Moose, Beaver, Fisher, Osprey, Peregrine Falcon, and Common Loon, all missing or in perilously low numbers just decades ago are now faring well.

Keeping wildlife populations healthy offers a host of benefits: healthier ecosystems upon which we all depend; more wildlife to enjoy; and, fewer species on the brink of extirpation mean less need for regulatory restrictions.

Our work, however, is not complete. A significant number of wildlife species need help because of threats such as habitat loss, fragmentation and degradation; invasive exotic species; diseases; and climate change.

The State Wildlife Grants program helps Vermont meet these challenges. It provides federal funds for conservation to prevent fish and wildlife populations from becoming endangered. Per Congressional requirements, the Wildlife Action Plan is centered on the identification and conservation of Species of Greatest Conservation Need (SGCN).

Selecting Species of Greatest Conservation Need

Vermont's Species of Greatest Conservation Need include 134 amphibians and reptiles, birds, fishes, invertebrates, mammals (vertebrates) of 470 in the state and 198 invertebrate species from out of an estimated 21,000. For plants, 645 species of an estimated 1,500 vascular and non-vascular species were selected.

The term Species of Greatest Conservation Need is not a statutory designation and therefore differs from terms "endangered" or "threatened" which are codified by federal and state Endangered Species Acts. Some SGCN have official protection status (e.g., threatened, endangered) whereas others may be in decline but are not currently listed as part of either the Federal or State Endangered Species programs. One guiding principle of the Wildlife Action Plan is to direct conservation attention to species and habitats *before* they become imperiled and recovery becomes more difficult and costly. Some of the species on the list may be relatively common including some game species. It is our goal to keep them common.

In Vermont, six Species Teams, with expertise in amphibians and reptiles, birds, fish, invertebrates, mammals and plants assessed the status of Vermont's native species. They applied assessment criteria such as the degree of species rarity, species designated as at-risk, population trends, species whose habitat are vulnerable to loss, habitat fragmentation, habitat conversion or succession changes and species threatened by exotic plants or animals. Changes to the SGCN list are summarized in table 5.1 and details of the SGCN selection process can be found in Chapter 8.

Table 5.1 Summary of Changes to SGCN Lists 2005:2015

Taxon	2005 SGCN	2015 SGCN	Change Notes
Amphibians & Reptiles	19	19	No changes
Birds	58	50	Removed: Long-eared Owl, Henslow's Sparrow, Osprey, Cooper's Hawk, Barn Owl, Veery, Blue-winged Teal Added: None
Fishes	33	29	Removed: Arctic Char, Atlantic Salmon (anadromous), Brassy Minnow, Muskellunge and Quillback Added: Northern Pearl Dace
Invertebrates	191	198	Removed: 19 species Added: 26 including 9 bumble bee species
Mammals	33	33	Removed: Black Bear, Mink Added: Moose and Snowshoe Hare
Plants	577	645	Added 68 species

Teams used the best information available at the time from local, regional, and national sources. However, while a wealth of information is available for some species, others (especially invertebrates, fish, small mammals and some reptiles and amphibians) are poorly known. Species were ranked with a conservation priority of high, medium or low. Those ranked medium and high constitute Vermont's Species of Greatest Conservation Need. Those ranked low priority are considered relatively secure. It is expected that low priority species will benefit from conservation efforts directed toward species ranked medium and high as well as from other ongoing wildlife management programs (e.g., federal aid to sportfish and wildlife).

Ongoing wildlife monitoring will help track species status and progress toward greater security. Regular Action Plan review and revision will provide opportunities to add additional species to the list as warranted and to remove those species deemed less in need of conservation action secure.

Use of and Changes to SGCN Lists

The lists of Species of Greatest Conservation Need that follow will help prioritize the allocation of State Wildlife Grant and other conservation funds. The list will also provide a quick measure of our success conserving Vermont's wildlife. It also raises the profile of a species to a wider audience of conservation partners and can encourage others to initiate projects that may benefit the species. It is important to note that presence on this list does not necessarily mean that conservation resources *will* be directed towards the animal or plant, but that conservation actions for the animal species are *eligible* for State Wildlife Grants funding, and may be more competitive for other grant programs.

The Species of Greatest Conservation Need list can be amended if important information becomes available about a species' status. For example, there are several current and pending inventory and assessment projects funded by State Wildlife Grants that could significantly increase our understanding of a species' status.

Big Game: White-Tailed Deer, Black Bear & Wild Turkey

Nearly 20 game and sportfish species are listed on the following pages as Species of Greatest Conservation Need (SGCN) due to concerns about population declines and loss of habitat.

White-tailed deer and wild turkey, however, were not selected as SGCN. Black Bear, which was an SGCN in the 2005 Wildlife Action Plan is no longer considered a Species of Greatest Conservation Need. Though absent or nearly extirpated from the state by 1865, their populations are now sufficiently large and stable. And, relative to SGCN, our knowledge of deer, turkey and bear biology and management is great.

White-tailed Deer, Black Bear and Wild Turkey rank high among Vermont's greatest wildlife restoration successes. Still their management remains of utmost concern because of their great importance to Vermonters and because of the significant roles they play in their ecosystems. Fortunately, management plans (developed with significant public involvement), harvest regulations and monitoring protocols have long been in place for these species and dependable implementation funds come through license fees and the Federal Aid to Wildlife Restoration Act.

Vermont Fish & Wildlife Department's [Big Game Management Plan \(2010-2020\)](#) is incorporated into the Wildlife Action Plan as Appendix H.

Conserving Vermont's Amphibians & Reptiles

Reptile & Amphibian Team

Doug Blodgett (team leader) Vermont Fish & Wildlife Department
Jim Andrews, Vermont Herp Atlas
Steve Faccio, VT Center for Ecostudies
Chris Slesar, Vermont Agency of Transportation

Team Charge

The Reptile and Amphibian Team was charged with identifying Species of Greatest Conservation Need (SGCN); describing the distribution and habitat usage for each SGCN; evaluating threats impacting SGCN and their habitat; identifying priority research needs to improve our ability to conserve these species; and, developing conservation strategies to address priority threats.

Introduction

For much of the year Vermont's 40 species of amphibians and reptiles, collectively known as herps or herptiles (from the Greek *Herpeton*), are secretive creatures shunning the fuss made over our more charismatic mega-fauna. But stand beside a Vermont wetland, pond or vernal pool on an early spring evening and the cacophony of calls from wood frogs, spring peepers, green frogs, and others and these enigmatic micro-fauna will make themselves noticed.

Vermont's reptiles and amphibians certainly deserve notice. As if their penchant for feasting on black flies, mosquitoes, garden slugs, rodents and other pests isn't reason enough to conserve them (some frogs are reported to eat as many as 3,000 insects a year), many also play critical roles in ecosystems, and serve as excellent indicators of the health of natural systems due to their sensitivity to toxic chemicals and habitat change.

Amphibians and reptiles face many conservation challenges in today's world, be it crossing high-traffic roads or the loss of habitat and connections between habitat patches. It could be argued that all 21 amphibians and 19 reptiles known to be extant in Vermont deserve Species of Greatest Conservation Need (SGCN) designation. The Action Plan Reptile and Amphibian Team took a conservative approach to selecting SGCN to highlight those species thought to be most in need of conservation assistance so that scarce resources can be directed toward their conservation.

Implementing the 2005 Wildlife Action Plan

A substantial amount of work, primarily through SWG funded projects, has been accomplished since the 2005 Action Plan to advance our knowledge of specific Vermont herps. Our on-going Rare Snakes of Vermont project, established in 2010 with SWG funding, focuses specifically on rare snake SGCN. It's significantly added to our knowledgebase of rattlesnake and ratsnake home ranges, their movements, mapping of critical SGCN snake habitats, population demographics, genetic assessment and other life history information. This investigation also revealed the presence of the lethal Snake Fungal Disease (SFD) in Vermont's rattlesnake population. A newly emerging skin fungus afflicting myriad snake species, SFD, is now an issue of serious regional concern and alarm in the eastern U.S. and has recently been detected in a dozen eastern states. The Rare Snakes project produced significant new findings and completion of a report on Vermont's two-year rattlesnake

research study (Spear et. al.). Two Vermont Recovery Plans were also completed since 2005; one for the threatened spiny softshell turtle and the second for the endangered timber rattlesnake.

A wealth of reliable documentation has been added to the [Vermont Reptile & Amphibian Atlas](#) throughout the state resulting from hundreds of additional logged sightings/locations of reptiles and amphibians. A survey of vernal pools (also SWG-funded) has catalogued some 2500 vernal pool amphibian breeding sites statewide. Turtle species have also received attention, including documenting/protecting the endangered spotted turtle, the threatened spiny softshell, and wood turtles – a species of special concern. Additional genetic research/assessment has been directed to the Mudpuppy revealing two distinct populations in Vermont (one in the Lake Champlain basin and the second, in the Connecticut River basin). In 2015, the Fowler’s Toad was listed as endangered in Vermont.

Northeast Partners in Reptile and Amphibian Conservation ([NEPARC](#)) and its national affiliate [PARC](#) have been particularly active recently in attempting to stem the tide of the ubiquitous international amphibian import trade to help protect US amphibians from imported, exotic diseases such as the newly identified salamander chytrid fungus *Batrachochytrium salamandrivorans* (Martel, A. et al.).

Selecting Amphibian & Reptile SGCN

The Herp Taxa Team deliberated extensively on SGCN selection criteria, and ultimately made no changes to the 2005 SGCN list of herp species, nor its priority rankings. No species were added nor deleted. Scientific nomenclature for several species was updated. Selection criteria included knowledge about current listing as endangered and threatened, population declines, rarity, vulnerability of habitat, life history traits, vulnerability to collection or take, other impacts from humans, and dispersal capability. Each species was examined across all criteria and the four-person team utilized a high, medium, and low conservation need ranking to attempt to separate species with greater need from those that may be more secure, at least in the short term. We assigned numerical rankings that assisted our assignment to high, medium, and low priority categories. This approach resulted in the selection of the same 12 species of high conservation need and seven of medium conservation need (table 5.2)

Table 5.1. Amphibian & Reptile Species of Greatest Conservation Need

High Priority	Medium Priority
Jefferson Salamander (<i>Ambystoma jeffersonianum</i> - and hybrids) ¹	Blue-spotted Salamander (<i>Ambystoma laterale</i>) ¹
Mudpuppy (<i>Nectar’s maculosus</i>) ¹	Spotted Salamander (<i>Ambystoma maculatum</i>)
Fowler’s Toad (<i>Bufo fowleri</i>) ¹	Four-toed Salamander (<i>Hemidactylium scutatum</i>)
Boreal Chorus Frog (<i>Pseudacris maculata</i>)	Common Musk Turtle (<i>Sternotherus odoratus</i>)
Spotted Turtle (<i>Clemmys guttata</i>) ¹	Northern Water Snake (<i>Nerodia sipedon</i>)
Wood Turtle (<i>Glyptemys insculpta</i>) ¹	DeKay’s Brownsnake (<i>Storeria dekayi</i>) ¹
Spiny Softshell Turtle (<i>Apalone spinifera</i>) ¹	Smooth Greensnake (<i>Opheodrys vernalis</i>) ¹
Five-lined Skink (<i>Plestiodon fasciatus</i>)	
Eastern Ribbonsnake (<i>Thamnophis sauritus</i>) ¹	
North American Racer (<i>Coluber constrictor</i>) ¹	
Eastern Ratsnake (<i>Pantherophis alleghaniensis</i>)	
Timber Rattlesnake (<i>Crotalus horridus</i>) ¹	

¹ Regional Species of Greatest Conservation Need in the Northeastern United States (Terwilliger, 2013)

Though some of Vermont’s amphibians and reptiles are at the periphery of their range (e.g., Boreal Chorus Frog, Mudpuppy, Fowlers Toad, and Mink Frog, a finding that challenges conventional

wisdom is that species populations have been documented to be more at risk of loss at the core of their range than at the periphery (Channel & Lomolino 2000, Lomolino 1995). This argues for us giving serious consideration to SGCN that may be peripheral in Vermont.

Reports on each amphibian and reptile Species of Greatest Conservation Need are in Appendix A1 of this document. The following is a summary of those reports.

Habitat Needs

Since many reptiles and amphibians use a variety of habitats annually and over the course of their lives, maintaining healthy populations entails maintaining connectivity between habitats. Connectivity also enables individuals to find alternative cover, food sources, breeding, or over-wintering sites when natural disasters occur. Furthermore, connectivity between populations ensures vital genetic exchange and allows for the re-colonization of areas where populations have been eliminated due to drought, winterkill, disease, or anthropogenic forces. This can only occur if the landscape is permeable to these animals—that is, development proceeds in a way that allows amphibians and reptiles to move freely across the landscape. To conserve our native amphibians and reptiles, especially those considered SGCN, it will be essential to maintain a network of interconnected sites where natural processes can occur.

Discussion of Threats to Vermont’s Amphibians & Reptiles

The threats identified most frequently for Vermont's reptile and amphibian populations are all closely related to habitat degradation: trampling and direct impacts, road and transportation system impacts, habitat fragmentation, habitat alteration, and habitat conversion.

We do not understand all the ramifications, but the pattern seen elsewhere in the US and the world is that increased human population density, higher consumption of land and other resources, and lack of awareness of the impacts to other species can lead to devastating losses of native biota (TWS 2004). Vermont is not immune from these sorts of impacts and our landscape is continuing to be developed (DeVillars 1999). Habitat alteration and loss is a near universal challenge to native amphibians and reptiles.

To address this threat, Vermont’s Agency of Natural Resources remains vigilant in its efforts to minimize loss of critical habitats under its jurisdiction through formal regulatory authority and mechanisms provided under Vermont’s Act 250 development law, Section 248 and wetlands protection permit processes. The Vermont Fish and Wildlife Dept. has developed some powerful new mapping (e.g., [Natural Resources Atlas](#)) and habitat/natural community analysis tools (Biofinder) to assist in identifying the states’ most diverse, valuable and vulnerable lands as targets for eventual conservation.

A significant, newly identified threat is a lethal Snake Fungal Disease (SFD) which causes significant and debilitating skin lesions on snakes. Widespread detection of SFD in the eastern US has prompted an extensive, on-going, regional research investigation into this novel fungus to assess the causes and conservation significance of this extremely serious threat to free-ranging snakes. Concern has also recently arisen over a novel, salamander chytrid fungus *Batrachochytrium salamandrivorans* (Martel, A. et al. 2015) identified on the Asian and European continents, and the threat of spread to North America via a ubiquitous international pet trade. The national conservation organization

Partners in Amphibian and Reptile Conservation (PARC) is now attempting to promulgate US/international herptile trade regulations to protect against this threat.

Crossing roads is a real problem for both amphibians and reptiles in Vermont. Vernal migrations of salamanders and frogs to breeding pools result in many dead and wounded animals when a busy road must be crossed. At some sites in Vermont, thousands of amphibians are killed during a single night, which may overwhelm the reproductive capacity to sustain the populations and, according to the Vermont Agency of Transportation, constitutes a public safety issue (C. Slesar, VTrans, pers. comm). Female turtles seeking nest sites are more at risk of being killed on roads than more sedentary males, resulting in a sex bias in some populations and raises questions about population persistence (Sheen & Gibbs. 2004, Marchand & Litvaitis 2004). The still abundant, but believed to be declining, wood turtle often encounters roads in Vermont during its annual movements along and away from riparian corridors. Snakes emerging from hibernation often bask on warm pavement, increasing their risk of being struck by vehicles.

An emerging awareness of herps' need for improved connectivity and safer wildlife crossings is taking hold in Vermont and the construction of several highway culverts and underpasses at strategic wildlife crossings are being planned and/or contemplated. Some of these structures are relatively expensive and require a good deal of up-front planning, but collaborative efforts are increasingly embraced and accepted in the transportation and wildlife management communities. For example, the Monkton Crossing is currently in development and will connect upland woods and breeding pools for amphibians. The project is partially funded by SWG, a Federal Highway Enhancement Grant, and \$119,000 of non-federal funds—mostly donations. VTrans, which recognizes that better crossings not only protect wildlife but also protect motorists, is a leader among state transportation agencies in road ecology.

Other factors that may negatively impact amphibians and reptiles now and in the foreseeable future include pollution, changes in hydrology, sedimentation, and global climate change.

Research & Monitoring Needs and Conservation Strategies

The Reptile and Amphibian Team identified priority research and monitoring projects to improve our ability to conserve Vermont's reptile and amphibian Species of Greatest Conservation Need. The Team also developed conservation strategies to address threats impacting each SGCN. Those recommended most frequently include:

Research & Monitoring Needs

1. Better determine habitat needs, identify significant breeding sites, vernal pools and habitat connections.
2. Better determine the distribution and relative abundance of populations in Vermont.
3. Better identify and evaluate threats.
4. Monitor trends in population size, distribution and habitat.

Conservation Strategies

5. Help people better value reptiles and amphibians and to understand the essential needs of all life stages, especially upland habitat in proximity to breeding pools.

6. Encourage reports of road-killed specimens, road crossings, and road basking areas to VFWD, VTTrans, and the [Vermont Reptile and Amphibian Atlas](#). Develop safer crossings at significant sites when roads are being upgraded.
7. Maintain habitat through appropriate management, direct habitat disturbance and site roadways away from sensitive sites such as breeding pools.
8. Continue to work cooperatively with landowners, habitat management agencies, towns and communities to protect habitat and maintain connectivity. Develop management guidelines for owners and managers of appropriate habitat.
9. Conserve known critical habitat through fee simple purchase, acquisition of development rights or easements, management agreements and education of private landowners and managers.
10. If loss of important sites is likely due to development, consider creating or enhancing other pools that might allow some adults to transfer to the new site if they encounter it or develop a new breeding population from dispersal of colonizers.
11. Protect turtle nests and adults by predator trapping.
12. Work with biologists to minimize impacts to SGCN populations and habitats during and following management activities for sport fish and game wildlife.
13. Participate in existing regulatory processes (e.g., Act 250, stream alteration permits) to protect and restore critical habitats.
14. Maintain continued vigilance, monitoring and research efforts for novel and lethal emerging herp disease issues including snake fungal disease, *Batrachochytrium salamandrivorans*, chytrid fungus, etc.
15. Begin implementation of vernal pool management guidelines as described by VFWD staff in “Conserving Pool-Specialist Amphibian Habitat”. (Mark Ferguson, VFWD White Paper, 2015)

Conclusion

Vermont's reptiles and amphibians are fortunate for several reasons. We have a much less developed and rural landscape than many states. For example, even the eastern newt, a very abundant species in Vermont, is declining in Rhode Island due to development and roads (C.J. Raithel, RI Dept of Environmental Management pers comm). We have an engaged Scientific Advisory Group on Reptiles and Amphibians that provides advice to the Vermont Endangered Species Committee. We also have a well-developed [Reptile and Amphibian Atlas](#) (VtHerpAtlas.org) that, mostly through volunteer efforts, has collected, and continues to collect valuable information on the distribution of reptile and amphibian species in Vermont and raises awareness of conservation need in Vermont. Interest is increasing with schools and groups in Vermont that host ‘salamander nights’, helping small amphibians cross roads safely and raise awareness about the impacts of traffic. The Vermont Fish and Wildlife Department continues to work on conservation projects that raise awareness and benefit reptiles and amphibians, including species listed here as SGCN, and we are working collaboratively with other agencies including the Vermont Transportation Agency, as well as an expanding number of conservation partners. More needs to be done, but with the foundation we

already have in place and the awareness and strengthening of partnerships promoted by Action Plan, we expect more conservation actions in our shared future.

Literature Cited

- Channel, R. and M.V. Lomolino. 2000. Dynamic biogeography and conservation of endangered species. *Nature* 403:84-86.
- (DEC) Vermont Department of Environmental Conservation. 6-2004. Biomonitoring and Aquatic Studies. <http://www.anr.state.vt.us/dec/waterq/bass.htm>
- DeVillars, J.P. 1999. An Open Letter to the People of Vermont. Vermont Keeping In Touch. U.S. Environmental Protection Agency Vermont State Unit. September 1999.
- Galbraith, D.A., R.J. Brooks, and G.P. Brown. 1997. Can management intervention achieve sustainable exploitation of turtles? Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles-An International Conference, pp. 186-194).
- Garber, S.D. and J. Burger. 1995. A 20-yr study documenting the relationship between turtle decline and human recreation. *Ecological Applications*. 5(4): 1151-1162.).
- Lomolino, M.V. and R. Channel. 1995. Splendid isolation: patterns of geographic range collapse in endangered mammals. *Journal of Mammalogy* 76(2): 335-347.)
- Marchand, M.N. and J.A. Litvaitis. 2004. Effects of habitat features and landscape composition on the population structure of a common aquatic turtle in a region undergoing rapid development. *Conservation Biology* 18(3): 758-767).
- Martel, A. et al. (2014) Recent introduction of a chytrid fungus endangers Western Palearctic salamanders. *Science* 346, 630; DOI: 10.1126/science.1258268
- Sheen, D.A. and J.P. Gibbs. 2004. Effects of roads on the structure of freshwater turtle populations. *Conservation Biology* 18(4):1143-1149.
- Spear, S., J. Bauder, D. Blodgett, C. Jenkins, K. Briggs. 2013. The Ecology of Timber Rattlesnakes (*Crotalus horridus*) in Vermont. Vermont Fish and Wildlife Department, Rutland, Vermont, USA.
- Terwilliger Consulting, Inc. and the Northeast Fish and Wildlife Diversity Technical Committee. 2013. [Taking Action Together: Northeast Regional Synthesis for State Wildlife Action Plans](#). A report submitted to the Northeast Fish and Wildlife Diversity Committee. Locustville, VA.
- The Wildlife Society (TWS). 2004. Position on Economic Growth. Adopted by the TWS Council September 2004.

Conserving Vermont's Birds

Birds Team

John Buck, Wildlife Biologist, Vermont Fish & Wildlife Department. (team leader)

Margaret Fowle, Conservation Biologist, Audubon Vermont

John Gobeille, Wildlife Biologist, Vermont Fish & Wildlife Dept.

Mark LaBarr, Conservation Program Manager and Biologist, Audubon Vermont

Dr. Allan Strong, University of Vermont

Dr. Rosalind Renfrew, Vermont Center for Ecostudies

Erin Talmadge, Director, Birds of Vermont Museum

Chip Darmstadt, Director, North Branch Nature Center

Dr. William Barnard, Norwich University

Sally Laughlin, former chair of the Endangered Species Committee and Bird Scientific Advisory Group

David Sausville, Wildlife Biologist, Vermont Fish and Wildlife Department

Team Charge

The Bird Team was charged with identifying Species of Greatest Conservation Need (SGCN); describing the distribution and habitat usage for each SGCN; evaluating threats impacting SGCN and their habitat; identifying priority research needs to improve our ability to conserve these species; and, developing conservation strategies to address priority threats.

Introduction

Vermont serves as host to 268 bird species for some, if not all, of their annual life cycle. These species occupy a wide variety of habitats ranging from Lake Champlain wetlands at about 100 feet above sea level to montane spruce-fir forests at elevations greater than 4000 feet above sea level. Included among these highs and lows are nine distinct biophysical regions all compressed into the 9600 square miles that constitute the small State of Vermont. Naturally following this diverse range of habitats are the diverse guilds of bird species that occupy them. Open water and marsh birds, grassland and shrub birds, deciduous, coniferous, boreal, and montane forest birds are all found within the small state of Vermont. Of the 268 species, 12 of them are listed as endangered or threatened. Another 39 are considered Species of Greatest Conservation Need.

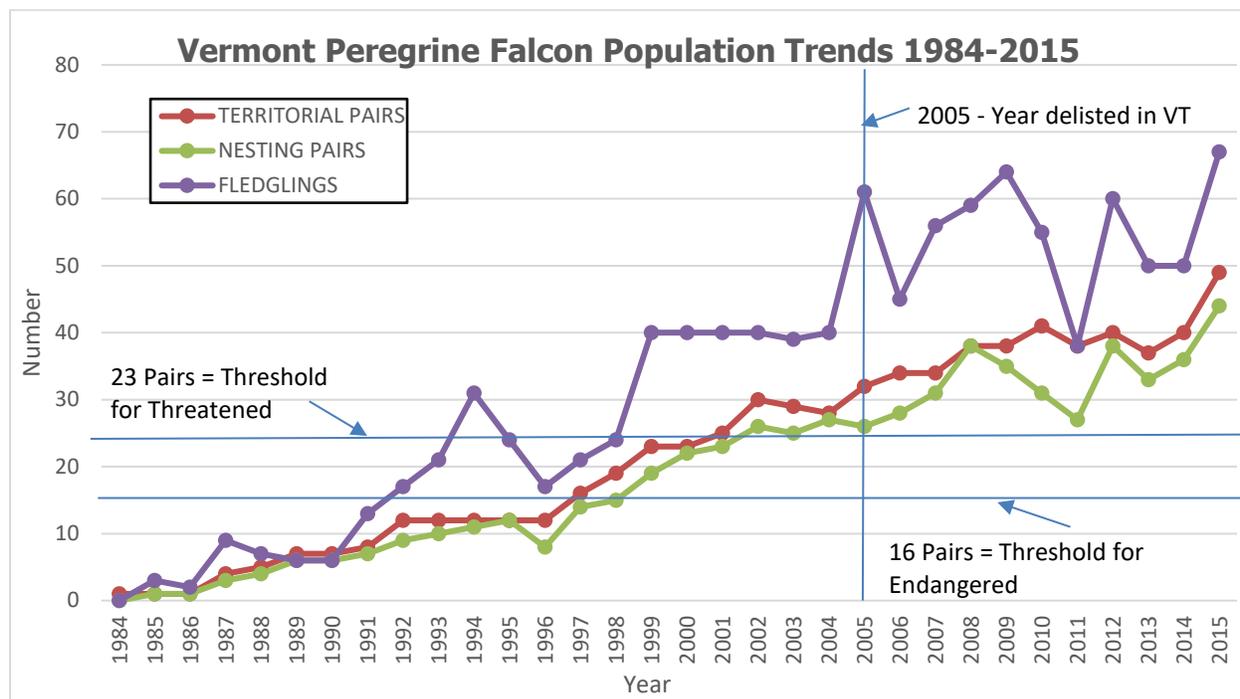
The Action Plan Bird Team convened in October of 2014 to assess the status of SGCN species identified in the 2005 Action Plan species and determine the appropriate category ranking for each of them in the 2015 plan. Each team member reviewed a suite of species and updated the existing narratives with current information about population trends, management actions, and recent research. The result of this effort was identifying 22 changes in prioritization. No new species were added to the priority list except Sandhill Crane as an emerging issue species. Four species were revised from High to Medium, 11 were revised from Medium to High, and seven species were revised from Medium to Low. The remaining 36 species retained their priority status from the 2005 assessment. This assessment resulted in modifying the Species of Greatest Conservation Need list from 58 to 50 species.

The issue of lead in the environment continues to present itself most visibly in the Common Loon. This species continues to experience lead-based morbidity and mortality from residual lead fishing tackle. The loss of shrubland and grassland habitat to natural plant succession and human

development pose a threat to the habitat specialists of these two habitats. These species include, Eastern Meadowlark, Grasshopper Sparrow, Bobolink, Golden-winged Warbler, Blue-winged Warbler, and Eastern Towhee.

Perhaps the single most significant emerging issue impacting birds in Vermont during the last 10 years has been the conversion of forest and grassland habitat to utility-scale wind and solar energy generation. Although descriptors such as ‘renewable’, ‘sustainable’, and ‘environmentally friendly’ create an image of energy development that is less harmful than fossil fuel, wind and solar energy development still involve habitat loss and impairment. In some cases, the habitat involved is rare and sensitive (i.e., montane forest) and supports rare and sensitive (e.g., Bicknell’s Thrush). Furthermore, collision deaths of resident and migratory birds directly related to wind turbines presents a population loss factor that is difficult to assess due to the relatively small amount of comparative mortality data and the cumulative mortality impact as birds migrate north and south along the Atlantic Flyway. The seemingly benign impact of alternative energy development to the public will create a challenge to VFWD biologists when developing equitable habitat mitigation. A sound depiction of the problem and reasonable solutions will have to be narrated by VFWD to achieve bird conservation success.

We are particularly pleased to note that since 2005 Peregrine Falcon, Common Loon, and Osprey were all de-listed. Thanks to 30 years of effort by the VFWD and many partners, populations of these species have recovered sufficiently to where they no longer require heightened protection as Threatened or Endangered species (2005).



Looking forward, possibilities for additional de-listings in coming years are positive as Common Tern appears to be reaching its down-listing goal and Bald Eagle nesting results have been steadily increasing since the first pair nested successfully in 2008. Our first Breeding Bird Atlas (1982) had only one record of a possible nesting; the second [Atlas](#) (2013) showed an 800% increase from the

first to the second atlas (Renfrew 2013). Additional population data has provided the background for revising the status of Coopers Hawk, and Veery from ‘Medium’ to ‘Low’.

Implementing the 2005 Wildlife Action Plan

Conservation efforts expanded beyond the restoration of Osprey, Peregrine Falcon, and Common Loon during the 10-years since the first Wildlife Action Plan include more focused attention on Common Tern, Black Tern, Grasshopper Sparrow, Spruce Grouse, and Bald Eagle. Each of the latter species benefit from intensive survey efforts to better determine their respective population status and corresponding listing status. Closer working relations with state airport managers was cultivated during the last action plan period resulting in greater awareness of bird species needs and their uses of grassland habitat at airports. It has led to a more diversified response to aircraft safety concerns. One profound outcome during this period is the completion and publication of Vermont’s Second [Breeding Bird Atlas](#) completed in 2013. Very much a collaborative effort, the Atlas was developed with more than 350 citizen scientists contributing more than 50,000 hours over five years to document every bird species breeding across the state. The effort was led by the Vermont Center for Ecostudies, the Fish & Wildlife Department and others, with significant funding from the SWG program. Beginning in 2008 the Wildlife Management Institute led the implementation of the [Woodcock Conservation Plan](#) in the northeast. Audubon Vermont’s [Forest Bird Initiative](#) and [Foresters for the Birds](#) provides technical assistance to landowners and foresters to support forest management and policies benefitting a suite of responsibility birds (include Wood Thrush, Black-throated Blue Warbler and Canada Warbler) in Vermont and along the Atlantic Flyway. The [Champlain Valley Bird Initiative](#), a partnership of Audubon VT, the Natural Resources Conservation Service and the University of Vermont similarly provides landowner with technical and financial assistance to protect and manage grassland and shrubland habitat (benefitting many SGCN including the Eastern Towhee, Golden-winged Warbler, Field Sparrow and Bobolink).

Selecting Bird SGCN

In contrast to lesser-known taxa, the Bird Team benefited from the relative wealth of available data on bird distribution and abundance. Data from Vermont’s original (1982) and current (2013) Breeding Bird Atlases and the USFWS Breeding Bird Surveys helped immensely in selecting the 50 SGCN. In addition to this hard data source, ongoing bird conservation programs, including the Vermont Endangered Species Scientific Advisory Group on Birds (SAG-Birds), Partners-In-Flight, North American Bird Conservation Initiative, National Audubon Society’s Watch List, and the American Bird Conservancy’s Green List all contributed to our understanding of which species belonged on Vermont’s SGCN list.

Selection criteria included current listing as endangered or threatened, population declines, rarity, vulnerability of habitat, life history traits, impacts from humans, and recent range expansion or contraction. Each species was examined across all criteria and the team developed a high, medium, and low conservation need ranking to attempt to separate species with greater need from those that may be more secure, at least in the short term (table 5.3).

Of the 58-species identified by the bird team in 2005, 37 (64%) retained their priority ranking from that list. Four were moved from ‘High’ to ‘Medium’. These were Peregrine Falcon, Common Loon, Purple Martin, and American Bittern. Moving from ‘Medium’ to ‘Low’, were Long-eared Owl, Henslow’s Sparrow, Osprey, Cooper’s Hawk, Barn Owl, Veery, and Blue-winged Teal. These seven were moved for different reasons that include better population information (Veery, and Cooper’s

Hawk), unlikely conservation opportunities (Long-eared Owl, Blue-winged Teal, and Henslow's Sparrow) and significant increases in state-wide population (Osprey). A total of 11 species were moved from 'Medium' to 'High'. By and large these changes were made based on a combination of long-term population data (i.e., national Breeding Bird Survey) and the recently completed second [Breeding Bird Atlas](#). Of the 11 species newly identified as high priority, only Rusty Blackbird was listed (Endangered) during the last 10 years. The other 10 species, while not meeting listing criteria, were raised to high priority based on the combination of habitat loss and long-term population decline and the likelihood that these two factors will continue during the next 10 years. The 10 High Priority species can be grouped by loss of their habitats: Wood Thrush and Red-shouldered Hawk (Deciduous Forest), American Kestrel, Eastern Meadowlark (Grassland), Brown Thrasher, Blue-winged Warbler (Shrubland), Olive-sided Flycatcher, Gray Jay, and Black-poll Warbler (Boreal Forest).

Table 5.3. Bird Species of Greatest Conservation Need

High Priority

Pied-billed Grebe (*Podilymbus podiceps*)¹
 Least Bittern (*Ixobrychus exilis*)¹
 American Black Duck (*Anas rubripes*)¹
 Bald Eagle (*Haliaeetus leucocephalus*)
 Northern Harrier (*Circus cyaneus*)¹
 Red-shouldered Hawk (*Buteo lineatus*)¹
 American Kestrel (*Falco sparverius*)¹
 Spruce Grouse (*Falcapennis canadensis*)¹
 Upland Sandpiper (*Bartramia longicauda*)¹
 Common Tern (*Sterna hirundo*)¹
 Black Tern (*Chlidonias niger*)¹
 Common Nighthawk (*Chordeiles minor*)¹
 Whip-poor-will (*Caprimulgus vociferus*)¹
 Chimney Swift (*Chaetura pelagica*)¹
 Olive-sided Flycatcher (*Contopus cooperi*)¹
 Gray Jay (*Perisoreus canadensis*)
 Sedge Wren (*Cistothorus platensis*)¹
 Bicknell's Thrush (*Catharus bicknelli*)¹
 Wood Thrush (*Hylocichla mustelina*)¹
 Brown Thrasher (*Toxostoma rufum*)¹
 Blue-winged Warbler (*Vermivora pinus*)¹
 Golden-winged Warbler (*Vermivora chrysoptera*)¹
 Blackpoll Warbler (*Dendroica striata*)
 Canada Warbler (*Wilsonia canadensis*)¹
 Eastern Towhee (*Pipilo erythrophthalmus*)¹
 Vesper Sparrow (*Pooecetes gramineus*)¹
 Grasshopper Sparrow (*Ammodramus savannarum*)¹
 Eastern Meadowlark (*Sturnella magna*)¹
 Rusty Blackbird (*Euphagus carolinus*)¹

Medium Priority

Common Loon (*Gavia immer*)¹
 American Bittern (*Botaurus lentiginosus*)¹
 Great Blue Heron (*Ardea herodias*)
 Black-crowned Night-heron (*Nycticorax nycticorax*)¹
 Northern Goshawk (*Accipiter gentilis*)¹
 Peregrine Falcon (*Falco peregrinus*)¹
 Ruffed Grouse (*Bonasa umbellus*)¹
 Sora (*Porzana carolina*)¹
 Lesser Yellowlegs (*Tringa flavipes*)
 American Woodcock (*Scolopax minor*)¹
 Black-billed Cuckoo (*Coccyzus erythrophthalmus*)¹
 Short-eared Owl (*Asio flammeus*)¹
 Black-backed Woodpecker (*Picoides arcticus*)
 Purple Martin (*Progne subis*)
 Chestnut-sided Warbler (*Dendroica pensylvanica*)
 Black-throated Blue Warbler (*Dendroica caerulescens*)¹
 Prairie Warbler (*Dendroica discolor*)¹
 Bay-breasted Warbler (*Dendroica castanea*)¹
 Cerulean Warbler (*Dendroica cerulea*)¹
 Field Sparrow (*Spizella pusilla*)¹
 Bobolink (*Dolichonyx oryzivorus*)¹

¹ Regional Species of Greatest Conservation Need in the Northeastern United States (Terwilliger, 2013)

Bird species rare in Vermont did not always make the SGCN listing. Species that have expanded their range in recent decades due to a proliferation of winter bird feeders, such as Tufted Titmouse, were excluded, as we did not consider Vermont to be a geographic area of responsibility for that species. Other species for which Vermont is on the extreme periphery of their breeding range, and for which confirmed breeding records are very infrequent, such as the Three-toed Woodpecker, were also not selected.

Reports on each Bird Species of Greatest Conservation Need are in Appendix A2 of this document. The following is a summary of those reports.

Birds and Their Habitat Needs

Vermont's bird SGCN utilize a variety of habitats from open and shrub-dominated wetlands, mature hardwood or coniferous forests, young regenerating forests, old fields, grasslands, and other cultural habitats such as buildings and structures. As birds are generally more mobile relative to most species from other taxa, they are usually better able to exploit smaller, more widely distributed habitat patches. However, most species benefit from the larger assemblages of similar habitat types, such as a contiguous forest area or large, agricultural (grassland) complex.

The Bird Team organized most birds into one of several habitat guilds, for which a conservation strategy would often be appropriate for all species in the guild. These guilds match the major habitat categories used in this report:

- Northern hardwood forest & Oak-pine-northern hardwood forest
- Spruce-fir northern hardwood forest
- Sub-alpine krummholz & Montane spruce-fir forests (high elevation areas)
- Early successional forest stages
- Riparian
- Lakes and ponds
- Wetlands (open, shrub and forested wetlands)
- Cliff & Talus
- Grassland
- Grassland/Edge
- Urban

Discussion of Threats Impacting Bird SGCN

New strains of avian influenza have been identified around the world, including western and central North America. To date these new viruses have had the greatest impact on commercial poultry farms and to some degree on the human population in Southeast Asia. Effects on wild bird populations have not been significant to date. However, the potential for viruses to adapt and thrive in a concentrated wintering ground could produce devastating effects. The impact of neonicotinoid pesticides on the continent's insect populations and ultimately on avian insectivores, remains poorly understood. More research is needed to fully understand any far-reaching consequences of this new breed of pesticide. It took more than thirty years and untold amount of money and of dedicated effort to recover populations of Eagle, Osprey, and other raptors after the 1972 ban of the pesticide DDT. It is hoped we will learn from this history lesson and not put bird species in a similar situation in the future. The impact of wind and solar electric generation facilities is still in its infancy. While the detrimental impact of habitat loss from the facilities is readily apparent, the cumulative impacts to populations created by

local and cumulative collision mortality are not well understood yet. The rate of growth of these two industries far outpaces the rate of knowledge growth about their relative impacts to continental bird populations. Finally, some habitats may be at risk to climate change. It is generally agreed that large blocks of contiguous habitat are best able to resist or more gradually shift due to climate change. A discussion of any of these emerging issues cannot be complete in the absence of habitat loss.

The loss of habitat is the primary source of bird population declines. As the land area available for birds to exist continues to shrink, ever declining bird populations are increasingly concentrated into the remaining, sometimes marginal quality space, and places species at greater risk of nest failure, predation, and disease. The threats to Vermont's bird populations most frequently identified for are all related to changes in habitat. In the case of the 50 SGCN, conversion of habitat was identified 82% of the time (42 SGCN). Habitat alteration (67%), habitat fragmentation (47%), and distribution of successional stages (35%) were all identified in descending order of frequency. This is the same pattern that emerged in the first Wildlife Action Plan. Many bird species find optimum habitat in young regenerating forests, which have declined statewide in recent decades. Similarly, grassland-dependent species, which are declining throughout the Northeast, are finding less and less suitable habitat in Vermont as farms are managed more intensively or sold and either developed or revert to forestland. The increased roads, housing units, and other attendant disturbances associated with human development further fragment habitat into smaller and smaller habitat units.

In these smaller habitat units, nesting birds are more vulnerable to habitat generalist predators such as Raccoons, Skunks, and Crows. Greater access is also available to the nest parasitizing Brown-headed Cowbird. Finally, the increasing numbers of houses in bird habitat often come with house pets, namely dogs and cats. These familiar companion animals, not in need of shelter or food, add an additional layer of disturbance and predation to nesting birds. Pet cats have been attributed to over 250 million bird deaths nationally each year.

Research & Monitoring Needs and Conservation Strategies

The research and monitoring needs and conservation strategies most frequently identified by the Bird Team and those best applied for multiple bird SGCN are as follows:

Research & Monitoring Needs

1. Better determine habitat requirements and habitat availability.
2. Better determine the distribution and relative abundance of populations in Vermont.
3. Better identify and evaluate threats including the impacts of wind and solar energy infrastructure and emerging diseases.
4. Obtain better knowledge of basic life history traits.

Conservation Strategies

1. Habitat Restoration efforts on public lands and conservation payments or other financial incentives, fee simple purchase, easements, management guidelines, and cooperative agreements with user groups and private landowners. Existing technical assistance/cost-share programs (EQIP, CRP) were frequently identified as potential funding sources to implement conservation on private lands. Important Bird Area designations can aid in the development of needed funds. Common habitat restoration themes include incentives and

planning to slow the rate of fragmentation and development and maintain blocks of contiguous forest, grasslands, early and late-successional habitats.

2. Species Restoration projects, which may involve active translocation of individuals or eggs from source populations to suitable Vermont habitats, and/or may involve efforts to provide suitable nesting sites and reduce predation or human disturbances around nesting sites.
3. Raise awareness within the public to build support and opportunities for conservation. Important Bird Area designations can help focus public attention on opportunities.
4. Developing and evaluating forestry practices that can enhance habitat suitability such as maintaining or increasing aspen stands or the retention of coarse woody debris and snags. Provide technical assistance to landowners and communities about best management practices (e.g., Vermont Fish and Wildlife Department's Forest Landowner Assistance Program and Audubon's [Forest Bird Initiative](#) and [Foresters for the Birds](#) program).
5. Support and participate in an international effort to maintain large blocks of undeveloped forests linked together by habitat corridors to provide a network of interconnected habitats throughout northeastern New England and southeastern Canada.
6. Identify, prioritize and conserve existing contiguous forest blocks and associated linkages that allow for upward and northward movement in response to climate change.
7. Participate in existing regulatory processes (e.g., Act 250) to protect and restore important habitats.

Conclusion

We are fortunate that Vermont bird species may be in a better place than those in other states. Vermont has a rural landscape and an economy where agricultural, forest commodities, and tourism play important roles; and Vermonters value their natural resources committing tax dollars to conservation and supporting land-use laws. Still, 50 of the 268 (19%) bird species are Species of Greatest Conservation Need and 12 of those are listed as threatened or endangered. We have recent conservation successes in the form of Peregrine Falcon, Common Loon, and Osprey de-listing. However, these are but three species out of 50 (6%) listed as SGCN and their restoration required funding and staffing that would be unimaginable to apply to all the remaining Species of Greatest Conservation Need. Good collaborative work with our partners (Audubon Vermont, Vermont Center for Ecostudies, University of Vermont, and U.S. Fish and Wildlife Service) is underway toward the restoration of Common Tern and Bald Eagle, as well as important monitoring efforts for Black Tern, Grasshopper Sparrow, and Least Bittern. Future conservation opportunities exist with the expansion of grassland habitat conservation through cooperative landowner agreements and land development regulation. Continued work with the state airport managers will also add to the security of this limited habitat. Broader scrutiny of mountain top developments is required if the rare montane forest habitat is to be conserved as significant development pressure is placed on these fragile locations. For Bicknell's Thrush and Blackpoll Warblers to coincide with human use of their habitat a better understanding of the limits of human disturbance to their habitat is needed. Continued work with private forest landowners and state and local governments is needed to retain the habitat values associated with stable, long-term ownership of contiguous forestland. The Vermont Department of Forests, Parks, and Recreation, Audubon Vermont, the Vermont Woodlands Association and Vermont Coverts will be valuable partners in this effort. Finally, more

intensive and purposeful inventory of the secretive marsh bird guild is necessary to accurately assess the status of these hard-to-sample species.

Literature Cited

Sauer, J. R., J. E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski, Jr., and W. A. Link. 2014. The North American Breeding Bird Survey, Results and Analysis 1966 - 2012. Version 02.19.2014 USGS Patuxent Wildlife Research Center, Laurel, MD.

The Atlas of Breeding Birds of Vermont. 1985. Laughlin and Kibbe, eds. U. Press of New England. Hanover, NH.

[The Second Atlas of Breeding Birds of Vermont](#). 2013. R. Renfrew, ed. University Press of New England, Hanover.

Terwilliger Consulting, Inc. and the Northeast Fish and Wildlife Diversity Technical Committee. 2013. Taking Action Together: Northeast Regional Synthesis for State Wildlife Action Plans. A report submitted to the Northeast Fish and Wildlife Diversity Committee. Locustville, VA.

Conserving Vermont's Fishes

Fish Team

Kenneth Cox, Vermont Fish & Wildlife Department (team leader)
Dr. William Barnard, Norwich University
Dr. Douglas Facey, Saint Michael's College
Mark Ferguson, Vermont Fish & Wildlife Department
Eric Howe, Lake Champlain Basin Program
Richard Langdon, Vermont Department of Environmental Conservation

Team Charge

The Fish Team was charged with identifying Species of Greatest Conservation Need (SGCN); describing the distribution and habitat usage for each SGCN; evaluating problems impacting SGCN and their habitat; identifying priority research needs to improve our ability to conserve these species; and, developing conservation strategies to address priority problems.

Introduction

Vermont with its estimated 7,100 miles of rivers and streams and 809 lakes and ponds supports populations of 92 fish species (Langdon et al. 2006). Eighty of these are recognized as being native to the state. A native species is one that was present in the state prior to early European colonization. The remaining 12 species are non-indigenous to Vermont. These fishes were either purposely introduced, legally and illegally, to waters of the state, such as for sport fish enhancement (e.g., Brown and Rainbow trout), or gained access inadvertently to the state via interstate waterways, such as canals (e.g., Gizzard Shad). Lake Champlain has the most diverse fish community of any Vermont water with about 71 species documented to exist there.

Vermonters are probably aware of the existence of about one-third of the fish species occurring in the state. Our familiarity with most of these fishes is rooted in sport fishing; that is, their recognized value as game fish and to a lesser degree their use as bait fish. As for the remaining two-thirds of Vermont species, many exist here largely out-of-sight of the public and others are viewed with ambivalence. Nonetheless, the diversity of Vermont's ichthyofauna contributes significantly to the functional ecological complexity of our aquatic systems. Many species are excellent indicators of the health of our environment, such as their sensitivity to toxic chemicals (e.g., mercury and PCBs) and habitat change. Additionally, sport fisheries, utilized and valued by the public, are dependent directly and indirectly on healthy communities and ecosystems.

Native fishes face many conservation challenges. The threats of habitat alteration, loss and fragmentation are pervasive in Vermont's rapidly changing landscape. The introduction of non-indigenous fishes, including associated aquatic pathogens and parasites, also pose risks to aquatic ecosystem health and native species conservation. Just within the past 20 years, seven non-native fishes have shown up in state and interstate waters. Whirling disease, caused by the parasite *Myxobolus cerebralis*, first appeared in native Brook Trout inhabiting Vermont sections of the Batten Kill as recently as 2002. Two viral diseases have also recently appeared in Vermont waters. Largemouth Bass virus was first detected in Lake Champlain in 2002 and a year later in Lake St. Catherine; and esocid lymphosarcoma infecting Lake Champlain Northern Pike in 2002

http://www.vtfishandwildlife.com/about_us/fish_division/fish_management/fish_health_program/). Viral hemorrhagic septicemia (VHS), which was first documented in 2005 infecting fishes in Lake Ontario has spread rapidly to the other Great Lakes and nearby inland waters and has been responsible for large and small-scale fish mortalities. Of 37 species of fish known to be susceptible to the VHS virus, 26 are found in the Great Lakes and 24 in Vermont. Unregulated or illegal transportation of fishes from out-of-state sources and between in-state waters is likely cause for the increasing incidences of disease-causing organisms appearing in fish populations in Vermont and other states. To date VHS infections have not been identified in Vermont fish populations; nonetheless, the Vermont Fish & Wildlife Department has taken proactive action to reduce the risks that the virus will find its way here, such as adopting more stringent bait fish and fish transportation regulations.

Implementing the 2005 Wildlife Action Plan

Since adoption of the 2005 Wildlife Action Plan, State Wildlife Grant funds have been used to increase our understanding and conservation of fish SGCN in the state. Some of the projects conducted under the 2005 Wildlife Action Plan include:

- Assessment of Lake Sturgeon in Large Vermont Tributaries to Lake Champlain;
- Development of Metrics to Assess the Quality of Riverine Habitat for Coldwater Fish Based on Stream Temperature;
- Aquatic Invasive Species – Hazard Analysis & Critical Control Point Training for Commercial Baitfish Dealers;
- Development of Guidelines for the Design of Stream Road Crossings for Passage of Aquatic Organisms in Vermont and the Vermont Culvert Aquatic Organism Passage Screening Tool;
- Aquatic Organism Passage at Stream & Road Crossings and Aquatic Organism Passage Barrier Assessments;
- Muskellunge Management & Conservation Planning in the Vermont Lake Champlain Basin;
- Development of In-House Capability to Detect Fish Disease Organisms by Polymerase Chain Reaction;
- Survey Design and Standard Operating Procedures for Forage Fish Assessment in Lake Champlain;
- Landlocked Atlantic Salmon Fry Stocking Evaluation;
- Development of Triploid Brook Trout Production Capability;
- Genetics of Lake Trout Populations in Northeastern Vermont Lakes
- Survey & Inventory of Round Whitefish Populations in Northeastern Vermont Lakes
- Survey of Fishes in the Large Lake Champlain Tributaries in Vermont
- Lacustrine Shoreline Planning
- Anadromous Atlantic Salmon Genetics
- Assessment of Stonecat Populations in the LaPlatte and Missisquoi Rivers of Vermont

- Genetic Examination of Lake Whitefish Population Sub-Structuring in Lake Champlain
- Development and Implementation of Disease Spread Prevention Systems to Minimize the Inadvertent Spread of Fish Diseases from Fisheries Management Activities, including the Rearing and Stocking of Cultured Fish, to Waters Supporting Fish SGCN.

Fish SGCN Selection

Selection criteria included 27 categories reflecting our knowledge about current listing as endangered and threatened; species rarity; population declines; vulnerability of habitats; life history traits; vulnerability to collection, harvest or other taking; other impacts from humans; and dispersal capability. Only native species were considered. Each species was examined across all criteria by the team. Based on this evaluation process the team assigned a high, medium and low rank to attempt to separate species with greater conservation needs from those with more secure status, at least in the short term. See Chapter 8 for details on selection criteria and process. This approach resulted in 27 species making either the rank of high conservation need or medium conservation need (table 5.4). Five species listed as SGCN in 2005 were removed from the list (Arctic Char, Atlantic Salmon-Anadromous, Brassy Minnow, Muskellunge and Quillback). One species, Northern Pearl Dace, has been added; and American Eel is now listed as two populations (Lake Champlain and Connecticut River) because their conservation needs differ.

Arctic Char has been removed as a SGCN after careful consideration of its status (extirpated) in the state and questions regarding if it was ever endemic to Vermont. Despite historical accounts of Arctic Char in Great and Little Averill ponds, the record is fraught with uncertainty. A specimen was collected in 1899 from Little Averill Pond and remains archived at the Smithsonian Institute (USNM 00061723). Unfortunately, the current condition of this fish defies taxonomic confirmation to species. Additionally, there is a morphological variant of Lake Trout, sometimes referred to as ‘lunge’, that remains to this day in Maidstone Lake in Essex County, and which bears external similarity to Arctic Char and possibly may have been misidentified to the latter species.

Atlantic Salmon, previously separated into anadromous (sea-run) and landlocked (freshwater resident) forms, have now been merged into a single category, Atlantic Salmon (naturally reproducing populations-Lake Champlain and Memphremagog basins). This was done for several reasons. First, anadromous Atlantic Salmon restoration in the Connecticut River was essentially terminated in 2012, when the U. S. Fish & Wildlife Service decided to withdraw from the program based on protracted years of poor adult returns to the river and the decision not to continue producing salmon fry at the White River National Fish Hatchery extensively damaged during the 2011 Tropical Storm Irene flood. State fishery agencies relied upon this fry production to stock salmon throughout much of the Connecticut River Basin distributed among the four cooperating states: Connecticut, Massachusetts, New Hampshire and Vermont. Second, there is conflicting accounts about the endemicity of landlocked salmon populations occurring in the state prior to European settlement. In contrast, there are historical accounts that anadromous salmon populations may have likely occurred in Lake Champlain and possibly had access to Lake Memphremagog. Lastly, all existing landlocked salmon populations in Vermont are introduced stocks exclusively or heavily dependent upon stocking hatchery-reared fish. A possible exception is Lake Champlain which historically may have supported a landlocked salmon population in addition to a sea-run one.

Brassy Minnow has been dropped as a SGCN on the basis that the species is reported to be currently of relatively low conservation concern and does not require significant additional protection or major management, monitoring, or research action. No major threats are known.

In 2008 the Vermont Fish and Wildlife Department decided to stock fingerling Muskellunge into the Missisquoi River to restore fishing opportunities for this important sport fish which has continued nearly every year since. About seven miles of the river between Swanton and Highgate Falls dams held the last known native population of the species in Vermont until sometime in the mid to late 1970s, when it appeared to become extirpated. Since the mid 1960s New York Department of Environmental Conservation has been stocking the Ohio River subspecies (Chautauqua line) Muskellunge into the Great Chazy River, a northern Lake Champlain tributary. Angler catches of Muskellunge on the Vermont side of the lake have been genetically tested and determined to be Chautauqua fish indicating straying is occurring. No fish of the St. Lawrence River subspecies to which the native Vermont population was related have yet to be identified among the fish genetically tested. The Department considered the possibility of maintaining a St. Lawrence line in its own hatchery system for species restoration purposes; however, it was decided this would be a too costly an option and hence juvenile fish are acquired from New York for stocking into the Missisquoi River and its delta for the purposes of developing a Muskellunge sport fishery. Development and management of a Muskellunge fishery qualifies for funding through license fees and the Federal Sport Fish Restoration Act.

Quillback has been dropped as a SGCN on the basis that the species is currently of relatively low conservation concern and does not require significant additional protection or major management, monitoring, or research action. No major threats are known.

Since the 2005 WAP American Eel in Vermont has been split into two populations: one having access to Lake Champlain via the St. Lawrence and Richelieu rivers and the other occupying the Connecticut River watershed. The reason for the separation is that different management strategies are being employed in each of the basins and commensurate population responses to these actions. Increases in Lake Champlain eel sightings in recent years are likely the result of management actions implemented by Canadian fishery agencies, such as closure of the Richelieu River commercial eel fishery in 1998, provision for eel passage on the Richelieu River at Chambly Dam in 1997 and St. Ours Dam in 2001, and experimental glass eel stocking in the Richelieu River (2.8 million eels) in 2005 to 2008. Eel management in the Connecticut River currently has focused American eel on construction of eelpasses (for enabling upstream juvenile eel movement around dams) and enumeration of immigrating eels.

Northern Pearl Dace (*Margariscus nachtriebi*) was formerly identified as a subspecies of the nominate Pearl Dace (*M. margarita*) but more recently is recognized as a distinct species by the American Fisheries Society (Page et al. 2013). The nominate species, now named Allegheny Pearl Dace, is relatively common to several watersheds located in southwestern Vermont. Northern Pearl Dace populations in Vermont are currently known from only two locations (upper Rock and Pike river drainages) near the Quebec border in the town of Franklin. Both rivers drain to Missisquoi Bay in Lake Champlain. More extensive fish community surveys are needed in northwestern part of the state to get a more complete understanding of its distribution, habitat use, and population threats.

Table 5.4. Fish Species of Greatest Conservation Need

High Priority

Northern Brook Lamprey (*Ichthyomyzon fossor*)¹
Silver Lamprey (*Ichthyomyzon unicuspis*)¹
American Brook Lamprey (*Lethenteron appendix*)¹
Lake Sturgeon (*Acipenser fulvescens*)¹
Round Whitefish (*Prosopium cylindraceum*)¹
Bridle Shiner (*Notropis bifrenatus*)¹
Blackchin Shiner (*Notropis heterodon*)
Blacknose Shiner (*Notropis heterolepis*)
Greater Redhorse (*Moxostoma valenciennesi*)
Stonecat (*Noturus flavus*)¹
Eastern Sand Darter (*Ammocrypta pellucida*)¹
Channel Darter (*Percina copelandi*)¹
Sauger (*Sander canadense*)¹

Medium Priority

Sea lamprey (CT River) (*Petromyzon marinus*)
Blueback Herring (CT River) (*Alosa aestivalis*)¹
Atlantic Salmon (naturally reproducing populations-Lake Champlain & Memphremagog basins) (*Salmo salar*)¹
Mottled Sculpin (*Cottus bairdi*)
American Eel (Lake Champlain pop) (*Anguilla rostrata*)¹
American Eel (CT River population) (*Anguilla rostrata*)¹
American Shad (*Alosa sapidissima*)¹
Mooneye (*Hiodon tergisus*)¹
Cisco or Lake Herring (*Coregonus artedii*)
Lake Whitefish (*Coregonus clupeaformis*)¹
Brook Trout (naturally reproducing populations) (*Salvelinus fontinalis*)¹
Lake Trout (naturally reproducing populations) (*Salvelinus namaycush*)¹
Redfin Pickerel (*Esox americanus*)
Northern Pearl Dace (*Margariscus nachtriebi*)
Silver Redhorse (*Moxostoma anisurum*)
Shorthead Redhorse (*Moxostoma macrolepidotum*)
Redbreast Sunfish (*Lepomis auritus*)¹

¹ Regional Species of Greatest Conservation Need in the Northeastern United States (Terwilliger, 2013)

Species of Greatest Conservation Need status for Blueback Herring is limited to the population residing in the Connecticut River. Similarly, Atlantic Salmon, Lake Trout, Brook Trout and Sea Lamprey are defined with limitations. Two populations of American eel—Connecticut River and Lake Champlain—are recognized individually as the conservation needs of these two runs differ significantly.

Although a disproportionate number of Vermont’s SGCN are at the periphery of their range, this should not diminish the importance of these species to the state’s biodiversity or in terms of their ecological significance. To illustrate this, of the 80 native Vermont fish species, nearly half of these are here on the eastern edge of each of the species’ natural North American range.

Reports on each Fish Species of Greatest Conservation Need are in Appendix A3 of this document. The following is a summary of those reports.

Habitat Needs

Vermont’s fish species use a variety of habitats: small ponds, large lakes, rivers, streams, and wetlands. Some habitats are used year-round and others are occupied seasonally, such as for spawning. Within water bodies, SGCN have specific habitat needs for example, riffles or pools in streams or deep, cold areas of lakes. Loss or degradation of any one critical habitat component can threaten the survival of the species in that particular water.

While most of our fishes are completely freshwater dependent, others spend portions of their lives in both freshwater and marine environments. Three SGCN (American Eel, Blueback Herring, and

American Shad. are dependent on both. Herring and shad have anadromous life cycles, that is spawning and at least a portion of the juvenile life occurs in freshwater; to attain maturity the fish must go to sea for a period of years. In contrast, eel is catadromous. Maturity is attained in freshwater and reproduction occurs in the ocean. Consequently, whether anadromous or catadromous, these species not only face problems at the Vermont landscape level, but also those at the regional and international scopes. To conserve our native fishes, and particularly SGCN, it is essential that we protect, enhance and restore habitat not only within Vermont but also, where appropriate, beyond our borders.

Discussion of Threats Impacting Fish SGCN

Factors affecting the security of SGCN are classified as either habitat or non-habitat problems. The most frequently identified habitat related problems impacting aquatic systems are habitat alteration, habitat fragmentation, habitat conversion, invasive non-indigenous species, and climate change. Habitat alteration includes activities, which diminish the quality and/or quantity of habitat features critical to the survival and maintenance of fish populations and other biota on which SGCN are dependent, including stream flows and lake water levels, water temperature regimes, and habitat diversity. Sedimentation is a form of habitat alteration by which the composition of the stream or lake bottoms are altered by greater than normal deposition of fine materials (e.g., silt, sand, organic matter) changing the composition and suitability of substrates to the detriment of their spawning, cover and food production values. Habitat conversion results in the total or near complete loss of function because of extreme habitat alteration. Examples of habitat conversion are loss of active floodplains, wetland draining and stream impoundments. Habitat fragmentation occurs when artificial structures, such as dams, impassable bridge structures, and dewatered stream channels, interfere with the movements of fish preventing their access to critical spawning areas or seasonal refugia. Habitat fragmentation also interferes with the natural dispersal of fish and genetic flow within and between populations. Climate change threatens several SGCN at the regional scale by altering (warming) their required thermal regimes. Invasive species, such as nonnative aquatic plants and zebra mussels, can impact aquatic habitats in a variety of ways. Exotic plants represent a “double edged sword” with respect to the conservation of certain fish species requiring abundant aquatic vegetation. Invasive plant species, such as Eurasian milfoil, may displace native plant communities on which fish are dependent for refugia, food production, and spawning. And, on the other hand, invasive vegetation control programs may eliminate these functions before native plants are restored to desired levels.

While virtually all fishes identified as SGCN are impacted by one or more problems to their habitats, non-habitat related problems are generally more variable from species to species. In some cases, non-habitat problems are a consequence of impacts on habitat. Those affecting SGCN include competition from other species, predation, loss of prey base, water pollution, disease and parasites, and over-harvest. The Sea Lamprey problem in Lake Champlain poses a challenging dilemma. Sea Lamprey has been identified as a known or potential parasite/predator on several SGCN. On the other hand, other SGCN may be threatened by certain control methods needed to control Sea Lamprey abundance and parasitism rates in the lake. Further research and monitoring is required to ensure that successful control measures minimize harm to SGCN.

Research & Monitoring Needs and Conservation Strategies

Priority research and monitoring projects and needs to improve our ability to conserve Vermont's fish SGCN are identified. Conservation strategies to address problems impacting each SGCN were developed. Those cited most frequently and those most effectively applied for multiple fish SGCN include:

Research & Monitoring Needs

1. Better determine the distribution and relative abundance of populations in Vermont.
2. Acquire better information on species' life histories, biology and habitat requirements.
3. Monitor and assess populations and habitats for current condition and future changes.
4. Identify and monitor problems for species and their habitats.
5. Establish a centralized fish database within the Agency of Natural Resources to manage fish and other aquatic data, track permits and management projects that impact aquatic species.

Conservation Strategies

6. Protect and restore aquatic, floodplain and riparian habitats through improved water quality; flow, water level and temperature regimes; sediment reduction; establishment of streamside buffers; floodplain restoration; and suitable aquatic habitat structure, diversity and complexity.
7. Maintain and restore aquatic organism passage and habitat connectivity at barriers (e.g., dams, culverts) to provide access to important habitats and maintain ecological connectivity.
8. Protect riparian and floodplain habitats through acquisition, easements, incentives, technical assistance and education.
9. Participate in existing regulatory processes (e.g., Act 250, stream alteration permits) to protect and restore important habitats.
10. Implement measures and programs to prevent the introduction and expansion of non-indigenous species to Vermont waters; develop and execute appropriate invasive species control programs.
11. Assess, monitor and manage as appropriate potential negative and beneficial effects of the Lake Champlain Sea Lamprey control program on SGCN and other non-target fishes.
12. Support and cooperate with inter-agency programs for the restoration of anadromous and catadromous fishes to the Connecticut River basin.
13. Update Vermont's baitfish rules as necessary and expand to include non-fish invasive bait species.
14. Support efforts to curb global climate change and its negative impacts on SGCN.
15. Support state and regional efforts to require reduction in emissions from coal burning power plants and other sources of acid precipitation.

Conclusion

Over the past decade, since implementation of the 2005 Vermont Wildlife Action Plan, meaningful progress has been made on several fronts to increase our understanding of SGCN and undertake

efforts to enhance their conservation in the state. Adult Lake Sturgeon have been documented ascending the Missisquoi, Lamoille and Winooski rivers to spawn and reproduction has been confirmed in these rivers (MacKenzie 2015). A sturgeon restoration plan is now under development.

Technical guidance was developed for the identification of stream crossing structures (e.g., culverts, bridges) where aquatic organism passage problems occur and to assist with the design of passable road-stream crossings. Even though structural improvements emphasize fish passage, other SGCN taxa are also beneficiaries, including numerous amphibian, reptile, mammal and invertebrate species.

Recent surveys of four northeastern Vermont lakes, where there had been historic occurrences of Round Whitefish populations, now appear to be limited to a single population in Lake Willoughby. With this knowledge, actions to conserve this population from potential threats are a critical need and deserve appropriate measures moving forward to secure the species presence in the state.

Other Fish SGCN that are currently receiving attention are Stonecat and Lake Whitefish. Additionally, the ANR continues to adopt and implement programs to minimize the introduction of invasive fish species and diseases to our native fish fauna. Since adoption of the 2005 Wildlife Action Plan four rules have been adopted into statute: (1) a list of prohibited, restricted and unrestricted fish species that may be imported and/or possessed in Vermont; (2) restrictions on the commercial harvest and sale of baitfish, as well as the personal harvest, use and movement of baitfish to minimize the risk of transporting aquatic invasive species, unwanted fish species, and fish diseases and pathogens; (3) a prohibition on the transport of fish in a manner which attempts to keep them alive and represents a risk of introducing unwanted organisms to new waters; and (4) procedures for a Rapid Response General Permit authorizing the ANR to quickly respond to and control an invasive nonnative species. These accomplishments establish a good base from which future conservation initiatives will emerge and continued progress will be made on those already on the ground.

Lastly, climate change represents an emerging threat to several fish species indigenous to the Vermont as well as to the integrity and function of aquatic communities and systems. This will require considerable commitments of agency and stakeholder resources to stem the threats that this global problem poses to our fauna and the ecological and economic values and uses that are so important to the citizens of Vermont.

Literature Cited

- (ANR) VT Agency of Natural Resources. 1/20/2005. Riparian Buffer Guidance, and Riparian Buffers and Corridors Technical Papers www.anr.state.vt.us/dec/dec.htm
- Kirn, R. 2007. Vermont Brook Trout Conservation Strategies. Vermont Fish & Wildlife Department. Montpelier, VT.
- Langdon, R.W., M.T. Ferguson, and K.M. Cox. 2006. [Fishes of Vermont](http://www.vtfishandwildlife.com/cms/One.aspx?portalId=73163&pageId=216868). Vermont Department of Fish and Wildlife, Waterbury, Vermont. <http://www.vtfishandwildlife.com/cms/One.aspx?portalId=73163&pageId=216868>
- MacKenzie, C. 2015. Vermont Restoration Plan for Lake Sturgeon in Lake Champlain. Draft 3. Vermont Department of Fish & Wildlife, Montpelier.
- Terwilliger Consulting, Inc. and the Northeast Fish and Wildlife Diversity Technical Committee. 2013. [Taking Action Together: Northeast Regional Synthesis for State Wildlife Action Plans](#). A report submitted to the Northeast Fish and Wildlife Diversity Committee. Locustville, VA.

Conserving Vermont's Invertebrates

Invertebrate Team

Mark Ferguson, Vermont Fish & Wildlife Department (team leader)
Steve Fiske, Vermont Dept of Environmental Conservation
Trish Hanson, Vermont Forest Parks & Recreation Department
Kent McFarland, Vermont Center for Ecostudies
Bryan Pfeiffer, Consulting Entomologist

Team Charge

The Invertebrate Team was charged with identifying Species of Greatest Conservation Need (SGCN); describing the distribution and habitat usage for each SGCN; evaluating problems impacting SGCN and their habitat; identifying priority research needs to improve our ability to conserve these species; and, developing conservation strategies to address priority problems.

Introduction

The role of invertebrates in our world is mostly unrecognized by humans. But once we get beyond the buzz of mosquitoes and our annoyance with blackflies, our reliance upon these tiny animals slowly unfolds. Within cool forest streams, stonefly and mayfly nymphs consume leaves that fall from forest trees and provide a food source for Brook Trout and other fishes. In the gardener's corner, bees, flies, wasps, and butterflies pollinate the flowers that will later yield the anticipated fruits and vegetables. Spiders wait to ambush flies in our homes. Dragonflies patrol the stream shores for their insect prey. Beetles, flies, and other invertebrates consume the wastes produced by the human world, leaving fertile soil in exchange. Mostly unnoticed and even avoided, these smallest of creatures provide an amazing array of functions that we depend upon in our everyday life. The diversity of species we are so fortunate to have is, itself, something to marvel.

Of the thousands of species that occur in Vermont, several are rare or threatened enough to be at risk of disappearing from the state in the future. The causes that lead to their predicament vary among species. One of the greatest obstacles to acting to help conserve these "at risk" invertebrates has been the scarcity of information that exists on their distribution, abundance, habitat requirements, life history characteristics, population trends, and threats. It is necessary to assess the status and needs of each species to adequately conserve populations and track the success of these actions. The invertebrate conservation outlined in our first Wildlife Action Plan (2005) therefore focused on obtaining this baseline information.

In the past decade, however, great strides were made in augmenting our knowledge of hundreds of species including bumble bees, butterflies, giant silkmoths, odonates (dragonflies and damselflies), carabid beetles and mussels. While this covers only a fraction of the more than 21,400 invertebrate species believed to be in Vermont, it's a significant advancement for invertebrate conservation. The 2015 Wildlife Action Plan includes specific conservation actions for several species and species groups that were not possible just a decade ago.

Pollinators: While the 2005 Wildlife Action Plan included 33 species of butterflies and moths, many of them pollinators, their role as pollinators was not critical to their selection as SGCN. Since 2005,

concerns over the status of pollinators in general (e.g. flies, wasps, moths, butterflies, beetles, bees, and hummingbirds), and native bees in particular, has become a worldwide concern. Pollination is defined as a mutually beneficial relationship between plants and pollinators wherein the plant provides pollen and/or nectar to the pollinator and the pollinator provides reproductive services for the plant (National Research Council, 2007). Roughly 75 percent of the 240,000 species of flowering plants world-wide rely on pollinators for flower reproduction (NRC, 2007). This includes many plant species that provide browse or forage for larger wildlife, as well as seeds and fruits to support birds and small mammals. These invertebrates also pollinate many commercial crops. In Vermont this includes blueberries, tomatoes, squash, apples, and other produce. The many drivers of pollinator declines include habitat loss and degradation, intensive agricultural practices, use of certain pesticides, diseases and pathogens (Heinz Center, 2013). For this second Wildlife Action Plan nine bumble bee species and 31 species of butterflies and moths—including the Monarch Butterfly—were selected as Species of Greatest Conservation Need.

Implementing the 2005 Wildlife Action Plan

Since the adoption of Vermont's first Wildlife Action Plan in 2005 several significant advances were made in the realm of invertebrate research and conservation, including the following—most of which were funded at least in part by the State Wildlife Grants program:

Vermont Butterfly Survey: The [Vermont Butterfly Survey](#) (2002-2007) surveyed the entire state and analyzed historic records and collections to document the distribution of 103 butterfly species, including 12 species new to Vermont, and giant silkworm moths (Saturnids) too. The project was a collaboration between VFWD, the Vermont Center for Ecostudies, and the Vermont Institute of Natural Sciences with more than 125 citizen scientists participating. Assessing the conservation status of each species and establishing a baseline for understanding future changes was the principle goal of the Atlas. Fifteen species were listed as Species of Greatest Conservation Need representing three ecological groups—wetlands, grasslands, and hardwood forests. The vulnerability to climate change was calculated for 14 butterfly SGCN currently found in Vermont. Three species were found to be extremely vulnerable to climate change, five were highly vulnerable, one moderately vulnerable, three presumed stable, and two could likely increase in numbers in Vermont (Table 5.5). We expect to see the Butterfly Survey repeated in ~2027 as a comparison to this baseline.

Peatland and Large River Dragonfly and Damselfly Survey: The first statewide assessment of odonate populations in Vermont, focused on peatlands and large river habitat, was completed in 2009 and provides vital species distribution and occurrence information which has broadened our understanding of rare habitat-specialist dragonfly and damselfly SGCN. Habitat data collected as part of the study provides a comparative baseline for future population trend monitoring. Among the investigation's results were: new encounters with *Gomphus abbreviatus* (S1S2) on two rivers and a moderate gain in the knowledge of *Ophiogomphus* spp. (four species), particularly on the White River; discovery of at least two previously unknown populations of *Neurocordulia yamaskinensis* (S3), a species that had been rarely encountered in Vermont; an expanded knowledge of *Somatochlora* spp. (seven species) distribution in and around peatlands, including *S. albicincta* (S1), *S. cingulata* (S1S2) and *S. franklini* (S1S2), revealing that Silvio Conte National Wildlife Refuge and West Mountain Wildlife Management Area have some of the highest *Somatochlora* diversity in New England; and two new peatland sites for *Williamsonia fletcheri* (S1S2). Future efforts toward odonate SGCN conservation will continue to rely on the information resulting from this and future field studies. For more information see the [Vermont Damselfly and Dragonfly Atlas](#).

Table 5.5. Results of a climate change vulnerability assessment of butterfly SGCN in Vermont (from McFarland, and Zahendra. 2010).

Common Name	Climate Change Vulnerability Index	Confidence	GRank	SRank
West Virginia White	Extremely Vulnerable	Very High	G4	S3S4
Bog Copper	Extremely Vulnerable	Very High	G4	S2
Edwards' Hairstreak	Extremely Vulnerable	Very High	G4	SU
Early Hairstreak	Highly Vulnerable	Very High	G4	S2S3
Hackberry Emperor	Increase Likely	Very High	G5	S2
Tawny Emperor	Increase Likely	Very High	G5	S2
Jutta Arctic	Moderately Vulnerable	Very High	G5	S1
Cobweb Skipper	Presumed Stable	Low	G4	S1
Mulberry Wing	Highly Vulnerable	Very High	G4	S2
Broad-winged Skipper	Presumed Stable	Very High	G5	S2
Black Dash	Highly Vulnerable	Very High	G4	S1S2
Dion Skipper	Highly Vulnerable	Very High	G4	S2
Two-spotted Skipper	Highly Vulnerable	Very High	G4	S2
Dusted Skipper	Presumed Stable	Very High	G4	S1

Vermont Bumble Bee Survey: Growing concerns about the decline of pollinators nationwide and locally prompted this survey. From 2012-2013 biologists and trained citizen scientists led by the Vermont Center for Ecostudies searched more than 1,500 locations across the state and recorded more than 10,000 individual bumble bee encounters. Survey data was then compared with historic data gleaned from public and private collection. The results provided sobering news about the status of Vermont’s 15 bumble bee species: more than one-quarter of these species have either vanished or are in serious decline. Harmful parasites accidentally imported from Europe and a class of pesticides toxic to bees are believed to account for North American bumble bee declines (Hatfield et. al. 2012).

Endangered Species Protection for Three Bumble Bee Species: Based on the results of the bumble bee survey, three species—the Rusty-patched Bumble Bee, Yellow-banded Bumble Bee, and Ashton Cuckoo Bumble Bee—were given protection under Vermont’s Endangered Species law in 2015. The Rusty-patched Bumble Bee, for example, was common in Vermont until the 1990s. But not a single specimen was found during the 2012-2013 statewide survey. Vermont’s bumble bee species appear to be in decline due to parasites imported from Europe and possibly the widespread use of a group of systemic insecticides referred to as ‘neonicotinoids’ (Hatfield et. al. 2012).

Freshwater Mussel Surveys: Freshwater mussels are recognized as the most endangered group of aquatic organisms in North America, with over two thirds of species considered extinct, endangered, or in need of special protection. In Vermont, 10 of the native eighteen species, or 55%, are listed under the state endangered species law, and several others are considered rare. One species, the dwarf wedgemussel, is federally endangered. Over the past decade surveys were conducted to determine the status of Vermont’s freshwater mussel populations to determine habitat needs, fish hosts and to establish appropriate species population goals and conservation strategies with a focus on the Brook Floater (*Alasmidonta varicosa*), Fluted-shell (*Lasmigona costata*), and Creek Heelsplitter (*L. compressa*)—all SGCN.

Tiger Beetle Surveys: Two state-threatened tiger beetle species, the Cobblestone Tiger Beetle and the Hairy-necked Tiger Beetle were the focus of dedicated surveys from 2005-2010 in Vermont. Data gathered in this study was combined with existing information to help inform the drafting of recovery plans for each species. More information can be found at the [Vermont Tiger Beetle Atlas](#).

Development of the Vermont Invertebrate Database: The paucity of basic information such as species presence, geographic distribution, habitat associations, and life history has limited our ability to direct conservation actions for most groups of invertebrates. However, a substantial amount of information exists that could be gleaned from past invertebrate collecting and research in Vermont, although it is scattered among various collections, government offices, research facilities, published works, gray literature, and other sources. In 2006 the Vermont Invertebrate Database project began the task of compiling and organizing information into a format that can easily be accessed so that it could provide a baseline from existing sources for a broad spectrum of invertebrate taxa for future invertebrate conservation and research planning efforts. This ongoing project is accessible to biologists, researchers, conservationists, land-use planners, educators, and other interested parties.

Compilation and Publication of the Ross Bell Carabid Beetle Collection: For more than six decades, Dr. Ross Bell of UVM and dean of Vermont's Entomologists collected carabid beetles in Vermont and across the world. It took a concerted effort by many of the entomologists that followed in his footsteps to catalog and map the thousands of beetles he collected over the years. [Carabidae of Vermont and New Hampshire](#) (Bell 2015) was released in 2015.

Restoration of the Carl Parsons Insect Collection: UVM's Zoological Museum includes more than half a million pinned and identified insects emphasizing Vermont species. This wealth of data covering invertebrate diversity over the past two hundred years had fallen into disrepair from neglect and lack of funding. A renewed interest in conserving this collection, led by the Vermont Center for Ecostudies (VCE), over the past decade has led to its near complete restoration.

Selecting Invertebrate SGCN

The task of assessing the conservation needs of Vermont's invertebrates is daunting. The number of species that occur within the state is not known; however, current estimates hover around 21,000 different species. In addition, many of our invertebrates have not yet been scientifically described. Life history, distribution, and abundance information is available for a small minority of Vermont's invertebrates that would be considered as conservation targets, such as freshwater mussels and some tiger beetles. Thus, the Invertebrate Team had to determine how best to assess conservation needs with limited information to draw upon. State and regional experts, as well as entomological hobbyists, have compiled a valuable knowledge base for selected groups of invertebrates over the last century. Although distributional information is often limited, an understanding of the natural history of many of these species enabled the team to move forward. It was the team's decision that identification of SGCN would focus on species and species groups for which adequate information was available.

SGCN selection criteria included: current listing as endangered and threatened; population declines; rarity; vulnerability of habitat; life history traits; vulnerability to collection or take; population limitations; regional status; historic occurrence; disjunct populations; habitat specialization; impacts by exotics; and dispersal capability. A review using these criteria resulted in a SGCN list of 198 species. 139 of these species are ranked High Priority SGCN and 59 are ranked Medium Priority.

These species were organized into 15 taxonomic groups to aid in the development of conservation reports (table 5.6).

Table 5.6. Invertebrate Groups, Vermont Wildlife Action Plan 2015

Group	# Species/ Group
Ant Group	2
Bumble Bee Group	9
Beetles-Carabid Group	67
Beetles-Tiger Beetle Group	7
Butterflies-Grassland Group	4
Butterflies-Hardwood Forest Group	4
Butterflies-Wetland Group	6
Moths Group	17
Mayflies/Stoneflies/Caddisflies Group	14
Odonates-Bog/Fen/Swamp/Marshy Pond Group	15
Odonates-Lakes/Ponds Group	7
Odonates-River/Stream Group	15
Crustaceans Group	3
Freshwater Mussels Group	13
Freshwater Snails Group	15
Total	198

The list of species within each of these groups can be found in table 5.7.

Table 5.7. Invertebrate Species of Greatest Conservation Need

MP=Medium Priority SGCN; HP=High Priority SGCN.

¹Regional Species of Greatest Conservation Need in the Northeastern United States (Terwilliger, 2013)

²Regional responsibility species identified in (White et al. 2014).

Ant Group (2)

An ant (*Myrmica lobifrons*) MP
A Slave-making Ant (*Temnothorax pilagens*) HP

Bumble Bee Group (9)

Rusty-patched Bumble Bee (*Bombus affinis*) HP
Ashton Cuckoo Bumble Bee (*Bombus ashtoni*) HP
Lemon Cuckoo Bumble Bee (*Bombus citrinus*) HP
Fernald's Cuckoo Bumble Bee (*Bombus fernaldae*) HP
Yellow Bumble Bee (*Bombus fervidus*) HP
American Bumble Bee (*Bombus pennsylvanicus*) HP
Confusing Bumble Bee (*Bombus perplexus*) HP
Red-belted Bumble Bee (*Bombus rufocinctus*) MP
Yellow-banded Bumble Bee (*Bombus terricola*) HP

Beetles-Tiger Beetle Group (7)

Boulder-beach Tiger Beetle (*Cicindela ancocisconensis*) ¹ HP
Hairy-necked Tiger Beetle (*Cicindela hirticollis hirticollis*) HP
Boreal Long-lipped Tiger Beetle (*Cicindela longilabris*) HP
Cobblestone Tiger Beetle (*Cicindela marginipennis*) ¹ HP
Northern Barrens Tiger Beetle (*Cicindela patruela*) ¹ HP
Puritan Tiger Beetle (*Cicindela puritana*) ¹ HP
Eastern Red-bellied Tiger Beetle (*Cicindela rufiventris*) HP

Butterflies-Grassland Group (4)

Dusted Skipper (*Atrytonopsis hianna*) MP
Cobweb Skipper (*Hesperia metea*) MP
Monarch (*Danaus plexippus*) HP
Regal Fritillary (*Speyeria idalia*) MP

Butterflies-Hardwood Forest Group (4)

Early Hairstreak (*Erora laeta*) HP
Hackberry Emperor (*Asterocampa celtis*) MP
Tawny Emperor (*Asterocampa clyton*) MP
West Virginia White (*Pieris virginianensis*) HP

Butterflies-Wetland Group (6)

Two-spotted Skipper (*Euphyes bimacula*) HP
Black Dash (*Euphyes conspicua*) HP
Dion Skipper (*Euphyes dion*) MP
Mulberry Wing (*Poanes massasoit*) HP
Bog Copper (*Lycaena epixanthe*) HP
Jutta Arctic (*Oeneis jutta*) HP

Ground Beetles-Carabid Group (67)

Agonum crenistriatum HP
Agonum darlingtoni HP
Agonum moerens MP
Agonum picicornoides HP
Agonum punctiforme MP
Agonum superioris MP
Amara erraticus HP
Amara laevipennis MP
Apristus latens HP
Atranus pubescens MP
Bembidion affine MP
Bembidion cordatum MP

Bembidion gratii HP
Bembidion mutatum HP
Bembidion quadratum HP
Bembidion robusticolle MP
Bembidion rolandi MP
Bembidion rufotinctum HP
Blethisa hudsonica MP
Blethisa julii HP
Blethisa quadricollis HP
Carabus goryi MP
Carabus maeander MP
Dicaelus dilatatus dilatatus HP
Dicaelus teter HP
Dicheirotrichus cognatus HP
Diplocheila impressicollis MP
Diplocheila striatopunctata HP
Dyschirius brevispinus MP
Dyschirius erythrocerus MP
Dyschirius politus politus HP
Elaphropus dolosus MP
Elaphropus levipes MP
Elaphrus fuliginosus HP
Geopinus incrassatus HP
Harpalus fulvilabris HP
Harpalus indigens MP
Harpalus providens MP
Lophoglossus scrutator HP
Nebria suturalis HP
Notiobia sayi MP
Notiophilus aquaticus MP
Notiophilus borealis HP
Notiophilus nemoralis HP
Notiophilus novemstriatus MP
Olisthopus micans HP
Patrobus foveocollis HP
Pentagonica picticornis MP
Pericompsum ephippiatus MP
Philodes alternans HP
Philodes rectangulus MP
Platynus cincticollis MP
Platypatrobus lacustris MP
Pseudamara arenaria MP
Pterostichus brevicornis brevicornis HP
Pterostichus castor MP
Pterostichus pinguedineus HP
Pterostichus punctatissimus HP
Scaphinotus bilobus MP
Schizogenius ferrugineus MP
Sericoda obsoleta MP
Sericoda quadripunctata MP
Sphaeroderus nitidicollis HP
Tachys oblitus MP
Tachys rhodeanus HP
Tetragonoderus fasciatus MP
Tetraleucus picticornis MP

Moths Group

A Noctuid Moth (*Zale submediana*) HP
Pine Barrens Zanclognatha (*Zanclognatha martha*) HP
Currant Spanworm (*Speranza ribearia*) HP
A Ghost Moth (*Sthenopis thule*) MP
A Noctuid Moth (*Lasionycta taigata*) MP
A Noctuid Moth (*Lemmeria digitalis*) MP
Franclemont's Lithophane (*Lithophane franclemonti*) HP
An Autumnal Noctuid Moth (*Pachypolia atricornis*) HP
Ostrich Fern Borer (*Papaipema sp. 2 nr. Pterisii*) HP
Barrens Moth (*Properigea costa*) MP
A Noctuid Moth (*Xestia fabulosa*) MP
A Noctuid Moth (*Xestia homogena*) HP
Pine Imperial Moth (*Eacles imperialis pini*) HP
New England Buckmoth (*Hemileuca lucina*) MP
Plum Sphinx (*Sphinx drupiferarum*) HP
Clemens' Sphinx (*Sphinx luscitiosa*) HP
A tortricid moth (*Eana georgiella*) MP

Mayflies/Stoneflies/Caddisflies Group (14)

A Caddisfly (*Ceraclea submacula*) HP
A Caddisfly (*Polycentropus glacialis*) HP
A Caddisfly (*Polycentropus iculus*) HP
A Caddisfly (*Rhyacophila amicis*) HP
A Caddisfly (*Rhyacophila brunnea*) HP
A Mayfly (*Ameletus browni*) HP
A Mayfly (*Baetisca rubescens*) HP
A Mayfly (*Eurylophella bicoloroides*) HP
Roaring Brook Mayfly (*Epeorus frisoni*) HP
Tomah Mayfly (*Siphonisca aerodromia*) HP
A Mayfly (*Siphonurus demaryi*) HP
Lawrence Sallfly (*Alloperla voinae*) HP
Appalachian Stonefly (*Hansonoperla appalachia*) HP
Spiny Salmonfly (*Pteronarcys comstocki*) HP

Odonates-Bog/Fen/Swamp/Marshy Pond Group (15)

Mottled Darner (*Aeshna clepsydra*) HP
Zigzag Darner (*Aeshna sitchensis*)² HP
Subarctic Darner (*Aeshna subarctica*)² HP
Comet Darner (*Anax longipes*) HP
Swamp Darner (*Epiaeschna heros*) HP
Cyrano Darner (*Nasiaeschna pentacantha*) HP
Spatterdock Darner (*Rhionaeschna mutata*) HP
Subarctic Bluete (*Coenagrion interrogatum*) HP
Petite Emerald (*Dorocordulia lepida*) HP
Ski-tailed Emerald (*Somatochlora elongata*)² HP
Forcipate Emerald (*Somatochlora forcipata*)² HP
Delicate Emerald (*Somatochlora franklini*)² HP
Kennedy's Emerald (*Somatochlora kennedyi*)² HP
Ebony Boghaunter (*Williamsonia fletcheri*) HP
Black Meadowhawk (*Sympetrum danae*)² HP

Odonates-Lakes/Ponds Group

New England Bluete (*Enallagma laterale*)² HP
Slender Bluete (*Enallagma traviatum*) HP
Lilypad Forktail (*Ischnura kellicotti*) HP
Ringed Emerald (*Somatochlora albicincta*)² HP

Lake Emerald (*Somatochlora cingulata*) HP
Banded Pennant (*Cellithemis fasciata*)² HP
Carolina Saddlebags (*Tramea carolina*) HP

Odonates-River/Stream Group (15)

American Rubyspot (*Hetaerina americana*) HP
Blue-fronted Dancer (*Argia apicalis*) HP
River Bluete (*Enallagma anna*)² HP
Rainbow Bluete (*Enallagma antennatum*)² HP
Big Bluete (*Enallagma durum*) HP
Stygian Shadowdragon (*Neurocordulia yamaskanensis*) HP
Spine-crowned Clubtail (*Gomphus abbreviatus*) HP
Midland Clubtail (*Gomphus fraternus*) HP
Rapids Clubtail (*Gomphus quadricolor*) HP
Cobra Clubtail (*Gomphus vastus*) HP
Skillet Clubtail (*Gomphus ventricosus*)² HP
Maine Snaketail (*Ophiogomphus mainensis*) HP
Rusty Snaketail (*Ophiogomphus rupinsulensis*) HP
Riverine Clubtail (*Stylurus amnicola*)² HP
Zebra Clubtail (*Stylurus scudderi*) HP

Crustaceans Group (3)

Appalachian Brook Crayfish (*Cambarus bartonii*) HP
Taconic Cave Amphipod (*Stygobromus borealis*) HP
An Amphipod (*Diporeia hoyi*) HP

Freshwater Mussels Group (13)

Eastern Pearlshell (*Margaritifera margaritifera*)¹ MP
Dwarf Wedgemussel (*Alasmidonta heterodon*)¹ HP
Elktoe (*Alasmidonta marginata*)¹ HP
Brook Floater (*Alasmidonta varicosa*)¹ HP
Alewife Floater (*Anodonta implicata*)¹ MP
Cylindrical Papershell (*Anodontoides ferussacianus*)¹ MP
Pocketbook (*Lampsilis ovata*)¹ HP
Creek Heelsplitter (*Lasmigona compressa*)¹ HP
Fluted-shell (*Lasmigona costata*) HP
Fragile Papershell (*Leptodea fragilis*)¹ HP
Black Sandshell (*Ligumia recta*)¹ HP
Pink Heelsplitter (*Potamilus alatus*) HP
Giant Floater (*Pyganodon grandis*) MP

Freshwater Snails Group (15)

Buffalo Pebblesnail (*Gillia altilis*) HP
Squat Dusksnail (*Lyogyrus granum*) HP
Pupa Dusksnail (*Lyogyrus pupoideus*) HP
Canadian Dusksnail (*Lyogyrus walkeri*) HP
Boreal Marstonia (*Marstonia lustrica*) HP
Spindle Lymnaea (*Acella haldemani*) HP
Mammoth Lymnaea (*Bulimnaea megasoma*) HP
Country Fossaria (*Fossaria rustica*) HP
Star Gyro (*Gyraulus crista*) MP
Dusky Ancylicid (*Laevapex fuscus*) MP
Thicklip Rams-horn (*Planorbula armigera*) MP
Liver Elimia (*Goniobasis livescens*) HP
Sharp Hornsnail (*Pleurocera acuta*) MP
Fringed Valvata (*Valvata lewisi*) HP
Mossy Valvata (*Valvata sincera*) HP

Reports on each invertebrate Species Group of Greatest Conservation Need are in Appendix A4 of this document. The following is a summary of those reports.

Habitat Needs

As invertebrates are the most diverse of Vermont's animals, the breadth of habitats they occupy is great. From deep lakes and slow rivers to the alpine peaks of our highest mountains, from the leaf litter of lowland floodplain forests to treetops in upland beech stands, there are invertebrates utilizing an amazing array of niches in every corner of Vermont. Many of these species have general habitat requirements, or live in natural communities that are common and secure within the state. A number of these are so abundant that they are treated as forest and agricultural pests. Such species do not normally require special conservation attention.

In contrast, habitat specialization is also a common strategy among invertebrates. Examples of habitats that host specialized invertebrates include fens, black spruce bogs, river cobble shores, large rivers, and alpine meadows. Certain herbivorous invertebrates feed only on specific plant hosts, exhibiting another form of specialization. While such specialization is often advantageous when the required habitat or plant host is plentiful, it creates a risk to these invertebrates when the habitat or host is rare, widely scattered, or also at risk (e.g., the Monarch Butterfly is suffering from limited winter habitat and loss of milkweed—its host plant for egg laying). In such cases, conservation attention is sometimes needed to ensure that these specialized invertebrates remain a part of Vermont's fauna.

Certain habitats in Vermont support highly diverse wildlife assemblages, including SGCN invertebrates. Good examples include Lake Champlain and its lower tributaries, where many of our freshwater mussel SGCN are located and peatlands for dragonfly and damselfly SGCN. These species-rich areas provide us the opportunity to help conserve many SGCN simultaneously.

Discussion of Threats Impacting Invertebrate SGCN

The greatest problems faced by SGCN invertebrates in Vermont relate to the loss, degradation, and fragmentation of their habitats. Poorly planned construction is ever-increasing on the landscape, often whittling away the wetland and upland habitats available to these creatures when these areas are not protected. As small habitat units disappear from the landscape, those remaining become more distant from one another; this presents an obstacle to those invertebrates that are limited to short-distance movement.

Declines in pollinators from bumble bees to the Monarch Butterfly has been noted nationwide and Vermont is no exception. The drivers of these declines likely vary from region to region and from species to species. In most cases it a combination of threats are probably responsible. One commonly cited threat is of a group of systemic insecticides referred to as 'neonicotinoids'. These pesticides are used on agricultural crops, and are also used in concentrated doses on home gardens, lawns, and ornamental trees. Several types of neonicotinoids are highly toxic to bees, in addition to making them more susceptible to parasites and pathogens.

Surface runoff from developed and agricultural lands can carry pollutant and sediment loads that find their way to rivers and streams, particularly during heavy rain events. The buildup of sediments on river bottoms embeds the natural substrate and can smother the invertebrates that reside there. Other pollutants entering streams and rivers can be detrimental to sensitive aquatic species.

Exotic species and diseases are negatively impacting several invertebrate SGCN, and will likely present increased challenges to conservation in the future as new foreign species invade our lands and waters. Parasites accidentally imported from Europe have ravaged Vermont's bumble bee

populations and are particularly deadly to those bees weakened by exposure to the neonicotinoid pesticides mentioned previously. Native freshwater mussels have been eliminated from several large areas of Lake Champlain by the ongoing Zebra Mussel invasion. A small exotic fly (*Tachinid spp*) originally introduced to control gypsy moths instead preys upon many native woodland moth species, including some of our giant silk moths. This may prompt the need for future inclusion as SGCN such species as the Luna, Polyphemus, and Cecropia silkmths.

Some of the challenges faced by invertebrate SGCN stem from their dwindling numbers and their life history characteristics. Low natural recruitment of offspring into the adult populations can hinder population recovery when numbers are low, such as with freshwater mussels. Other factors shared by several invertebrate SGCN groups that limit or impact populations include trampling/direct impacts, limited localized populations, and the requirement of specialized habitats.

Research & Monitoring Needs and Conservation Strategies

Over the past decade significant efforts have been made to address the lack of knowledge about many invertebrate SGCN. Data has been gathered through both field surveys and through the analysis of existing collections both public and private. Despite these efforts, however, our greatly expanded invertebrate datasets still pale in comparison those of other taxonomic groups and additional research is still needed to better guide conservation efforts. The Invertebrate Team therefore identified priority research and monitoring projects to improve our ability to conserve Vermont's invertebrate SGCN. The Team also developed conservation strategies to address problems impacting each SGCN. Those used most frequently and those best applied to multiple invertebrate SGCN include:

Research & Monitoring Needs

1. Define habitat requirements of SGCN within Vermont, utilizing current knowledge of researchers and field investigations as well as important life history characteristics when such information is lacking.
2. Obtain baseline SGCN distributional and abundance data by conducting surveys throughout the state particularly for additional invertebrate groups, such as spiders, moths, land snails and Orthoptera (grasshoppers, crickets).
3. Freshwater mussels:
 - A. Centralize freshwater mussel data currently managed by multiple entities.
 - B. Resurvey sites known to support rare mussels in the past that have not been surveyed in at least the past decade.
 - C. Determine lampricide impacts on juvenile mussels and the long-term effects on adults.
4. Determine associations between invertebrate SGCN and targeted habitat types and/or natural communities (e.g., wetlands and wetland butterflies) to determine hotspots for conservation planning. Begin with habitat specialists and uncommon/threatened habitats.
5. Develop a threat analysis for odonates and coordinate with regional threat analyses.
6. Assess potential and existing impacts of threats to SGCN populations and their habitats.
7. Monitor trends in SGCN population size and structure, and in habitat.
8. Monitor current and potential threats to SGCN species.

Priority Conservation Strategies

1. Conserve high priority SGCN sites through acquisition, easements, technical assistance, and other cooperative means.
2. Protect and restore aquatic habitats on which SGCN are dependent through pollution abatement, riparian buffers (ANR 2005), flow regulation, easements, and other means.
3. Develop mowing plans for state lands (e.g., parks, roadsides (FWHA 2007, rest stops, old fields and rights-of-way) to benefit SGCN pollinators and to limit the spread of invasive plants. Develop similar mowing BMPs for use by partners, municipalities and VTtrans.
4. Continue developing recovery plans for listed species including freshwater mussels and tiger beetles. Develop Best Management Practices (BMPs) and management guidelines where appropriate (e.g., for bumble bees).
5. Work with farmers and other landowners to promote the growth and retention of milkweed and other wildflowers in old fields and pastures to benefit bumble bees, Monarch Butterfly and other pollinators.
6. Work with foresters to avoid impacts to SGCN populations and habitats during forest management activities.
7. Work with biologists to minimize impacts and maximize benefits to SGCN invertebrate populations and habitats during and following management activities for sport fish and game wildlife.
8. Participate in existing regulatory processes (e.g., Act 250, stream alteration permits) to protect and restore critical habitats.

Conclusion

The work to conserve our invertebrate SGCN is well underway. We now have statewide data for butterflies and bumble bees, and targeted data for rare dragonflies, damselflies, and freshwater mussels. Efforts to gather and organize invertebrate data from private individuals, museums, and universities are in progress. This expanded base of knowledge can help everyone interested in invertebrate conservation focus on the species, habitats and threats that are most in need of attention and launch new initiatives directed at invertebrate conservation.

Literature Cited

- (ANR) VT Agency of Natural Resources. 1/20/2005. Riparian Buffer Guidance, and Riparian Buffers and Corridors Technical Papers www.anr.state.vt.us/dec/dec.htm
- Bell, R.T. 2015. [Carabidae of Vermont and New Hampshire](#). Shires Press, Manchester Center, VT.
- Blust, Michael, Bryan Pfeiffer, and Kent McFarland. 2015. Vermont Odonata Atlas. Vermont Center for Ecostudies – Vermont Atlas of Life. Retrieved from <http://val.vtecostudies.org>
- (FHWA) Federal Highway Administration. 2007. A Manager’s Guide to Roadside Revegetation Using Native Plants. [FHWA-WFL/TD-07-006](#).
- Hatfield, R., S. Jepsen, E. Mader, S. H. Black, and M. Shepherd. 2012. Conserving Bumble Bees. Guidelines for Creating and Managing Habitat for America's Declining Pollinators. The Xerces Society for Invertebrate Conservation. Portland, OR.
- McFarland, K., and S. Zahendra. 2010. Vermont Butterfly Survey 2002-2007; final report to the Natural Heritage Program of the Vermont Department of Fish and Wildlife. Vermont Center for Ecostudies.
- National Research Council. 2007. Status of Pollinators in North America. Washington, D.C.: The National Academies Press.
- Pfeiffer, Bryan (Wings Environmental). 2009 An Investigation of Odonata in Vermont Rivers and Peatlands. Submitted to the Vermont Fish & Wildlife Department 3/11/2010.
- The Heinz Center. 2013. Pollinators and the State Wildlife Action Plans: Voluntary Guidance for State Wildlife Agencies. Washington, DC.
- Vermont Atlas of Life. 2015. Vermont Tiger Beetle Atlas. Vermont Center for Ecostudies – Vermont Atlas of Life. Retrieved from <http://val.vtecostudies.org>
- White, Erin L., Pamela D. Hunt, Matthew D. Schlesinger, Jeffrey D. Corser, and Phillip G. deMaynadier. 2014. [A conservation status assessment of Odonata for the northeastern United States](#). New York Natural Heritage Program, Albany, NY.

Conserving Vermont's Mammals

Mammal Team Members

Alyssa Bennett, Vermont Fish & Wildlife Department

Chris Bernier, Vermont Fish & Wildlife Department (team leader)

Dr. William Kilpatrick, University of Vermont

Dr. James Murdoch, University of Vermont

Dr. Peter Smith, Green Mountain College

Christopher Spatz, Cougar Rewilding Foundation/Northeast Wolf Coalition

Species-specific contributions from:

Moose: Cedric Alexander (Vermont Fish & Wildlife Department),

New England Cottontail: John Gobeille (Vermont Fish & Wildlife Department),

Wolf: John Benson, PhD, Diane Bentivegna, Maggie Howell and Adam Katrick
(Northeast Wolf Coalition),

Wolf and Cougar: John Laundre, PhD. (Cougar Rewilding Foundation and Northeast
Wolf Coalition).

Team Charge

The Mammal Team was charged with identifying mammals of greatest conservation need (SGCN), describing the distribution and habitat usage for each SGCN; evaluating threats impacting SGCN and their habitat; identifying priority research needs to improve our ability to conserve these species; and, developing conservation strategies to address priority threats.

Introduction

For a relatively small state, Vermont is characterized by an impressive diversity of habitat types. This diversity is of course a function of the state's variable climate, geological past and rich human history. The nine distinct biophysical regions that comprise Vermont range in character from that of the low, warm and comparatively dry Champlain Valley where farmers make good use of its productive agricultural soils to that of the cold and largely forested Northeastern Highlands where the underlying granite may be the only thing harder than the animals that call this remote part of the state home. This landscape diversity provides the underpinnings for a similarly diverse suite of mammals ranging from boreal species such as the Canada Lynx to those that are better known inhabitants of the south such as Gray Fox and Southern Flying Squirrel. In total, sixty-one mammal species presently exist in Vermont or were here just prior to European settlement. While many of these species are abundant and readily recognizable on the landscape such as deer and Woodchuck, other once common species such as wolf and Mountain Lion are now believed to be extirpated and are clearly in need of a concerted conservation strategy if they are to be restored. In between these extremes, however, exist a host of mammals that are either poorly understood, occur in low numbers and/or in specific habitats, are known to be in decline, or are susceptible to any number of identified threats. The updating of Vermont's Wildlife Action Plan was necessary not only to reevaluate the status of these more vulnerable mammals, but also to reassess our current knowledge and understanding of the challenges

that lie ahead for all of Vermont's wildlife. It's also an opportunity to measure the progress made to date in addressing these challenges.

While all the threats identified in the 2005 Wildlife Action Plan (e.g., habitat conversion alteration and fragmentation, competition, pollution, loss of prey base, impacts of roads) continue to be of concern today, the knowledge and experience gained over the past 10 years has positioned us to better understand the implications of these threats and the actions we must take to address them. Since 2005, for example, the decimation of bat populations throughout the region because of White-nose Syndrome (WNS) provides a stark demonstration of the vulnerability of Vermont's wildlife to the spread of exotic diseases. It highlights the importance of not only implementing measures to avoid the introduction and spread of such pathogens but the value of a solid foundation of baseline population data for these species as well. Similarly, mounting evidence of resident Canada Lynx in the northeast corner of Vermont since 2005 provides clear indication of the critically important role a connected landscape plays in terms of maintaining wildlife diversity as well as of the importance of conserving and managing the unique habitats upon which such specialized species depend.

Although many of Vermont's mammals are extremely adaptable and resilient such as the ubiquitous Raccoon, Red Fox, and Striped Skunk, others are sensitive to any number of threats and will require continued vigilance in our efforts to better understand these threats and to implement appropriate conservation strategies. While some threats may be relatively simple, readily identifiable and/or reasonably preventable, others will continue to challenge us through the future and will require comprehensive, multifaceted solutions.

Some of the mammal SGCN presently appear to be secure such as Moose and Bobcat, but could be at risk in the foreseeable future due to loss of critical habitats or to population declines resulting from a variety of environmental threats such as climate change, interspecific competition and disease. Several species are facing immediate known threats such as with several of the bat species (disease) and American Marten (climate change) and could easily exist only as a memory on the Vermont landscape in the absence of appropriate and timely action. Others are listed primarily because little is known about their population status and/or distribution in Vermont such as with several of the smaller, more secretive species like the voles and shrews. Despite the specific challenges facing these SGCN, the Mammal Team interpreted the selection criteria for listing broadly in the hopes of preventing further declines in any of Vermont's native mammals.

Implementing the 2005 Wildlife Action Plan

Since its adoption in 2005, Vermont's Wildlife Action Plan has guided the implementation of numerous mammal related initiatives aimed at filling critical knowledge gaps and addressing the challenges they face. While most of this work has been focused primarily in Vermont, the research and monitoring needs identified in the plan, as well as the conservation strategies, have been used to justify the state's participation in several regional and even national initiatives.

Perhaps the best example of such is Vermont's response to White-nose Syndrome. Prior to the availability of State Wildlife Grant funds in 2003, Vermont's efforts to monitor bat populations were limited to periodic hibernacula surveys. But since then, the Vermont Fish &

Wildlife Department developed and implemented what has become one of the more significant state bat conservation initiatives in the region. Major elements of this initiative are:

- Collection of a broad array of statewide bat population data on both summer range and winter hibernacula to determine species composition and relative abundance across the state;
- A study of Indiana Bat maternity colony distribution, size, and habitat use throughout the state;
- Detailed risk assessments to determine wind energy facility impacts to Vermont's bat populations; and,
- A technical assistance and outreach program for land managers and conservation organizations to develop and support the management and protection of important Indiana bat habitat.

Then, in 2008, when White-nose Syndrome was identified in the state, the VFWD was thrown into triage mode to conduct disease surveillance, collect diagnostic samples and coordinate at the state, regional and national levels. However, the experience and knowledge gained by VFWD staff from the original SWG-funded work proved instrumental in positioning the state as a leader in the nation's response to this unprecedented challenge. In the past few years our bat conservation efforts have focused on ongoing surveillance, protection of hibernacula and maternity colony sites, and research into the development of alternative hibernaculum.

Similarly, the work conducted here in Vermont on Canada Lynx has also contributed to the conservation/restoration of this species in the region. Guided by the strategies outlined in the 2005 Wildlife Action Plan, the VFWD continues to partner with other states and organizations in the region, for example, to monitor for its presence (2012 to present – Vermont Trappers Association, US Fish and Wildlife Service, US Forest Service, New Hampshire Fish and Game) in recognition of the critically important role such information plays in the implementation of appropriate conservation strategies. Also, the VFWD remains engaged with its regional partners to identify and conserve critical connective corridors facilitating the continued existence of lynx and many other species across the northern Appalachians ([Staying Connected Initiative](http://stayingconnectedinitiative.org/) <http://stayingconnectedinitiative.org/>). Since 2009, Staying Connected Initiative partners have permanently conserved more than 300,000 forested and wetland acres that include wildlife corridors and road crossings essential to healthy wildlife populations across the region.

Since 2005, the VFWD has also undertaken initiatives to study American Marten and Black Bear. The bear research aims to determine the level of impact that wind power facilities have on bear use of adjacent beech stands, but study's findings have significance for the region in terms of critical habitat protection for the species, the permitting requirements of future energy developments and a better understanding of how bears utilize the landscape and maintain genetic diversity across potential anthropogenic barriers.

Ongoing American Marten research and monitoring was spurred by the discovery of individual marten in southern Vermont near a previously deemed failed reintroduction

attempt (1989-1991). Although this work is largely focused on mapping the current distribution and abundance of the species in Vermont, several aspects of this work have regional utility; particularly the testing of a marten occurrence model in collaboration with the New York Department of Environmental Conservation, an assessment of the genetic structure of marten populations across New England, and the evaluation of various measures to minimize the incidental take of marten in traps set for other species. Working in accordance with Vermont's Wildlife Action Plan, the effort to evaluate the status of mammals here in the state and to assess the challenges they face is clearly of regional, and even national, significance.

As noted above, we knew very little about the status and needs of many of our small mammal SGCN, so in 2007 Vermont initiated its [Small Mammal Atlas](#) to determine the distribution, relative abundance, and habitat requirements for all small mammal species. Field surveys yielded the capture of 2,844 small mammals representing 20 different species and distribution maps based on historical and current records were constructed for all small mammal species in Vermont.

In addition to the projects highlighted above, the 2005 Wildlife Action Plan was used to justify and develop several key SWG funded research projects designed to fill critical knowledge gaps and address specific threats, including:

- An evaluation of Bobcat habitat uses and movements to identify Bobcat home range requirements and key habitat and resource needs;
- A Beaver Wetland Conservation Technical Assistance program to help landowners and land managers resolve conflicts with Beaver on their properties while allowing Beaver to continue maintaining the wetlands they create for the benefit of beaver and the many SGCN that rely on these incredibly productive habitats; and
- A detailed GIS analysis and prioritization of more than 4,000 forest blocks, the corridors connecting these blocks, and the locations across the state where wildlife crosses roads in significant numbers.

Selecting Mammal Species of Greatest Conservation Need

Of the sixty-one mammal species native to Vermont, the Mammal Team opted to list 34 as Species of Greatest Conservation Need. Those species that were the most vulnerable (faced with immediate threats to survival or showing a significant population decline) were ranked as high. In addition, species that were extirpated locally but were known to exist in adjacent states were included on the high list. In all, 17 species were designated as having high conservation priority (table 5.8). Eighteen additional species were ranked as medium priority.

The Mammal Team was influenced by the Congressional intent of the State Wildlife Grants program of “keeping common species common” so some of the species in the medium category are those that might be well-distributed and even locally abundant now, but that team members felt were at risk in the foreseeable future due to the increasing potential for mortality, habitat loss/fragmentation or other identifiable threat. Mammals may have been included in the medium category either because little was known about their population

status, distribution, and/or trends in Vermont or they have been considered extirpated in the region (table 5.8).

Table 5.8. Mammal Species of Greatest Conservation Need

High Priority

Water Shrew (*Sorex palustris*)¹
 Long-tailed or Rock Shrew (*Sorex dispar*)¹
 Pygmy Shrew (*Sorex hoyi*)
 Little Brown Bat (*Myotis lucifugus*)¹
 Indiana Bat (*Myotis sodalis*)¹
 Small-footed Bat (*Myotis leibii*)¹
 Northern Long-eared Bat (*Myotis septentrionalis*)¹
 Silver-haired Bat (*Lasionycteris noctivagans*)¹
 Tri-colored Bat (*Perimyotis subflavus*)¹
 Eastern Red Bat (*Lasiurus borealis*)¹
 Hoary Bat (*Lasiurus cinereus*)¹
 New England Cottontail (*Sylvilagus transitionalis*)¹
 Rock Vole (*Microtus chrotorrhinus*)
 Woodland Vole (*Microtus pinetorum*)
 Northern Bog Lemming (*Synaptomys borealis*)
 American Marten (*Martes americana*)¹
 Canada Lynx (*Lynx canadensis*)

Medium Priority

Masked Shrew (*Sorex cinereus*)
 Smoky Shrew (*Sorex fumeus*)¹
 Hairy-tailed Mole (*Parascalops breweri*)¹
 Big Brown Bat (*Eptesicus fuscus*)¹
 Snowshoe Hare (*Lepus americanus*)
 Southern Flying Squirrel (*Glaucomys volans*)
 Northern Flying Squirrel (*Glaucomys sabrinus*)
 Muskrat (*Ondatra zibethicus*)
 Southern Bog Lemming (*Synaptomys cooperi*)¹
 Wolf (*Canis sp?*)
 Gray Fox (*Urocyon cinereoargenteus*)
 Long-tailed Weasel (*Mustela frenata*)
 Northern River Otter (*Lontra canadensis*)
 Bobcat (*Lynx rufus*)¹
 Eastern Mountain Lion (*Puma concolor cougar*)
 Moose (*Alces alces*)

¹ Regional Species of Greatest Conservation Need in the Northeastern United States (Terwilliger, 2013)

Of the 33-species identified as SGCN in Vermont’s 2005 Wildlife Action Plan, only Mink was delisted during this revision process. The removal of Mink from the list (from medium in 2005 to low in 2015) was precipitated by the fact that very little evidence could be found in the scientific literature supporting the primary concern regarding their vulnerability to environmental toxins. Therefore, in consideration of this and of the existing framework for monitoring the species (trapper derived harvest, catch per unit effort and pelt sales data), the widespread and abundant nature of the current population, and the continued listing of other indicator species such as the Northern River Otter, team members concluded the species was secure for the foreseeable future and that processes were well established for detecting and reacting to changes in the species’ vulnerability to environmental toxins.

In its 2015 revision process, the Mammal Team identified specific threats to two additional species and assigned them both as medium priority SGCN. Since 2005, several threats for Moose have emerged having the potential to impact populations at a regional scale. The most significant is the recently documented, unprecedented mortality resulting from acute winter tick infestations across parts of its range. Much work is currently underway to assess the effects of this tick related mortality as well as to evaluate other potential stressors influencing the population health of this species along the southern edge of its range.

Similar to Moose, Snowshoe Hare also exist in Vermont at the southern periphery of its range which alone makes it vulnerable to certain threats such as a changing climate but, unlike Moose, the species is a habitat specialist reliant upon early successional northern forest habitat types. Although hare populations appear secure at present, forest management trends in recent decades have led to declines in early successional habitat throughout the state creating concern for the species’ long-term persistence. To further justify the SGCN status for Snowshoe Hare, team members also acknowledged that the species serves as

primary prey for an array of furbearers including other SGCN species (e.g. Canada Lynx and American Marten) and that its security in the state could be jeopardized by shifting carnivore communities responding to climate change.

In addition to removing and adding species to the SGCN list, the Mammal Team also reassigned two previously identified SGCN from medium to high (Little Brown Bat and Northern Long-eared Bat) and two from high to medium (Southern Bog Lemming and Woodland Vole). The former changes were based entirely on the emergence of WNS in 2008 that resulted in the dramatic decimation of these previously healthy bat populations and the latter on the findings of the SWG-funded [Small Mammal Atlas](#) which indicated populations of these species to be more secure than was previously believed.

Reports on each of the mammal Species of Greatest Conservation Need are in Appendix A5 of this document.

Habitat Needs

The habitat requirements of the mammals listed as SGCN are as diverse as the species themselves and are reflective of Vermont's varied landscape. While some species are habitat generalists (e.g., Moose) simply requiring undeveloped open space, others are specialists, dependent upon very specific habitat conditions to fulfill their life cycles (e.g., Indiana Bat, and American Marten). Collectively, the habitat needs of the SGCN encompass nearly every identifiable habitat type in the state from the most common and ubiquitous northern hardwood forests to the more scarce and unique alpine meadows. Depending on the species in question, even some of the cultural habitat types can play an important role in the conservation of these species. Thus, in general, maintaining healthy populations of Vermont's native mammals requires the conservation of critical habitats, both specific and broad in nature, and the important connecting corridors linking key habitats across the state and region. It also means conserving large blocks of contiguous forestland with corridors, such as riparian buffers, to provide a network of interconnected habitat blocks suitable for the wide-ranging species such as Canada Lynx, and American Marten as well as for the numerous, less travelled species that make use of the many niches such a conserved landscape provides.

Discussion of Threats to Mammal Species of Greatest Conservation Need

The threats most frequently identified to the 34 SGCN mammals were: Conversion of Habitat (28), Habitat Alteration (28), Loss of Prey Base (16), Competition (14), Disease (12), Genetics (12) and Climate Change (11).

We do not understand all the ramifications, but the pattern seen elsewhere in the US and the world is that increased human population density, higher consumption of land and other resources, and a lack of awareness of impacts to other species can lead to devastating losses of native biota (TWS 2004). Vermont is not immune from these sorts of impacts and our landscape is continuing to be developed (DeVillars 1999). For example, Vermont lost an average of 4,800 acres of wildlife habitat each year to development between 1997 and 2007 (Plumb). Habitat alteration and loss is a near universal challenge to many native mammal SGCN.

Occupying only those limited portions of the state where suitable habitat conditions prevail, some species are found in low numbers and/or in isolated patches making their long-term persistence susceptible to direct habitat impacts and reliant upon functioning connective corridors. Similarly, other species, while abundant to either the north or south of Vermont, exist in the state at the furthest extent of their ranges making them vulnerable to a changing climate and the resulting shifts in biotic communities. Despite our successes at conserving large tracts of land in the state in response to these threats, current trends in the forest products industry and applied forest management practices complicate our ability to manage lands for some species particularly those that rely on early successional habitats. Adequately protecting and managing the landscape to meet the needs of Vermont's SGCN through the future is undoubtedly amongst the greatest challenge we face.

In recent years, the emergence of several pathogens such as WNS, chronic wasting disease (CWD), and Winter Tick (also known as Moose Tick) provide more than ample evidence of the severe consequences such agents can inflict upon whole populations of mammals. In a matter of a few years, for example, we witnessed once thriving populations of bats dwindle to alarming numbers leaving at least one species, the Northern Long-eared Bat, subject to the protections of the federal Endangered Species Act and another, the Little Brown Bat, subject to Vermont's endangered species law. In other states, we watched as biologists scrambled to prevent the further spread of CWD and to minimize the disease's impact on local deer herds. These experiences not only demonstrate the potentially grave consequences such diseases and pathogens have for Vermont's wildlife, but also illustrate the importance of stemming the flow of such agents into the state and implementing sound response protocols should new diseases be discovered within our borders.

Pollution was also identified as a potential threat to several species including bats and otter. Industrial pollutants and heavy metals such as PCBs and mercury can build up in the bodies of animals exposed to these toxins (Novak, 1987). In Vermont, for example, trace amounts of mercury were readily detected in the tissue of several otters sampled during annual necropsy work. Although the ramifications are not clear, it is likely that the biomagnification of these toxins negatively affects reproduction and survival. Bats are particularly susceptible to pesticides and other environmental poisons because they store some lipophilic (fat soluble) pesticides in brown adipose fat tissue. These stores are released as bats use their fat reserves during hibernation. Bats can, therefore, be exposed to both chronic and acute poisoning which can result in death. In addition, broad spectrum insecticides can deplete insect diversity and limit the food sources available for several the smaller, insectivorous mammals such as the bats and shrews.

Perhaps the biggest challenge for some species such as bats, wolf, and Mountain Lion is the public's acceptance of and desire to conserve them. Sensational and often inaccurate presentations of public health issues, property damage and potential risk factors involving these species have created an exaggerated fear of these ecologically important animals. The resulting unwarranted negative public perception presents an especially serious threat to the recovery and conservation of these species. For some species, recovery efforts must begin with a public outreach and education effort.

Research and Monitoring Needs and Conservation Strategies

The Mammal Team developed research, monitoring, and conservation strategies for each individual SGCN species. Below is a compilation of the strategies that arose most frequently:

Research and Monitoring

1. Determine the distribution and relative abundance of populations in Vermont.
2. Identify, evaluate and monitor threats.
3. Determine critical habitat needs and connectivity requirements.
4. Determine life history requirements.

Conservation Strategies

1. Develop outreach and education programs that promote the conservation of SGCN and the habitats that they depend on, and increase awareness of the importance of maintaining or restoring these species.
2. Identify the habitat requirements of SGCN and develop strategies for conservation and protection through fee simple purchase, easements, management guidelines, and cooperative agreements with user groups and landowners, etc. (i.e., bat hibernacula and maternity roost trees, Bobcat denning sites, reverting field habitat for New England Cottontail, bear-scarred beech stands, connective corridors, etc.).
3. Initiate an international effort to maintain large blocks of undeveloped forests linked together by habitat corridors to provide a network of interconnected habitats throughout northeastern New England and southeastern Canada.
4. Maintain riparian buffers along streams (see ANR 2005).
5. Maintain and restore habitat connectivity and minimize fragmentation of forest blocks. Identify and prioritize wildlife road crossing locations. Work with the Agency of Transportation and adjacent landowners to reduce wildlife mortality and increase the potential for movement from one side of the road to the other.
6. Work to eliminate pollution that causes acid rain, the deposition of heavy metals, and global climate change.
7. Continue to work cooperatively with landowners, towns, and communities to protect critical habitats and maintain connectivity. Provide *Conserving Vermont's Natural Heritage* to municipal and regional planners (Austin et.al. 2004)
8. Participate in existing regulatory processes (e.g., Act 250, stream alteration permits) to protect and restore critical habitats.

Conclusion

Vermont is at a crossroad. Due primarily to conscious choices made by her citizens in the last 100 years (restoration of White-tailed Deer, Beaver, Wild Turkey, Fisher populations, enactment of Act 250 legislation and wetland regulations, etc.), as well as economic forces that essentially allowed the state to bypass the Industrial Revolution (Bryan, pers com),

Vermont has remained predominantly rural throughout the 20th century. Many mammal species, therefore, are at population levels that are likely higher than they were prior to European settlement (Fisher, Red Fox, White-tailed Deer, Raccoon, Bobcat). Today, however, with Vermont's population growing, development pressures increasing and increased roads and traffic the potential for significant habitat destruction in the next 10 years is high. In addition, global climate change is already influencing the potential residency of some native mammal populations in Vermont (Royar, pers com). The decisions made by Vermonters today will chart the course for the future and influence the long-term viability of our native wildlife populations.

Literature Cited

- (ANR 2005) VT Agency of Natural Resources. 1/20/2005. Riparian Buffer Guidance, and Riparian Buffers and Corridors Technical Papers www.anr.state.vt.us/dec/dec.htm
- Austin, J.M. C. Alexander, E. Marshall, F. Hammond, J. Shippee, E. Thompson. VT League of Cities and Towns. 2004. Conserving Vermont's Natural Heritage. A Guide to Community-Based Planning for the Conservation of Vermont's Fish, Wildlife and Biological Diversity. Vermont Fish & Wildlife Department and Agency of Natural Resources. Waterbury, VT.
www.vtfishandwildlife.com/library.cfm?libbase_=Reports_and_Documents
- Bryan, F. Political Science Department, University of Vermont, Burlington, VT
- Cool, K. L. 1997. Michigan Gray Wolf Recovery and Management Plan for the Michigan Department of Natural Resources, Lansing, Michigan. Prepared by the Michigan Gray Wolf Recovery Team.
- Bat Conservation International. 2013. North American Bat Conservation Partnership Strategic Plan, <http://www.batcon.org/pdfs/BCI%20Strategic%20Plan%202013.pdf>
- Novak, M., J.A. Baker, M.E. Obbard, and B. Malloch. Wild Furbearer Management and Conservation in North America. Ontario Trappers Assoc. 1150pp.
- Northeast Endangered Species and Wildlife Diversity Committee. 1999. Wildlife Species of Regional Conservation Concern in the Northeastern United States. Northeast Wildlife V.54.
- Plumb. 2011 [Environmental Trends Report: The Population Connection](#). Vermonters for Sustainable Population.
- Royar, Kim. Vermont Fish & Wildlife Department.
- Sanders, Chris. 2004. Vermont Species Bat Conservation and Recovery Plan. 55 pp.
- Terwilliger Consulting, Inc. and the Northeast Fish and Wildlife Diversity Technical Committee. 2013. [Taking Action Together: Northeast Regional Synthesis for State Wildlife Action Plans](#). A report submitted to the Northeast Fish and Wildlife Diversity Committee. Locustville, VA.
- The Wildlife Society (TWS). 2004. Position on Economic Growth. Adopted by the TWS Council September 2004.
- Wildlife Species of Regional Conservation Concern in the Northeastern United States. Northeast Wildlife Vol. 54, 1999.
- Wydevan, Adrian P., T.K. Fuller, W. Weber, K. MacDonald. 1998. The potential for wolf recovery in the northeastern United States via dispersal from southeastern Canada. Wildlife Society Bulletin, 26 (4): 776-784.

Conserving Vermont's Plants

Plant Team

Bob Popp, Botanist, Vermont Fish & Wildlife Department
Aaron Marcus, Botanical Information Manager, Vermont Fish & Wildlife Department
Everett Marshall, Heritage Information Manager, Vermont Fish & Wildlife Department
Eric Sorenson, Natural Community Ecologist, Vermont Fish & Wildlife Department
Bob Zaino, State Lands Ecologist, Vermont Fish & Wildlife Department
Charlie Hohn, Natural Community Information Manager, Vermont Fish & Wildlife Dept.

Partners

Flora Advisory Group to the Endangered Species Committee (FLAG)
New England Plant Conservation Program Vermont Task Force
Vermont Forest Parks and Recreation
Vermont Department of Environmental Conservation
US Fish & Wildlife Service
US Forest Service
Natural Resource Conservation Service
Vermont Land Trust
St. Michaels College
University of Vermont
Green Mountain College
Vermont Botanical and Bird Club
New England Wildflower Society
Vermont Center for Ecostudies
NatureServe
Network of Natural Heritage Programs and Conservation Data Centers

Team Charge

The Plant Team identified Species of Greatest Conservation Need (SGCN); described the habitats and natural community types they occur in; evaluated impacts to SGCN and their habitat; identified priority research needs to improve our ability to conserve these species; and developed conservation strategies to address priority problems.

Introduction

Vermont is home to approximately 2,000 species of native plants. This includes 1,200 native vascular plants (seed and flowering plants, ferns and fern allies) and 800 non-vascular plants also known as bryophytes (mosses, liverworts, and hornworts). Many species are quite common (e.g., sugar maple, jewelweed) while others are exceedingly rare (e.g., the Green Mountain Quillwort which is found only in Vermont). For a small, northern state such diversity is remarkable.

Plant diversity is an important part of Vermont's biodiversity and they provide food, habitat and shelter for many animal species. Most plant species occur widely enough on the landscape that human activities do not put them at risk. Rare plants, however, often require specialized habitats and occur in relatively few locations. Some species are rare because availability of their habitats has

always been limited or they are at the edge of their range in Vermont. Others have recently become rare as land uses have affected their traditional habitat. Rare species may require management or protection to ensure their survival in a working or natural landscape.

Vermont's plant diversity is driven, in part, by the different biomes that inhabit the state.

While most of the state is dominated by Northern Hardwood Forest, there are also extensive areas of boreal forest in the higher elevations and the northern part of the state, and oak-hickory forests in the Champlain and Connecticut River Valleys. There are even remnant alpine tundra and coastal beach species.

Plant distribution and diversity is also determined by the following factors: the type of the bedrock; surficial deposits (gravels, sands, silts, and clays) that were laid down during and after the last glaciation; soil chemistry; climate, elevation, topography; and past land use history. Vermont has extensive areas of calcareous (limy) bedrock that is conducive to high plant diversity. While acidic soils or bedrock areas have distinctly less plant species diversity, they still contribute to the overall diversity in the state in that certain species are adapted to these conditions.

Vermont Fish and Wildlife Department's botanists and ecologists met to develop SGCN selection criteria and to cross-walk rare plants with natural community types (Thompson and Sorenson 2005). The Team also benefited by work by field botanists in the last 35 years and the rich documentation in locally and regional herbaria for information going back to the 18th century.

Vascular plants identified as SGCN include gymnosperms (includes conifers), angiosperms (flowering plants), and ferns and allies (seedless vascular plants that disperse by spores). Bryophytes collectively are mosses, hornworts, and liverworts. The emphasis of this report is on vascular plants as there is much greater knowledge of them, in part because they are easier to identify. However, bryophytes can be an important component of many habitats and natural community types and even dominate certain types, such as dwarf shrub bog.

Selecting Plant SGCN

The team selected plants as Species of Greatest Conservation Need from the Vermont Natural Heritage Inventory's (VNHI) list of rare plants. Of the approximately 1,200 vascular and 800 bryophytes native to Vermont, 813 were selected as Species of Greatest Conservation Need, 493 vascular plants and 320 bryophytes.

The 439 vascular plants were further prioritized by means of the New England Plant Conservation Program's [Flora Conservanda](#), which identifies those vascular plants that are rare globally, regionally or are locally disjunct. Those species identified as rare globally and regionally (222) are ranked High Priority and those considered locally rare, 271 species, are ranked Medium Priority. A full list can be found beginning on page 8 of this chapter.

The list of rare VNHI plants include those species that the rarest and often have threats to some or all the populations. These ranks, explained in a following paragraph are based on knowledge of experts, field research over the last 35 years, and more than 125 years of historical records from the literature and specimens documented in regional herbaria. The plant ranks are based on the number of presumed occurrences and the threats to these populations.

A comprehensive review and update of the ranks of vascular plants was completed in the fall of 2014 by the VFWD working with members of the Flora Advisory Group to the Endangered Species Committee and others with knowledge of Vermont's flora. The taxonomy was updated to match the New Flora of Vermont (Gilman, 2015) and Flora Novae Angliae (Haines, 2011).

Dorothy Allard, a member of the Flora Advisory Group and a professional bryologist, ranked all the bryophyte species in the state and maintains a list in conjunction with VNHI that was last updated on April 2, 2011.

The VNHI rarity ranks are defined as: S1— very rare, thought to have 5 or fewer populations with some degree of threat; S2 – rare, thought to have 20 or fewer populations with some degree of threat; and SH – historical, documented from the state, but no currently known populations. VNHI also tracks uncommon species that contain a state rank of S3. These species are generally thought to have 21 to 100 populations. They can be considered watch list species and if their numbers decline substantially they may be considered rare in the future.

Plants and Their Habitat Needs

Vermont's plant SGCN occupy a broad and diverse array of natural habitats and community types found in the state. In some cases, these species take advantage of anthropogenic dominated areas that mimic natural habitats, such as wet agricultural meadows, transmission line rights-of-way, or sandy opening in developed areas.

The New Flora of Vermont (Gilman, 2015) generally describes the habitats for all vascular plants, including SGCN. The habitat for SGCN bryophytes can be found in the literature listed in references.

Vascular plant SGCN were cross-walked to the natural community types where they are commonly found (Appendix I). This crosswalk was only partially completed for bryophyte SGCN because the habitat requirements of some of these species do not align well with natural communities. The natural community approach of conserving rare species conserves representative examples of each natural community type in different physiographic regions of the state. This approach is a more cost-effective way to protect a multitude SGCN, than trying to protect individual species occurrences.

Conserving Vermont's Plant SGCN

The following are highlights of plant conservation work in the state since 2005.

- Monitored hundreds of the rare plant populations state-wide through efforts of VFWD staff, New England Plant Conservation Program Vermont Task Force, New England Plant Conservation volunteers, and our partners.
- Discovered hundreds of new rare plant locations over the past 25 years while conducting natural community inventories, such as the bog-fen and oak-pine, and state lands.
- Added 11 plant species to the state Endangered and Threatened Species list providing additional monitoring and protection.

- Re-discovered at least 14 plant species that had not been observed in the state for at least 25 years (listed as state historic).
- Documented plant SGCN in the Natural Heritage Database by entering field data for thousands of new and updated records of rare and uncommon species occurrences.
- Revised the Vermont Natural Heritage Inventory's rare plant ranking list in 2014 to include new species and varieties that are now recognized due to taxonomic revisions and nomenclatural changes. This is the first major revision of the list since 2009. The project entailed several hundred taxonomic and rank changes and standardized the ranking of subspecies, varieties, and exotic sub-taxa.
- Collected seeds from numerous high and medium priority SGCN for storage at New England Wildflower Society seed banking facility.
- Developed a list of plant species that are threatened by collection within the state and regionally to improve data sharing while protecting rare species. This collective solution was completed because herbarium images are now available online through the Consortium of Northeast Herbaria [portal](#) and the locations of certain rare species are suppressed.
- Helped protect and mitigate impacts to threatened and endangered plant species from development and facilitated scientific research of these species through state endangered species permitting.
- Discovered a plant species new to science in 2013 a quillwort (*Isoetes viridimontana*), currently known only from one pond site in Vermont.
- Managed invasive plant species that were impacting rare plant populations at multiple sites across the state.
- Supported the 2015 publication of the [New Flora of Vermont](#) by Arthur Gilman.

Discussion of Problems Impacting Plant SGCN

The most significant near-term threats to plant SGCN across the state is conversion, alteration, and fragmentation of natural habitats and invasive plants and animals. Other sometime less obvious threats to plant SGCN include pollinator declines; plant diseases; suppression of natural processes; an overabundance of certain animals; air pollution, including acid deposition; and how natural and anthropogenic plant habitats are managed.

Long-term threats are from increasing human population and footprint; and the many issues related to climate change. We can expect that there will be dramatic shifts in plant communities and diversity in the coming decades and centuries from a warming climate. This inevitability is one that we should start planning for, as there is no turning back from much carbon dioxide we have put into the atmosphere.

For decades state plant conservation efforts in Vermont, and nationwide, have been at a significant disadvantage compared with fish and wildlife conservation, due to a dearth of federal funding. Since 1937 states have received federal Wildlife Restoration Program funds (Pittman Robertson) for wildlife conservation (birds and mammals) and since 1950 Sportfish Restoration Program funds (Dingell Johnson). While the State Wildlife Grants program provides funds for fish and wildlife that

don't directly benefit from these other programs, plant conservation is not eligible. The short-lived federal Landowner Incentive Program (2002-2005) provided funding for plant conservation, but was cancelled by Congress in 2006. The only federal funds currently available for plant conservation are through the Endangered Species Act for federally endangered plants. In Vermont only three plant species are eligible, the Jesup's Milk-vetch, Barbed-bristle Bulrush and Small Whorled Pogonia.

Research & Monitoring Needs and Conservation Strategies

The research and monitoring needs most frequently identified by the Plant Team and those would benefit multiple plant SGCN are as follows:

Research & Monitoring Needs

1. Document the distribution, abundance, and viability of populations
2. Monitor species
3. Assess condition and viability of associated habitat or natural community
4. Determine life history, such as seedling establishment, pollination needs, threats from invasives, and seed dispersal strategies.
5. Refine the plant/natural community crosswalk, to facilitate using natural communities in conservation planning to protect assemblages of rare plant species.
6. Follow species distribution changes over time, to document changes related to climate shifts.

Conservation Strategies

1. Implement the Vermont Flora Task Force's annual priority Action List of species to inventory and stewardship priorities in coordination with the New England Plant Conservation Program (NEPCoP). Conduct site visits with VFWD staff, NEPCoP trained volunteers and Task Force members.
2. Offer landowners and land managers technical assistance through inventory and stewardship to support private lands stewardship for plant SGCN. Inform landowners how they can manage their forests for rare plant populations when enrolled in the state's Use Value Appraisal Program (Current Use).
3. Work with landowners and partners to develop conservation easements on lands containing plant SGCN. The Vermont Land Trust and The Nature Conservancy in consultation with the VNHI provide opportunities for protection of rare plants through inclusion in easements and with monitoring of populations.
4. Manage information on plant SGCN in the Natural Heritage Database. Update the rarity ranks of plants based on new information. Include documentation of rare plant abundance, location, viability, habitat description, threats, and landowner contact information and permission. Incorporate rare plant data from VFWD field inventories and various partners, researchers, and citizen science.
5. Support species restoration through habitat and natural community management and restoration to restore or mimic natural processes. Carry on restoration work at the Vermont Army National Guard's Camp Johnson with planned burns of the Pine-Oak-Heath

Sandplain community, in part for the benefit of rare sandplain plants. Where necessary, remove competing vegetation to maintain a necessary seral stage. Partner with utility companies and develop and implement annual work plans for habitats with plant SGCN on utility properties and rights-of-way.

6. Manage rare plant populations that are threatened by invasive species. Update the Vermont Flora Task Force Action list with species that have management or stewardship needs. Coordinate with partners who provide stewardship services or manage the land.
7. Share the data with partners. Also, provide generalized information to public through the Agency's [Natural Resources Atlas](#) and the Vermont Center for Geographic information to be used in project and conservation planning.
8. Facilitate species restoration through the banking of live plant material by collecting seeds or cuttings that may be used to restore or enhance existing populations threatened with extirpation. NEPCoP in conjunction with the Vermont Task Force prioritizes which plants need to have live material collected. The collection effort is to be coordinated with annual species inventory and stewardship priorities. Plan for species restoration through assisted migration and provide guidance and advice to independent efforts to restore or introduce new populations of SGCN.
9. Educate the public through outreach about Vermont's plants, particularly SGCN. Tell natural history stories about the habitat in which they occur and include their interaction with animal species.
10. Develop conservation strategies for suites of plant species at the natural community formation level or similar higher-level grouping by generalized habitat type.
11. Determine the pollination needs of plant SGCN. Conserve and manage habitat of pollinators that are important to plant SGCN.
12. Develop a long-term funding plan for the VFWD's Plant Program to support conservation of our state's plant diversity. Currently the VFWD's funding for plant inventory, monitoring and stewardship is almost solely from the Department's state funds. Explore funding options from a variety of state, federal and private sources. Create a plant funding committee.
13. Coordinate with state agencies on management, monitoring, and information sharing. Incorporate plant SGCN into the long-range management of Agency of Natural Resources lands. Review annual work plans for potential conflict and where necessary conduct site visits to avoid or mitigate the impacts. Coordinate and share information with ANR's Lakes and Ponds' aquatic plant survey. Coordinate with Vermont Agency of Transportation and Department of Buildings and General Services on SGCN that occur in lands that they manage or own.
14. Share species data with NatureServe, which serves as an umbrella organization for the international network of natural heritage programs. NatureServe creates global datasets with range-wide maps for each species with a corresponding species rarity rank. They also reconcile taxonomic differences between different jurisdictions.
15. Work with our federal, municipal and NGO partners to prioritize management practices and stewardship needs and enhance information sharing. The U.S. Forest Service currently

monitors numerous populations of rare plants on their lands. The U.S. Fish & Wildlife Service monitors rare species on its Wildlife Refuges. Also, VFWD monitors federally listed species through the U.S. Fish and Wildlife Service's Cooperative Endangered Species Conservation Fund (Section 6 of the Endangered Species Act).

16. Develop management plans that include rare plants for landowners with Natural Resource Conservation Service. Coordinate with the Vermont Land Trust who monitors populations of rare plants that are incorporated into their easements. Work with municipal governments who provide protection to rare species and monitor populations.
17. Coordinate and prioritize research with universities and colleges to encourage a focus on high priority conservation needs.
18. Identify, prioritize and maintain existing contiguous forest blocks and associated linkages that allow for movement in response to climate change with consideration to the physical landscape, especially with the makeup of the bedrock. That is, certain plants require a calcareous (limy) bedrock type while others thrive on more acidic conditions.
19. Participate in regulatory processes, such as Acts 250 and Section 248, the Vermont Wetlands Rule, and the endangered species law to protect rare, threatened and endangered plants. Some of these laws only afford protection to those legally listed as threatened or endangered in Vermont. There has been an effort to add protection of habitat to the endangered species law, which would increase the viability of populations in or near developments.
20. List additional species, as warranted, as threatened or endangered to provide additional protection for vulnerable species.

Plant Species of Greatest Conservation Need

MP=Medium Priority SGCN; HP=High Priority SGCN

Conifers and relatives

Creeping Juniper (*Juniperus horizontalis*) HP

Ferns and relatives

Aleutian Maidenhair-fern (*Adiantum aleuticum*) HP

Green Mountain Maidenhair-fern (*Adiantum viridimontanum*) HP

Mountain Spleenwort (*Asplenium montanum*) HP

Green Spleenwort (*Asplenium viride*) HP

Upswept Moonwort (*Botrychium ascendens*) HP

Prairie Moonwort (*Botrychium campestre*) HP

Common Moonwort (*Botrychium lunaria*) HP

Mingan Moonwort (*Botrychium minganense*) HP

Blunt-lobed Grapefern (*Botrychium oneidense*) HP

Rugulose Grape-fern (*Botrychium rugulosum*) HP

Spatulate Moonwort (*Botrychium spathulatum*) MP

Shade Moonwort (*Botrychium tenebrosum*) HP

Weft Fern (*Crepidomanes intricatum*) HP

Laurentian Bladder Fern (*Cystopteris laurentiana*) HP

Northern Ground-cedar (*Diphasiastrum complanatum*) MP

Ground-fir (*Diphasiastrum sabinifolium*) MP

Male Fern (*Dryopteris filix-mas*) HP

Fragrant Fern (*Dryopteris fragrans*) MP

Marsh Horsetail (*Equisetum palustre*) MP

Northern Oak Fern (*Gymnocarpium jessoense* ssp. *parvulum*) HP

Mountain Fir Clubmoss (*Huperzia appressa*) HP

Fir Clubmoss (*Huperzia selago*) HP

Engelmann's Quillwort (*Isoetes engelmannii*) MP

Lake Quillwort (*Isoetes lacustris*) MP

River-bank Quillwort (*Isoetes riparia*) MP

Tuckerman's Quillwort (*Isoetes tuckermanii*) MP

Green Mountain Quillwort (*Isoetes viridimontana*) MP

Northern Adder's-tongue (*Ophioglossum pusillum*) HP

Massachusetts Fern (*Parathelypteris simulata*) MP

Stiff Clubmoss (*Spinulum canadense*) MP

Alpine Woodsia (*Woodsia alpina*) HP

Smooth Woodsia (*Woodsia glabella*) HP

Virginia Chain-fern (*Woodwardia virginica*) MP

Flowering Plants

Slender Copperleaf (*Acalypha gracilens*) MP

Yellow Giant Hyssop (*Agastache nepetoides*) HP

Purple Giant Hyssop (*Agastache scrophulariifolia*) HP

Boreal Bentgrass (*Agrostis mertensii*) MP

Wild Garlic (*Allium canadense* var. *canadense*) MP

Siberian Chives (*Allium schoenoprasum*) MP

Burdick's Wild Leek (*Allium tricoccum* var. *burdickii*) HP

Water Hemp (*Amaranthus tuberculatus*) HP

Small Round-leaved Orchid (*Amerorchis rotundifolia*) HP

Champlain Beach Grass (*Ammophila breviligulata* ssp. *champlainensis*) HP

Long-headed Thimbleweed (*Anemone cylindrica*) MP

Early Thimbleweed (*Anemone multifida* var. *multifida*) HP

Alpine Sweet-grass (*Anthoxanthum monticola* ssp. *monticola*) HP

White Camas (*Anticlea glauca*) HP

Putty-root (*Aplectrum hyemale*) HP

Lyre-leaved Rock-cress (*Arabidopsis lyrata*) MP

Dwarf Mistletoe (*Arceuthobium pusillum*) MP

Arethusa (*Arethusa bulbosa*) HP

Green Dragon (*Arisaema dracontium*) MP

Spiked Grass (*Aristida longespica* var. *geniculata*) MP

Boreal Wormwood (*Artemisia campestris* ssp. *canadensis*) HP

Beach Wormwood (*Artemisia campestris* ssp. *caudata*) HP

Blunt-leaved Milkweed (*Asclepias amplexicaulis*) MP

Butterfly-weed (*Asclepias tuberosa*) MP

Whorled Milkweed (*Asclepias verticillata*) MP

Canada Milk-vetch (*Astragalus canadensis* var. *canadensis*) HP

Jesup's Milk-vetch (*Astragalus robbinsii* var. *jesupii*) HP

Blake's Milk-vetch (*Astragalus robbinsii* var. *minor*) HP

Smooth False-foxglove (*Aureolaria flava* var. *flava*) MP

Feverweed (*Aureolaria pedicularia*) MP

Downy False-foxglove (*Aureolaria virginica*) MP

Yellow Bartonian (*Bartonia virginica*) MP

Dwarf Birch (*Betula minor*) HP

Small Bidens (*Bidens discoidea*) MP

Downy Wood-mint (*Blephilia ciliata*) HP

Smooth Wood-mint (*Blephilia hirsuta* var. *glabrata*) HP

Hairy Wood-mint (*Blephilia hirsuta* var. *hirsuta*) HP

Strawberry Blite (*Blitum capitatum*) MP

Drummond's Rock-cress (*Boechera stricta*) MP

Green Rock-cress (*Borodinia missouriensis*) HP

Northern Rock-cress (*Braya humilis*) HP

Wild Chess (*Bromus kalmii*) MP

Langsdorf's Bluejoint (*Calamagrostis canadensis* var. *langsdorfii*) HP

Short-flower Bluejoint (*Calamagrostis canadensis* var. *macouniana*) HP

Pickering's Reed-grass (*Calamagrostis pickeringii*) MP

Bentgrass (*Calamagrostis stricta* ssp. *inexpansa*) HP

Northern Water-starwort (*Callitriche hermaphrodita*) HP

Large Water-starwort (*Callitriche heterophylla*) MP

Fairy Slipper (*Calypso bulbosa* var. *americana*) HP

Twin-flower Hedge Bindweed (*Calystegia silvatica* ssp. *fraterniflora*) HP

Low Bindweed (*Calystegia spithamea* ssp. *spithamea*) HP

Spring Cress (*Cardamine bulbosa*) MP

Cuckoo Flower (*Cardamine dentata*) HP

Small-flower bittercress (*Cardamine parviflora* var. *arenicola*) MP

Emmon's Sedge (*Carex albicans* var. *emmonsii*) MP

Foxtail Sedge (*Carex alopecoidea*) HP

Contracted Sedge (*Carex arcta*) MP

Awned Sedge (*Carex atherodes*) HP

Atlantic Sedge (*Carex atlantica* var. *atlantica*) MP

Howe's Sedge (*Carex atlantica* var. *capillacea*) MP

Blackish Sedge (*Carex atratiformis*) HP

Bicknell's Sedge (*Carex bicknellii*) HP

Bigelow's Sedge (*Carex bigelowii* ssp. *bigelowii*) HP

Bush's Sedge (*Carex bushii*) HP

Buxbaum's Sedge (*Carex buxbaumii*) MP

Capillary Sedge (*Carex capillaris* ssp. *capillaris*) HP
 Creeping Sedge (*Carex chordorrhiza*) HP
 Clustered Sedge (*Carex cumulata*) MP
 Davis' Sedge (*Carex davisii*) HP
 Urchin Sedge (*Carex echinodes*) MP
 Bog Sedge (*Carex exilis*) MP
 Bronze Sedge (*Carex foenea*) MP
 Garber's Sedge (*Carex garberi*) HP
 Flaccid Sedge (*Carex glaucoidea*) HP
 Slender Sedge (*Carex gracilescens*) HP
 Pale Sedge (*Carex livida*) HP
 False Hop Sedge (*Carex lupuliformis*) MP
 Fernald's Sedge (*Carex merritt-fernaldii*) MP
 Michaux Sedge (*Carex michauxiana*) MP
 Troublesome Sedge (*Carex molesta*) HP
 Nerveless Muehlenberg Sedge (*Carex muehlenbergii* var. *enervis*) HP
 Muehlenberg's Sedge (*Carex muehlenbergii* var. *muehlenbergii*) MP
 Few-fruited Sedge (*Carex oligocarpa*) HP
 Richardson's Sedge (*Carex richardsonii*) HP
 Schweinitz's Sedge (*Carex schweinitzii*) HP
 Scirpus-like Sedge (*Carex scirpoidea* ssp. *scirpoidea*) HP
 Hay Sedge (*Carex siccata*) MP
 Dioecious Sedge (*Carex sterilis*) HP
 Thin-flowered Sedge (*Carex tenuiflora*) HP
 Sheathed Sedge (*Carex vaginata*) HP
 Wiegand's Sedge (*Carex wiegandii*) MP
 Willdenow's Sedge (*Carex willdenowii*) HP
 Pignut Hickory (*Carya glabra*) MP
 Pale Painted-cup (*Castilleja septentrionalis*) HP
 Prairie Redroot (*Ceanothus herbaceus*) HP
 Nodding Chickweed (*Cerastium nutans* ssp. *nutans*) HP
 Wild Sensitive Plant (*Chamaecrista nictitans* var. *nictitans*) MP
 Bush's Goosefoot (*Chenopodium berlandieri* var. *bushianum*) HP
 Fogg's Goosefoot (*Chenopodium foggii*) HP
 Field Thistle (*Cirsium discolor*) MP
 Virginia Spring Beauty (*Claytonia virginica*) HP
 Small-flowered Collinsia (*Collinsia parviflora*) HP
 Canada Horse-balm (*Collinsonia canadensis*) MP
 Autumn Coral-root (*Corallorhiza odontorhiza* var. *odontorhiza*) MP
 Flowering Dogwood (*Cornus florida*) MP
 Golden Corydalis (*Corydalis aurea*) HP
 Pygmyweed (*Crassula aquatica*) MP
 Biltmore Hawthorn (*Crataegus biltmoreana*) MP
 Stinking Hawthorn (*Crataegus boyntonii*) HP
 Brainerd's Hawthorn (*Crataegus brainerdii*) HP
 Precocious Hawthorn (*Crataegus chrysocarpa* var. *praecox*) HP
 Dodge's Hawthorn (*Crataegus dodgei*) HP
 Faxon's Hawthorn (*Crataegus faxonii*) HP
 Zigzag Hawthorn (*Crataegus irrasa* var. *irrasa*) MP
 Kennedy's Hawthorn (*Crataegus kennedyi*) HP
 Western Long-spine Hawthorn (*Crataegus macracantha* var. *occidentalis*) HP
 Oakes' Hawthorn (*Crataegus oakesiana*) HP
 Pea Hawthorn (*Crataegus pisifera*) HP
 Poplar Hawthorn (*Crataegus populnea*) HP
 Fleshy Hawthorn (*Crataegus succulenta* var. *succulenta*) HP
 Plains Frostweed (*Crocyanthemum bicknellii*) MP
 Rattlebox (*Crotalaria sagittalis*) MP
 Buttonbush Dodder (*Cuscuta cephalanthi*) MP
 Broad-flower Dodder (*Cuscuta gronovii* var. *latiflora*) HP
 Northern Wild Comfrey (*Cynoglossum virginianum* var. *boreale*) HP
 Low Cyperus (*Cyperus diandrus*) MP
 Houghton's Cyperus (*Cyperus houghtonii*) HP
 Ram's Head Lady's-slipper (*Cypripedium arietinum*) HP
 Makasin's Yellow Lady's-slipper (*Cypripedium parviflorum* var. *makasin*) HP
 Tansy Mustard (*Descurainia pinnata* var. *brachycarpa*) HP
 Large-bracted Tick-trefoil (*Desmodium cuspidatum*) HP
 Perplexed Tick-trefoil (*Desmodium perplexum*) MP
 Prostrate Tick-trefoil (*Desmodium rotundifolium*) MP
 Diapensia (*Diapensia lapponica* ssp. *lapponica*) HP
 Few-flowered Panic-grass (*Dichantherium oligosanthes*) MP
 Few-flowered Panc-grass (*Dichantherium oligosanthes* ssp. *scribnerianum*) MP
 Spherical Panic-grass (*Dichantherium sphaerocarpon*) MP
 Rock Draba (*Draba arabisans*) HP
 Hoary Draba (*Draba cana*) HP
 Smooth Draba (*Draba glabella*) HP
 American Dragonhead (*Dracocephalum parviflorum*) HP
 American Waterwort (*Elatine americana*) HP
 Small Waterwort (*Elatine minima*) MP
 Tidal Spikerush (*Eleocharis aestuum*) HP
 Flat-stem Spikerush (*Eleocharis compressa* var. *compressa*) HP
 Wright's Spikerush (*Eleocharis diandra*) HP
 Olive Spikerush (*Eleocharis flavescens* var. *olivacea*) MP
 Slender Spikerush (*Eleocharis nitida*) HP
 Few-flowered Spikerush (*Eleocharis quinqueflora*) MP
 Robbins Spikerush (*Eleocharis robbinsii*) MP
 MacGregor's Wild Rye (*Elymus macgregorii*) HP
 Southern Wild-rye (*Elymus villosus* var. *arkansanus*) HP
 Hairy Wild-rye (*Elymus villosus* var. *villosus*) MP
 Black Crowberry (*Empetrum nigrum*) HP
 Marsh Willow-herb (*Epilobium palustre*) MP
 Hyssop-leaved Fleabane (*Erigeron hyssopifolius*) HP
 Provancher's Dwarf Fleabane (*Erigeron philadelphicus* var. *provancheri*) HP
 Slender Cotton-grass (*Eriophorum gracile*) MP
 Rough Cotton-grass (*Eriophorum tenellum*) MP
 Sessile-leaved Boneset (*Eupatorium sessilifolium*) MP
 Nodding Spurge (*Euphorbia nutans*) HP
 Rough-leaved Aster (*Eurybia radula*) MP
 Shortleaf Fescue (*Festuca brachyphylla* ssp. *brachyphylla*) HP
 Autumn Fimbristylis (*Fimbristylis autumnalis*) MP
 False Mermaid-weed (*Floerkea proserpinacoides*) HP
 Limestone Swamp Bedstraw (*Galium brevipes*) HP
 Bog Bedstraw (*Galium labradoricum*) HP
 Hairy Bedstraw (*Galium pilosum*) MP
 Fringe-top Closed Gentian (*Gentiana andrewsii*) HP
 Felwort (*Gentianella amarella*) HP
 Stiff Gentian (*Gentianella quinquefolia*) MP
 Spring Avens (*Geum vernum*) HP

Sharp Manna-grass (*Glyceria acutiflora*) MP
 Eastern Manna-grass (*Glyceria septentrionalis*) MP
 Giant Rattlesnake-plantain (*Goodyera oblongifolia*) HP
 Nodding Stickseed (*Hackelia deflexa* ssp. *americana*) HP
 Spurred Gentian (*Halenia deflexa*) MP
 Alpine Sweet-broom (*Hedysarum alpinum*) MP
 Sneezeweed (*Helenium autumnale*) MP
 Harsh Sunflower (*Helianthus strumosus*) MP
 Umbellate Hawkweed (*Hieracium umbellatum*) HP
 Mare's-tail (*Hippuris vulgaris*) MP
 Longleaf Bluet (*Houstonia longifolia*) MP
 Beach Heather (*Hudsonia tomentosa*) HP
 Green Violet (*Hybanthus concolor*) HP
 Golden-seal (*Hydrastis canadensis*) HP
 Broad-leaved Waterleaf (*Hydrophyllum canadense*) HP
 Great St. John's-wort (*Hypericum ascyron*) MP
 Orange-grass St. John's-wort (*Hypericum gentianoides*) MP
 Red Pine-sap (*Hypopitys lanuginosa*) HP
 Smooth Holly (*Ilex laevigata*) MP
 Large Whorled Pogonia (*Isotria verticillata*) MP
 Tapering Rush (*Juncus acuminatus*) MP
 Alpine Rush (*Juncus alpinoarticulatus*) MP
 Greater Poverty Rush (*Juncus antheratus*) MP
 Greene's Rush (*Juncus greenei*) MP
 Soldier Rush (*Juncus militaris*) MP
 Secund Rush (*Juncus secundus*) MP
 Woodland Rush (*Juncus subcaudatus*) MP
 Torrey's Rush (*Juncus torreyi*) HP
 Highland Rush (*Juncus trifidus*) HP
 Vasey Rush (*Juncus vaseyi*) HP
 Hairy Lettuce (*Lactuca hirsuta*) HP
 Beach Pea (*Lathyrus japonicus* var. *maritimus*) MP
 Pale Vetchling (*Lathyrus ochroleucus*) HP
 Marsh Vetchling (*Lathyrus palustris*) MP
 Lesser Pinweed (*Lechea minor*) HP
 Hairy Pinweed (*Lechea mucronata*) MP
 Minute Duckweed (*Lemna perpusilla*) HP
 Turion Duckweed (*Lemna turionifera*) HP
 Violet Bush-clover (*Lespedeza frutescens*) MP
 Hairy Bush-clover (*Lespedeza hirta* ssp. *hirta*) MP
 Trailing Bush-clover (*Lespedeza procumbens*) MP
 Large White-flowered Ground-cherry (*Leucophysalis grandiflora*) HP
 Stiff Yellow Flax (*Linum medium*) HP
 Grooved Yellowflax (*Linum sulcatum* var. *sulcatum*) HP
 Lily-leaved Twayblade (*Liparis liliifolia*) HP
 Tulip Tree (*Liriodendron tulipifera*) MP
 American Shore-grass (*Littorella americana*) MP
 Great Blue Lobelia (*Lobelia siphilitica* var. *siphilitica*) HP
 Hairy Spike Lobelia (*Lobelia spicata* var. *hirtella*) HP
 Hairy Honeysuckle (*Lonicera hirsuta*) HP
 Swamp Fly-honeysuckle (*Lonicera oblongifolia*) MP
 Many-fruited False-loosestrife (*Ludwigia polycarpa*) HP
 Wild Lupine (*Lupinus perennis*) HP
 Spiked Wood-rush (*Luzula spicata*) HP
 Virginia Bugleweed (*Lycopus virginicus*) MP
 Lance-leaved Loosestrife (*Lysimachia hybrida*) MP
 Winged-loosestrife (*Lythrum alatum* ssp. *alatum*) HP
 White Adder's-mouth (*Malaxis monophyllos* var. *brachypoda*) HP
 Green Adder's-mouth (*Malaxis unifolia*) MP
 Mountain Sandwort (*Minuartia groenlandica*) HP
 Marcescent Sandwort (*Minuartia marcescens*) HP
 Marble Sandwort (*Minuartia rubella*) HP
 Large-leaved Sandwort (*Moehringia macrophylla*) HP
 Dotted Horsemint (*Monarda punctata*) HP
 Red Mulberry (*Morus rubra*) HP
 Schreber's Muhly (*Muhlenbergia schreberi*) MP
 Sprout Muhly (*Muhlenbergia sobolifera*) MP
 Woodland Muhly (*Muhlenbergia sylvatica*) MP
 Smaller Forget-me-not (*Myosotis laxa*) MP
 Spring Forget-me-not (*Myosotis verna*) MP
 Low Water-milfoil (*Myriophyllum humile*) MP
 Boott's Rattlesnake-root (*Nabalus boottii*) HP
 Glaucous Rattlesnake-root (*Nabalus recemosus*) MP
 Slender Naiad (*Najas gracillima*) MP
 Guadalupe Naiad (*Najas guadalupensis*) MP
 Auricled Twayblade (*Neottia auriculata*) HP
 Southern Twayblade (*Neottia bifolia*) HP
 Dwarf Water-lily (*Nymphaea leibergii*) HP
 Bog Aster (*Oclemena nemoralis*) MP
 Nodding Evening-primrose (*Oenothera nutans*) HP
 Woodland Cudweed (*Omalotheca sylvatica*) MP
 Blunt-fruited Sweet-cicely (*Osmorhiza depauperata*) HP
 Violet Wood-sorrel (*Oxalis violacea*) HP
 American Ginseng (*Panax quinquefolius*) HP
 Stiff Witch-grass (*Panicum flexile*) HP
 Philadelphia Panic-grass (*Panicum philadelphicum* var. *philadelphicum*) MP
 Smooth Forked Chickweed (*Paronychia canadensis*) HP
 Hairy Forked Chickweed (*Paronychia fastigiata*) HP
 Slender Paspalum (*Paspalum setaceum* var. *muhlenbergii*) MP
 Pale Beardtongue (*Penstemon pallidus*) MP
 Carey's Smartweed (*Persicaria careyi*) MP
 Sweet Coltsfoot (*Petasites frigidus* var. *palmatus*) MP
 American Reed (*Phragmites australis* ssp. *americanus*) HP
 Strawberry-tomato (*Physalis grisea*) MP
 Obedient Plant (*Physostegia virginiana*) MP
 Black-seeded Clearweed (*Pilea fontana*) HP
 Butterwort (*Pinguicula vulgaris*) HP
 Jack Pine (*Pinus banksiana*) MP
 Slender Mountain-rice (*Piptatheropsis pungens*) MP
 White-fringed Orchid (*Platanthera blephariglottis* var. *blephariglottis*) MP
 Tubercled Orchid (*Platanthera flava* var. *herbiola*) MP
 Hooker's Orchid (*Platanthera hookeri*) MP
 Large Roundleaf Orchid (*Platanthera macrophylla*) MP
 Roundleaf Orchid (*Platanthera orbiculata*) MP
 Glaucous Bluegrass (*Poa glauca* ssp. *glauca*) HP
 Inland Bluegrass (*Poa interior*) HP
 Wavy Bluegrass (*Poa laxa* ssp. *fernaldiana*) HP
 Agassiz Kentucky Bluegrass (*Poa pratensis* ssp. *agassizensis*) HP

Lax Bluegrass (*Poa saltuensis* ssp. *languida*) HP
 May-apple (*Podophyllum peltatum*) HP
 Riverweed (*Podostemum ceratophyllum*) MP
 Eastern Jacob's Ladder (*Polemonium vanbruntiae*) HP
 Racemed Milkwort (*Polygala polygama*) MP
 Ambiguous Milkwort (*Polygala verticillata* var. *ambigua*) HP
 Whorled Milkwort (*Polygala verticillata* var. *verticillata*) MP
 Common Solomon's-seal (*Polygonatum biflorum*) MP
 Douglas' Knotweed (*Polygonum douglasii*) MP
 Erect Knotweed (*Polygonum erectum*) HP
 Slender Knotweed (*Polygonum tenue*) MP
 White-flowered Leafcup (*Polymnia canadensis*) HP
 Snail-seed Pondweed (*Potamogeton bicupulatus*) MP
 Tuckerman's Pondweed (*Potamogeton confervoides*) MP
 Hill's Pondweed (*Potamogeton hillii*) HP
 Vasey's Pondweed (*Potamogeton vaseyi*) MP
 Ogden's Pondweed (*Potamogeton x ogdenii*) HP
 Bird's-eye Primrose (*Primula mistassinica*) HP
 Marsh Mermaid-weed (*Proserpinaca palustris*) MP
 Wild Plum (*Prunus americana*) MP
 Low Sand Cherry (*Prunus pumila* var. *depressa*) MP
 Susquehanna Sand Cherry (*Prunus susquehanae*) MP
 Pinedrops (*Pterospora andromedea*) HP
 Hoary Mountain-mint (*Pycnanthemum incanum*) MP
 Blunt Mountain-mint (*Pycnanthemum muticum*) MP
 Bog Wintergreen (*Pyrola asarifolia* ssp. *asarifolia*) MP
 Lesser Pyrola (*Pyrola minor*) HP
 Scarlet Oak (*Quercus coccinea*) MP
 Scrub Oak (*Quercus ilicifolia*) MP
 Dwarf Chinquapin Oak (*Quercus prinoides*) MP
 Allegheny Crowfoot (*Ranunculus allegheniensis*) MP
 Bristly Buttercup (*Ranunculus hispidus* var. *hispidus*) HP
 Virginia Meadow-beauty (*Rhexia virginica*) MP
 Roseroot (*Rhodiola rosea*) HP
 Great Laurel (*Rhododendron maximum*) HP
 Pinxter-flower (*Rhododendron periclymenoides*) MP
 Capillary Beak-rush (*Rhynchospora capillacea*) HP
 Lake-cress (*Rorippa aquatica*) HP
 Needle-spine Rose (*Rosa acicularis* ssp. *sayi*) HP
 Shining Rose (*Rosa nitida*) MP
 Black-eyed Susan (*Rudbeckia hirta* var. *hirta*) HP
 Western Dock (*Rumex occidentalis*) HP
 Small Pearlwort (*Sagina decumbens*) HP
 Peach-leaf Willow (*Salix amygdaloides*) HP
 Bog Willow (*Salix pedicellaris*) MP
 Satiny Willow (*Salix pellita*) MP
 Tea-leaved Willow (*Salix planifolia*) HP
 Bearberry Willow (*Salix uva-ursi*) HP
 Water Pimpernel (*Samolus parviflorus*) MP
 Canada Burnet (*Sanguisorba canadensis*) MP
 Short-styled Snakeroot (*Sanicula canadensis* var. *canadensis*) HP
 Long-styled Snakeroot (*Sanicula canadensis* var. *grandis*) HP
 Yellow Mountain Saxifrage (*Saxifraga aizoides*) HP
 Purple Mountain Saxifrage (*Saxifraga oppositifolia* var. *oppositifolia*) HP
 White Mountain Saxifrage (*Saxifraga paniculata*) HP
 Pod-grass (*Scheuchzeria palustris*) MP
 Smith's Bulrush (*Schoenoplectiella smithii* var. *smithii*) MP
 Slender Bulrush (*Schoenoplectus heterochaetus*) HP
 Torrey's Bulrush (*Schoenoplectus torreyi*) MP
 Barbed-bristle Bulrush (*Scirpus ancistrochaetus*) HP
 Georgia Bulrush (*Scirpus georgianus*) HP
 Whip Nutsedge (*Scleria triglomerata*) HP
 Shale Barren Skullcap (*Scutellaria parvula* var. *missouriensis*) HP
 Small Skullcap (*Scutellaria parvula* var. *parvula*) HP
 Wild Senna (*Senna hebecarpa*) HP
 Starry Catchfly (*Silene stellata*) HP
 Eastern Blue-eyed-grass (*Sisyrinchium atlanticum*) MP
 Cutler's Goldenrod (*Solidago leiocarpa*) HP
 Sweet Goldenrod (*Solidago odora* ssp. *odora*) MP
 Snowy Aster (*Solidago ptarmicoides*) HP
 River-ledge Goldenrod (*Solidago racemosa*) HP
 Squarrose Goldenrod (*Solidago squarrosa*) MP
 Elm-leaved Goldenrod (*Solidago ulmifolia*) MP
 Branching Bur-reed (*Sparganium androcladum*) HP
 Lesser Bur-reed (*Sparganium natans*) MP
 Shiny Wedgegrass (*Sphenopholis nitida*) HP
 Blunt Sphenopholis (*Sphenopholis obtusata*) HP
 Case's Ladies'-tresses (*Spiranthes casei* var. *casei*) HP
 Rough Dropseed (*Sporobolus compositus*) MP
 Small Dropseed (*Sporobolus neglectus*) HP
 Rough Hedge-nettle (*Stachys hispida*) HP
 Marsh Woundwort (*Stachys pilosa* var. *pilosa*) MP
 Trailing Stitchwort (*Stellaria alsine*) MP
 Slender Pondweed (*Stuckenia filiformis*) HP
 Hybrid Thread-leaved Pondweed (*Stuckenia x fennica*) MP
 Ontario Aster (*Symphyotrichum ontarionis*) HP
 Inland Lance-leaf Aster (*Symphyotrichum lanceolatum* var. *interior*) HP
 Crooked-stem Aster (*Symphyotrichum prenanthoides*) HP
 Small White Aster (*Symphyotrichum racemosum*) MP
 Tradescant Aster (*Symphyotrichum tradescantii*) MP
 White-arrow Aster (*Symphyotrichum urophyllum*) HP
 Yellow Pimpernel (*Taenidia integerrima*) HP
 Rue-anemone (*Thalictrum thalictroides*) MP
 Border Meadow-rue (*Thalictrum venulosum*) HP
 Sticky False-asphodel (*Triantha glutinosa*) MP
 Deer-hair Sedge (*Trichophorum cespitosum*) MP
 Bashful Bulrush (*Trichophorum planifolium*) MP
 False Pennyroyal (*Trichostema brachiatum*) HP
 Common Arrow-grass (*Triglochin maritima*) HP
 Three-bird Orchid (*Triphora trianthophora*) MP
 Hairy-glumed False Oats (*Trisetum spicatum* var. *pilosiglume*) MP
 Cork Elm (*Ulmus thomasii*) HP
 Inflated Bladderwort (*Utricularia radiata*) MP
 Northeastern Bladderwort (*Utricularia resupinata*) MP
 Perfoliate Bellwort (*Uvularia perfoliata*) MP
 Boreal Blueberry (*Vaccinium boreale*) MP
 Dwarf Bilberry (*Vaccinium caespitosum*) MP
 Deerberry (*Vaccinium stamineum*) MP
 Alpine Bilberry (*Vaccinium uliginosum*) HP
 Mountain Cranberry (*Vaccinium vitis-idaea*) MP

Marsh Valerian (*Valeriana uliginosa*) HP
 Narrow-leaved Vervain (*Verbena simplex*) HP
 Water-speedwell (*Veronica catenata*) HP
 Culver's-root (*Veronicastrum virginicum*) HP
 Squashberry (*Viburnum edule*) MP
 Lance-leaved Violet (*Viola lanceolata* ssp. *lanceolata*) MP
 Early Blue Violet (*Viola palmata*) MP
 Lobed Violet (*Viola subsinuata*) HP
 Eight-flowered Fescue (*Vulpia octoflora* var. *tenella*) HP
 Northern Yellow-eyed-grass (*Xyris montana*) MP
 Horned Pondweed (*Zannichellia palustris*) MP

Hornworts

A Hornwort (*Anthoceros agrestis*) MP

Liverworts

A Liverwort (*Anastrophyllum helleranum*) MP
 A Liverwort (*Anastrophyllum michauxii*) MP
 A Liverwort (*Anastrophyllum saxicola*) MP
 A Liverwort (*Aneura maxima*) MP
 A Liverwort (*Athalamia hyalina*) MP
 A Liverwort (*Barbilophozia hatcheri*) MP
 A Liverwort (*Barbilophozia kunzeana*) MP
 A Liverwort (*Calypogeia suecica*) MP
 A Liverwort (*Cephalozia connivens*) MP
 A Liverwort (*Cephaloziella arctica*) MP
 A Liverwort (*Cephaloziella elachista*) MP
 A Liverwort (*Cephaloziella massalongi*) MP
 A Liverwort (*Cephaloziella rubella* var. *elegans*) MP
 A Liverwort (*Cephaloziella rubella* var. *rubella*) MP
 A Liverwort (*Cephaloziella stellulifera*) MP
 A Liverwort (*Chandonanthus setiformis*) MP
 A Liverwort (*Chiloscyphus pallescens* var. *fragilis*) MP
 A Liverwort (*Chiloscyphus polyanthos*) MP
 A Liverwort (*Fossombronina foveolata*) MP
 A Liverwort (*Frullania brittoniae*) MP
 A Liverwort (*Frullania inflata*) MP
 A Liverwort (*Frullania oakesiana*) MP
 A Liverwort (*Frullania plana*) MP
 A Liverwort (*Frullania selwyniana*) MP
 A Liverwort (*Gymnocolea inflata*) MP
 A Liverwort (*Gymnomitrium concinnatum*) MP
 A Liverwort (*Harpanthus drummondii*) MP
 A Liverwort (*Harpanthus scutatus*) MP
 A Liverwort (*Jubula pennsylvanica*) MP
 A Liverwort (*Jungermannia caespiticia*) MP
 A Liverwort (*Jungermannia evansii*) MP
 A Liverwort (*Jungermannia pumila*) MP
 A Liverwort (*Jungermannia sphaerocarpa*) MP
 A Liverwort (*Kurzia pauciflora*) MP
 A Liverwort (*Lejeunea lamacerina* ssp. *gemminata*) MP
 A Liverwort (*Lophocolea cuspidata* var. *alata*) MP
 A Liverwort (*Lophocolea minor*) MP
 A Liverwort (*Lophozia alpestris*) MP
 A Liverwort (*Lophozia ascendens*) MP
 A Liverwort (*Lophozia badensis* var. *badensis*) MP
 A Liverwort (*Lophozia collaris*) MP

A Liverwort (*Lophozia excisa*) MP
 A Liverwort (*Lophozia heterocolpos* var. *heterocolpos*) MP
 A Liverwort (*Lophozia laxa*) MP
 A Liverwort (*Lophozia sudetica*) MP
 A Liverwort (*Marchantia alpestris*) MP
 A Liverwort (*Marchantia aquatica*) MP
 A Liverwort (*Marsupella sphacelata*) MP
 A Liverwort (*Metzgeria crassipilis*) MP
 A Liverwort (*Mylia taylorii*) MP
 A Liverwort (*Nardia scalaris* ssp. *scalaris*) MP
 A Liverwort (*Pellia megaspora*) MP
 A Liverwort (*Plagiochila austinii*) MP
 A Liverwort (*Radula obconica*) MP
 A Liverwort (*Riccia huebeneriana* ssp. *sullivantii*) MP
 A Liverwort (*Scapania cuspiduligera* var. *cuspiduligera*) MP
 A Liverwort (*Scapania gymnostomophila*) MP
 A Liverwort (*Scapania irrigua* ssp. *irrigua*) MP
 A Liverwort (*Scapania lingulata* var. *lingulata*) MP
 A Liverwort (*Scapania mucronata* ssp. *mucronata*) MP
 A Liverwort (*Scapania paludicola* var. *paludicola*) MP
 A Liverwort (*Scapania umbrosa*) MP
 A Liverwort (*Tritomaria exsectiformis* ssp. *exsectiformis*) MP
 A Liverwort (*Tritomaria quinquedentata* var. *quinquedentata*) MP

Mosses

A Moss (*Amphidium lapponicum*) MP
 A Moss (*Amphidium mougeotii*) MP
 Knochle Moss (*Anacamptodon splachnoides*) MP
 A Moss (*Andreaea rothii*) MP
 A Moss (*Anomobryum filiforme*) MP
 A Moss (*Aphanorhagma serratum*) MP
 Arctoa Moss (*Arctoa fulvella*) MP
 A Moss (*Atrichum tenellum*) MP
 A Moss (*Aulacomnium androgynum*) MP
 A Moss (*Barbula indica* var. *indica*) MP
 A Moss (*Brachythecium acutum*) MP
 A Moss (*Brachythecium campestre*) MP
 A Moss (*Brachythecium digastrum*) MP
 A Moss (*Brachythecium erythrorrhizon*) MP
 Falcate Feather Moss (*Brachythecium falcatum*) MP
 A Moss (*Brachythecium turgidum*) MP
 A Moss (*Bryoandersonia illecebra*) MP
 A Moss (*Bryohaplocladium microphyllum*) MP
 A Moss (*Bryum pallens*) MP
 A Moss (*Bryum pallescens*) MP
 A Moss (*Bryum weigeli*) MP
 A Moss (*Bucklandiella microcarpa*) MP
 Elf Cap Moss (*Buxbaumia aphylla*) MP
 Hump-backed Elves (*Buxbaumia minakatae*) MP
 A Moss (*Calliargon obtusifolium*) MP
 A Moss (*Calliargon trifarium*) MP
 A Moss (*Campylium polygamum*) MP
 A Moss (*Campylium radicale*) MP
 A Moss (*Cinclidium stygium*) MP
 A Moss (*Cirriphyllum piliferum*) MP
 A Tree Moss (*Climacium kindbergii*) MP
 A Moss (*Codiophorus aduncoides*) MP

A Moss (*Codriophorus fascicularis*) MP
 A Moss (*Conardia compacta*) MP
 A Moss (*Cynodontium alpestre*) MP
 A Moss (*Cynodontium strumiferum*) MP
 A Moss (*Cynodontium tenellum*) MP
 A Moss (*Cyрто-hypnum pygmaeum*) MP
 A Moss (*Cyrtomnium hymenophylloides*) MP
 A Moss (*Dichelyma capillaceum*) MP
 A Moss (*Dichelyma falcatum*) MP
 A Moss (*Dichelyma pallescens*) MP
 A Moss (*Dicranella cerviculata*) MP
 A Moss (*Dicranella schreberiana*) MP
 A Moss (*Dicranodontium denudatum*) MP
 A Moss (*Dicranum muehlenbeckii*) MP
 Ontario Dicranum Moss (*Dicranum ontariense*) MP
 A Moss (*Didymodon fallax*) MP
 A Moss (*Didymodon ferrugineus*) MP
 A Moss (*Didymodon rigidulus* var. *rigidulus*) MP
 A Moss (*Didymodon tophaceus*) MP
 A Moss (*Distichium capillaceum*) MP
 A Moss (*Ditrichum flexicaule*) MP
 A Moss (*Ditrichum tortuloides*) MP
 A Moss (*Drepanocladus longifolius*) MP
 A Moss (*Drummondia prorepens*) MP
 A Moss (*Entodon brevisetus*) MP
 An Emerald Dewdrops Moss (*Ephemerum cohaerens*) MP
 An Emerald Dewdrops Moss (*Ephemerum spinulosum*) MP
 A Moss (*Eurhynchium hians*) MP
 Small Pocket Moss (*Fissidens exilis*) MP
 A Moss (*Fissidens subbasilaris*) MP
 A Moss (*Fontinalis hypnoides* var. *duriaei*) MP
 A Moss (*Forsstroemia trichomitria*) MP
 A Moss (*Grimmia hartmanii*) MP
 A Moss (*Grimmia longirostris*) MP
 A Moss (*Grimmia muehlenbeckii*) MP
 A Moss (*Grimmia pilifera*) MP
 A Moss (*Grimmia trichophylla*) MP
 A Moss (*Grimmia unicolor*) MP
 A Moss (*Hamatocaulis vernicosus*) MP
 Rock Thread Moss (*Haplohymenium triste*) MP
 Blandow's Helodium Moss (*Helodium blandowii* var. *elodioides*) MP
 A Moss (*Helodium paludosum*) MP
 A Moss (*Heterocladium dimorphum*) MP
 Closter's Brook-hypnum (*Hygrohypnum closteri*) MP
 A Moss (*Hygrohypnum duriusculum*) MP
 A Moss (*Hygrohypnum luridum*) MP
 A Moss (*Hygrohypnum micans*) MP
 A Moss (*Hygrohypnum molle*) MP
 A Moss (*Hygrohypnum montanum*) MP
 A Moss (*Hygrohypnum subeugyrium*) MP
 A Moss (*Hylocomiastrum pyrenaicum*) MP
 A Moss (*Hyophila involuta*) MP
 A Moss (*Hypnum fauriei*) MP
 A Moss (*Hypnum plicatulum*) MP
 A Moss (*Hypnum recurvatum*) MP
 A Moss (*Isopterygiopsis pulchella*) MP
 A Moss (*Leptodictyum humile*) MP
 A Moss (*Leskea gracilescens*) MP
 A Moss (*Leskea obscura*) MP
 A Moss (*Leucodon brachypus* var. *brachypus*) MP
 A Moss (*Limprichtia cossonii*) MP
 A Moss (*Limprichtia revolvens*) MP
 Lindberg's Maple-moss (*Lindbergia brachyptera*) MP
 A Moss (*Loeskeobryum brevirostre*) MP
 Triangular Swan Moss (*Meesia triquetra*) MP
 A Moss (*Microbryum davallianum*) MP
 Micromitrium Moss (*Micromitrium tenerum*) MP
 A Moss (*Mnium thomsonii*) MP
 A Moss (*Myurella julacea*) MP
 A Neckera Moss (*Neckera besseri*) MP
 A Moss (*Neckera complanata*) MP
 A Moss (*Niphotrichum canescens* ssp. *canescens*) MP
 A Moss (*Orthotrichum ohioense*) MP
 A Moss (*Orthotrichum pumilum*) MP
 A Moss (*Paludella squarrosa*) MP
 A Moss (*Palustriella commutata*) MP
 A Moss (*Philonotis marchica*) MP
 A Moss (*Philonotis muehlenbergii*) MP
 A Moss (*Physcomitrium immersum*) MP
 A Moss (*Plagiobryum zieri*) HP
 A Moss (*Plagiomnium drummondii*) MP
 A Moss (*Plagiomnium rostratum*) MP
 A Moss (*Platydictya jungermannii*) MP
 A Moss (*Platydictya subtilis*) MP
 A Moss (*Pogonatum dentatum*) MP
 Andalusian Pohlia Moss (*Pohlia andalusica*) MP
 A Moss (*Pohlia annotina*) MP
 A Moss (*Pohlia bulbifera*) MP
 A Moss (*Pohlia drummondii*) MP
 A Moss (*Pohlia elongata* var. *elongata*) MP
 A Moss (*Pohlia prolifera*) MP
 A Moss (*Pohlia sphagnicola*) MP
 A Moss (*Pohlia sphagnicola* Bruch & Schimp. Broth.) MP
 A Moss (*Polytrichastrum formosum*) MP
 A Moss (*Polytrichastrum longisetum*) MP
 A Moss (*Ptychomitrium incurvum*) MP
 Felt Round Moss (*Rhizomnium pseudopunctatum*) MP
 Blue Dew (*Saelania glaucescens*) MP
 A Moss (*Schistidium liliputanum*) MP
 A Moss (*Schistidium papillosum*) MP
 A Moss (*Schistidium viride*) MP
 Luminous Moss (*Schistostega pennata*) MP
 A Moss (*Schwetschkeopsis fabronia*) MP
 A Moss (*Scorpidium scorpioides*) MP
 A Moss (*Sematophyllum adnatum*) MP
 A Moss (*Sematophyllum demissum*) MP
 A Moss (*Sematophyllum marylandicum*) MP
 A Moss (*Sphagnum andersonianum*) MP
 A Moss (*Sphagnum angermanicum*) MP
 A Moss (*Sphagnum atlanticum*) MP
 A Moss (*Sphagnum austinii*) MP
 Bartlett's Peatmoss (*Sphagnum bartlettianum*) MP

A Moss (*Sphagnum brevifolium*) MP
Low Peatmoss (*Sphagnum compactum*) MP
A Moss (*Sphagnum contortum*) MP
Henry's Peatmoss (*Sphagnum henryense*) MP
A Moss (*Sphagnum inundatum*) MP
A Moss (*Sphagnum isoviitae*) MP
Lindberg's Sphagnum (*Sphagnum lindbergii*) MP
A Moss (*Sphagnum mcqueenii*) MP
A Moss (*Sphagnum platyphyllum*) MP
Beautiful Peatmoss (*Sphagnum pulchrum*) MP
Five-ranked Bogmoss (*Sphagnum quinquefarium*) MP
Recurved Peatmoss (*Sphagnum recurvum*) MP
A Moss (*Sphagnum riparium*) MP
A Peatmoss (*Sphagnum subfulvum*) MP
Delicate Peatmoss (*Sphagnum tenellum*) MP
Giant Peatmoss (*Sphagnum torreyanum*) MP
A Moss (*Sphagnum viride*) MP
A Moss (*Syntrichia ruralis*) MP
A Moss (*Thelia asprella*) MP
A Moss (*Timmia megapolitana* ssp. *megapolitana*) MP
A Moss (*Tomenthypnum falcifolium*) MP
A Moss (*Tortella fragilis*) MP
A Moss (*Tortella inclinata* var. *densa*) MP
A Moss (*Tortella inclinata* var. *inclinata*) MP
A Moss (*Tortula mucronifolia*) MP
A Moss (*Tortula obtusifolia*) MP
A Moss (*Trichostomum crispulum*) MP
A Moss (*Weissia muhlenbergiana*) MP

Literature Cited

- Vermont Fish and Wildlife. No date. Vermont Natural Heritage Inventory Database.
- Vermont Dept. Forest, Parks and Recreation. 2105. Voluntary Harvesting Guidelines for Landowners in Vermont
- Natureserve. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, VA. U.S.A. Available <http://explorer.natureserve.org>
- Thompson E.H. and E.R. Sorenson. 2005. Wetland, Woodland, Wildland: A Guide to the Natural Communities of Vermont Fish and Wildlife and The Nature Conservancy.

Vascular plants

- Brumback, W.E. and J. Gerke. 2013. Flora Conservanda: New England 2012. The New England Plant Conservation Program (NEPCoP) List of Plants in Need of Conservation. *Rhodora*: October 2013, Vol. 115, No. 964, pp. 313-408.
- New England Wild Flower Society. 2015. State of the Plants: Challenges and Opportunities for Conserving. New England's Native Flora.
- Gilman, A.V. 2015. New Flora of Vermont. The New York Botanical Garden Press.
- Haines, A. *Flora Novae Angliae*. 2011. A Manual for the Identification of Native and Naturalized Higher Vascular Plants of New England. New England Wildflower Society.
- Seymour, F.C. 1969. The flora of Vermont; a manual for the identification of ferns and flowering plants growing without cultivation in Vermont. Vermont Agricultural Experiment Station Bulletin.
- Flora of North America Editorial Committee, eds. 1993+. *Flora of North America North of Mexico*. 16+ vols. New York and Oxford. Vol. 1, 1993; vol. 2, 1993; vol. 3, 1997; vol. 4, 2003; vol. 5, 2005; vol. 7, 2010; vol. 8, 2009; vol. 19, 2006; vol. 20, 2006; vol. 21, 2006; vol. 22, 2000; vol. 23, 2002; vol. 24, 2007; vol. 25, 2003; vol. 26, 2002; vol. 9, 2014

Bryophytes

- Flora of North America Editorial Committee, eds. 2007 and 2014. *Flora of North America North of Mexico*. New York and Oxford. vol. 27, 2007; vol. 28, 2014
- Flora of North America Editorial Committee, eds., Vol. 29. In prep. *Flora of North America Editorial Committee*, Oxford University Press.
- Anderson, Lewis E., Howard A. Crum and William R. Buck. 1990. List of the Mosses of North America North of Mexico. *The Bryologist*. Vol. 93, No. 4 pp. 448-499
- Stotler, R. and B. Crandall-Stotler. 1977. A checklist of the liverworts and hornworts of North America. *The Bryologist* 80:405–428.
- Stotler, R. E. and B. Crandall-Stotler. 2005b. A revised classification of the Anthocerotophyta and a checklist of the hornworts of North America, North of Mexico. *The Bryologist* 108:16–26.