

The New Hampshire Dragonfly Survey:

A Final Report



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Executive Summary

The New Hampshire Dragonfly Survey (NHDS) was a five year effort (2007-2011) to document the distributions of all species of dragonflies and damselflies (insect order Odonata) in the state. The NHDS was a partnership among the New Hampshire Department of Fish and Game (Nongame and Endangered Wildlife Program), New Hampshire Audubon, and the University of New Hampshire Cooperative Extension. In addition to documenting distribution, the NHDS had a specific focus on collecting data on species of potential conservation concern and their habitats. Core funding was provided through State Wildlife Grants to the New Hampshire Fish and Game Department.

The project relied extensively on the volunteer efforts of citizen scientists, who were trained at one of 12 workshops held during the first four years of the project. Of approximately 240 such trainees, 60 went on to contribute data to the project, with significant data submitted by another 35 observers with prior experience. Roughly 50 people, including both trained and experienced observers, collected smaller amounts of incidental data. Over the five years, volunteers contributed a minimum of 6400 hours and 27,000 miles. Separate funding facilitated targeted surveys along the Merrimack and Lamprey rivers and at eight of New Hampshire Audubon's wildlife sanctuaries.

A total of 18,248 vouchered records were submitted to the NHDS. These represent 157 of the 164 species ever reported for the state, and included records of four species not previously known to occur in New Hampshire. Data were collected at roughly 1200 sites located in 221 of the 259 towns in the state, with approximately 130 sites receiving a minimum of three visits spaced evenly through the odonate flight season.

In combination with an extensive database (11,700+ records) that pre-dates the NHDS, this effort has yielded the first comprehensive statewide survey coverage for an entire insect order. These data can serve as a valuable baseline against which future changes in odonate distribution can be measured, and a repeat survey is recommended in 20-30 years. In the short term, NHDS will inform conservation rankings both at the state and regional scales, and identify areas where continued survey work may increase knowledge of rare or potentially sensitive species. A preliminary assessment suggests that many species of potential conservation concern are more common and/or widespread than previously believed.

Table of Contents:

Executive Summary	previous
Background	1
Methods	2
Volunteer training and retention	2
Survey protocols	3
Special projects	4
Results	5
Volunteer effort	5
Figure 1. NHDS site locations	5
Figure 2. Timing of NHDS site visits	6
Distributions of Damselflies and Dragonflies in New Hampshire	6
Table 1. New or undetected species during NHDS	7
Table 2. State and county species records	8
Figure 3. Town species richness through time	13
Figure 4. Species distributions by town	14
Figure 5. Seasonal variation in species richness	34
Table 3. Species flight periods	35
Discussion	40
Conservation	40
Survey Coverage	40
Outreach	42
Acknowledgements	43
References	44
Appendices	45

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Front cover photographs, clockwise from top left:

Dragonhunter (*Hagenius brevistylus*) – photo by Pamela Hunt

Crimson-ringed Whiteface (*Leucorrhinia glacialis*) on pitcher plant – photo by Pamela Hunt

emerging Ebony Jewelwing (*Calopteryx maculata*) – photo by Pamela Hunt

Great Brook, New London – photo by Pamela Hunt

young dragonfly enthusiast – photo by Francine Geissler

Center photo by Pamela Hunt

Background

The insect order Odonata comprises the dragonflies and damselflies, and contains roughly 6000 species worldwide and 450 in North America north of Mexico. Dragonflies and damselflies spend most of their lives (usually 1-3 years) as aquatic larvae, occupying all freshwater habitats from small streams and seeps to large lakes and rivers, with a handful of species also found in brackish or saline environments. Larvae undergo an incomplete metamorphosis into flying adults that live for up to two months. At all life stages, odonates are exclusively predatory, preying on other arthropods or small aquatic vertebrates.

People have been documenting the Odonata of New Hampshire since at least the mid-19th century, when the relative ease of accessing northern habitats in the White Mountains drew entomologists from as far away as Philadelphia. Data from roughly a century of collecting was compiled in the early 1970s in the first published overview of the distributions of dragonflies and damselflies in the state (White and Morse 1973). This publication listed 134 species as occurring in the state, 23 of these noted for the first time by the authors. In the decades that followed, casual collecting continued, but it was not until the late 1990s that the first field guides made it easier for amateur insect enthusiasts to identify Odonata. The result was a surge of new records from 2000-2006, and another 17 new species added to the state list. By the mid-2000s, a total of 160 species had been recorded in New Hampshire. A database of all available records through the end of 2006 (Hunt, unpubl. data) contains over 11,700 records dating back into the 19th century. These data are included in species maps and informed presentation of flight period data (see Results).

The NH Wildlife Action Plan identified invertebrates as a group in need of more detailed information that could inform conservation. Given the increased knowledge of Odonata distributions in the state, but their absence from most considerations of conservation priorities (the exception being the State-Endangered Ringed Boghaunter, *Williamsonia lintneri*), NH Audubon and NH Fish and Game, with funding from State Wildlife Grants, undertook a conservation assessment of the order for New Hampshire (Hunt 2006). This assessment compiled data from NH and neighboring states in an attempt to determine which species and/or habitats should be considered conservation priorities. The result was a list of 56 species in need of more detailed data, plus a general conclusion that odonates of large rivers, peatlands, and high-elevation lakes might be more sensitive to environmental change than those of other habitats.

The New Hampshire Dragonfly Survey (NHDS) is a direct outgrowth of the recommendations made by Hunt (2006). Also funded by State Wildlife Grants, its three principal goals were:

- 1) Obtain better information on the distribution and abundance of Odonata of potential conservation concern in New Hampshire,
- 2) Collect data from poorly surveyed parts of the state, and
- 3) Increase public awareness of dragonfly diversity and conservation.

Elsewhere in the northeastern United States, similar surveys have been completed in Maine (Brunelle and deMaynadier 2005), New York (White et al. 2006), Rhode Island (V. Brown, unpubl. data), and West Virginia (Olcott 2011). Materials and results from the Maine and New York surveys informed protocol development for the NHDS.

Methods

Survey protocols

The NHDS protocol (available at: <https://sites.google.com/site/nhdragonflysurvey/>) included three major components: 1) site selection, 2) survey timing, and 3) vouchering. Sites during the pilot year in 2007, and to a lesser extent in 2008-11, were chosen to represent high quality wetlands as determined by the NH Wildlife Action Plan habitat maps. As the survey progressed, however, it became clear that volunteers were more likely to visit sites close to and/or familiar to them rather than those pre-selected by the NHDS coordinator. Searches for specific species (e.g., *Williamsonia lintneri*, northern peatland specialists) were facilitated by examination of aerial photographs. Although the NHDS was never designed to be a systematic survey (such as a Breeding Bird Atlas), the focus on town species richness (see above) served to encourage volunteers to visit undersurveyed areas, resulting in generally similar coverage across most of the state.

Because most species of odonates are only active for a period of a few weeks, a full sample of the diversity at a site requires multiple visits spaced throughout the flight season. The NHDS followed the lead of the NY survey by setting three primary survey periods: 1) late May to mid-June, 2) mid-to-late July, and 3) mid-August to early September. A site was considered to meet minimum survey criteria if it was surveyed somewhat thoroughly at least once during each period. Exceptions were made for northern and high elevation sites where there is very little odonate activity early in the season. Special visits were needed for early flying species like *Williamsonia lintneri*. Irrespective of date, all surveys ideally occurred on warm calm days so as to maximize odonate activity.

To ensure minimal identification error, the NHDS created four vouchering categories, depending on the rarity and/or ease of identification of each species. These were also based on the vouchering categories established for the NY survey, although modified for New Hampshire. From least to most restrictive, the NHDS vouchering categories were as follows: 1) visual detection only, 2) catch and release, 3) photograph, and 4) specimen. These categories are hierarchical, in that a species requiring a photograph can also be vouchered using a specimen, etc. The NHDS database was designed to “flag” records that did not meet minimum vouchering criteria. This flag could be overridden by the NHDS coordinator in cases where 1) an observer had demonstrated proficiency with the species, 2) the species had already been vouchered from the site (or sometimes town – generally for common species), or 3) the species’ distribution in the state was well enough understood that vouchering criteria were relaxed. This last rule primarily applied to very common and widespread species for which specimens were technically required, but which were acceptable with capture by a competent observer later in the survey. All records not meeting vouchering criteria and not overridden are retained in the database but

considered “unverified.” Similarly, the NHDS coordinator could “invalidate” a record that technically met minimum vouchering criteria but which for other reasons was viewed as suspect. Most examples included species well out of their expected range when reported by inexperienced observers. In all cases, invalidated records remained in the NHDS database but were not used to generate species maps or flight periods.

Adult specimens submitted to the NHDS coordinator will be stored at the University of New Hampshire (UNH) insect collection. Some specimens collected by visiting experts were kept for private collections or transferred to the collector’s respective institution. Exuviae submitted to the NHDS coordinator are currently stored in the coordinator’s private collection, pending decisions about which (primarily the more noteworthy ones) should be transferred to UNH. Voucher photos are stored at NH Audubon and have been provided on a disk to NHFG.

Volunteer training and retention

The NHDS was primarily a volunteer citizen science project. Volunteers were trained at a total of 12 workshops conducted in May and June of 2007-2010 (Appendix A). Workshops were located throughout the state in an effort to reach as many interested participants as possible. They consisted of an indoor component including an overview of odonate biology, background on the Odonata of NH, and outline of the NHDS goals and methods (Appendix B). In 2007 there were separate field trips conducted on a different day from the indoor workshop, but in 2008-2010 these were replaced with an afternoon field experience on the same day (weather permitting).

Beginning in the summer of 2007, the NHDS produced a quarterly newsletter (*The Dragonhunter*) that was distributed to all volunteers. *The Dragonhunter* served to inform NHDS participants of recent findings, alert them to upcoming trips, and suggest species or habitats to focus on in the near future. By the time the NHDS was completed, a total of 15 issues had been produced. At the start of the NHDS, project materials such as the volunteer manual, data sheets, and newsletter were stored on the NH Fish and Game website. In 2010, a separate website (<https://sites.google.com/site/nhdragonflysurvey/>) was created to facilitate rapid updates by NHDS staff and a designated volunteer. Resources uploaded to the website included updated species-richness maps, town lists, and identification aids. There was also a calendar where information on field trips was posted.

Early in the NHDS, an email list was created to facilitate communication with volunteers. This list was used by the project coordinator to announce field trips, share findings from the field, and provide additional aids for identification as needed. In 2009, this list was converted to a Google Group (<http://groups.google.com/group/nh-dragonfly-survey?hl=en>), thus allowing any member to post to the group as a whole. The result was a much more involved discussion among volunteers, in addition to a more efficient way to manage the entire email list. As of December 2011, the NHDS Google Group had 138 members. In 2009, one of the NHDS volunteers created a “Flickr” page to facilitate photo sharing (<http://www.flickr.com/groups/nhdragonfly/>). This page proved extremely useful in helping volunteers with identification, while at the same time served as something of a forum for sharing stories and dragonfly encounters. It was even instrumental in recruiting a handful of new volunteers and collecting data from photographers that were not active in the NHDS.

From the very beginning of the NHDS, it was recognized that there would be uneven coverage of the state. The majority of New Hampshire's population lives in the southern third of the state, and even there it is biased towards the southeast. One of the reasons workshops were held in the north and west was to maximize recruitment of volunteers from those regions. Regional survey effort was measured indirectly by the number of species recorded in each town, as updated at the end of each season. For many volunteers, elevating one or more of their local towns to a higher species category was a major motivator for continued data collection. Using current town species totals, the NHDS coordinator identified "focal areas" that were generally lacking data, and encouraged volunteers to visit those parts of the state. While this approach met with some success in the south, both new volunteer recruitment and existing volunteer effort were still low in the north by the end of 2009. In 2010 and 2011, the gaps in northern coverage were addressed by several 1-3 day trips to areas in the White Mountains and Coos County, with the specific goal of collecting data from pre-selected towns. As a result of all these efforts, the NHDS ended with relatively uniform coverage statewide. Although there was still a higher proportion of poorly-covered towns in the north and west, coverage was far better than it would have been in the absence of focal areas and dedicated field trips.

Special projects

In addition to the volunteer efforts, there were four additional sources of extensive data for the NHDS. All these contributed significant amounts of data from areas which otherwise would have remained undersurveyed. The four supplementary data sources are as follows (see also Appendix C):

- In 2007 and 2008, the NHDS coordinator surveyed eight NH Audubon properties using the NHDS protocol, with staff time funded by specific sanctuary endowments. All sanctuaries received 3-5 visits, with one (Ponemah Bog in Amherst) visited weekly in 2007 as part of another study on odonate survey methodology (Bried et al. 2011).
- Work on the Merrimack River in 2007 was conducted in partnership with the Amoskeag Fishways Learning Center (Manchester, NH). Funding was provided by a grant to the Fishways from Minnesota Public Television's "SciGirls" program, an effort to expose young girls to science-based inquiry.
- The Northeast Regional Meeting of the Dragonfly Society of the Americas was held in western Rockingham County July 30-August 2, 2009. This resulted in a number of significant records, although very few of the participants were considered NHDS volunteers.
- Work on the Lamprey River in 2011 was primarily conducted as part of a senior thesis project by Morgan Dube, a student at the University of NH, and funded through an Undergraduate Research Award. Staff time on this project was funded by the Lamprey River Advisory Committee through a grant from the National Park Service's Wild and Scenic Rivers Program.

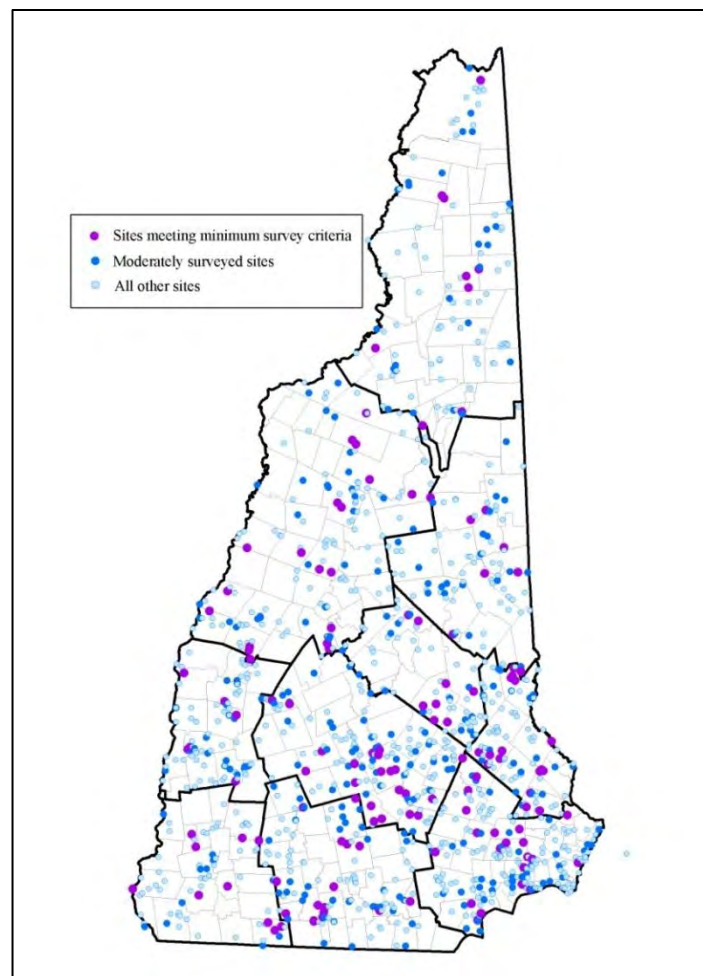
Results

Volunteer effort

Of the 242 people trained during the NHDS, approximately 60 went on to collect and submit data following the NHDS protocol. An additional 35 volunteers who had not attended a workshop also made significant contributions (see also Special Projects, above), and incidental records were obtained from roughly 50 observers. Although not all volunteers submitted records of their hours and miles for the project, over 6400 hours and 27,000 miles were contributed towards the NHDS during 2007-2011 (Appendix D). Using rates of \$20.93/hour and \$0.49/mile, this volunteer contribution was worth a minimum of \$148,000 as in-kind match. Note that hours and miles were not accurately recorded in 2007, so the actual number is certainly significantly higher.

In total, 18,748 odonata records (18,248 after vouchering) were submitted from approximately 1200 sites in 221 towns across New Hampshire (Fig. 1, Appendix D). Of these sites, approximately 130 received at least three visits spaced according to the protocol, although not all such visits were thorough surveys. Visits occurred between mid-April and early December, with over 50% during July and August (Fig 2.)

Figure 1. Distribution of sites surveyed during the NHDS. “Moderately surveyed” sites include those that were well-surveyed in only two of the three time periods recommended by the NHDS protocol.



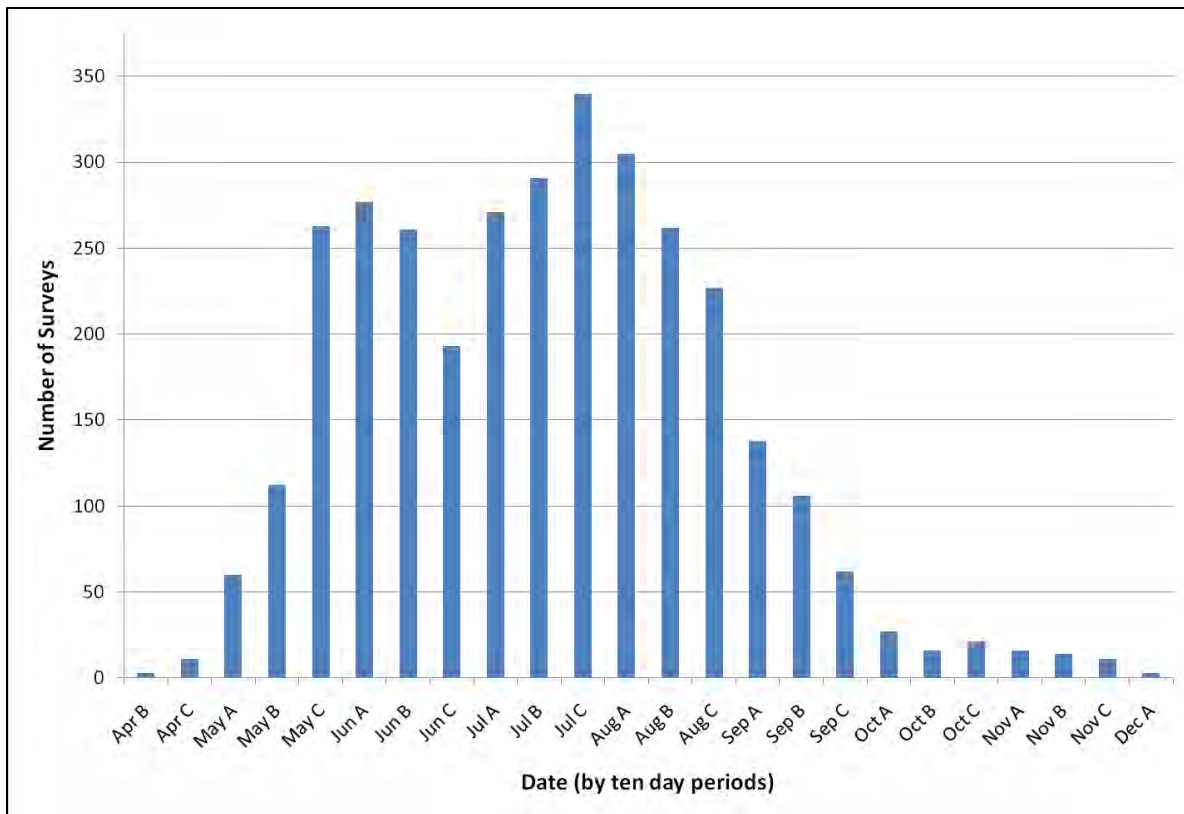


Figure 2. Distribution of survey visits by date over the course of the NHDS (2007-2011). Dates are grouped into 10-day periods: E.g., May A = 1-10 May, May B = 11-20 May, and May C = 21-31 May.

Distributions of Damselflies and Dragonflies in New Hampshire

During the NHDS, 157 species of Odonata were reported from New Hampshire. Four of these were reported for the state for the first time, bringing the state species total to 164 species. Seven species previously known to occur in the state were not reported. Considering all available data, it is likely that at least two, and possibly five, of these 164 species were reported in error, and a conservative interpretation would indicate that 159 species have been proven to occur in New Hampshire. For the purposes of this report, *Tachopteryx thoreyi* and *Sympetrum rubicundulum* are no longer considered to occur in New Hampshire, and the state list stands at 162 species. Three additional species (*Aeshna sitchensis*, *Ophiogomphus colubrinus*, and *Epitheca semiaquea*) are retained on the state list pending verification of older records or discovery of new ones. An overview of new, non-detected, and questionable species is provided in Table 1.

Through a combination of NHDS and pre-NHDS data, records of Odonata have been obtained for all ten counties and all but 15 of the 259 towns and unincorporated areas of the state. During the period from 2007 to 2011, data were collected in 221 towns. The following tables (Table 2) and maps (Figures 3-4) present an overview of species distribution by county and town during both the NHDS and over the entire history of collection in New Hampshire. Figure 5 and Table 3 present information on flight periods.

Table 1. Species either recorded for the first time in NH during the NHDS or previously reported from the state but not recorded during the NHDS. Maps and flight periods for all species except those indicated with an asterisk are included in this report. Scientific and common names follow Paulson and Dunkle 2012.

Species	NHDS Status	Notes
<i>Argia bipunctata</i> (Seepage Dancer) *	Not recorded	Listed as occurring in NH by Westfall and May (2006). No further information is available on this record, and given that the species is not conclusively known to occur north of NJ, it is not included on the NH list.
<i>Enallagma antennatum</i> (Rainbow Bluet)	Not recorded	Discovered along Connecticut River in Lebanon in 2006 (Hunt et al. 2010).
<i>Enallagma doubledayi</i> (Atlantic Bluet) *	Not recorded	A published record from Madison (Paulson 2002) turns out to have been a misidentified <i>E. civile</i> (D. Paulson, pers. comm.). Species not known to occur in NH.
<i>Tachopteryx thoreyi</i> * (Gray Petaltail)	Not recorded	Old record from Manchester in 1903 (see White and Morse 1973) is now generally believed to be in error. Species probably has never occurred in NH.
<i>Aeshna septentrionalis</i> (Azure Darner) *	Not recorded	Undated record from “White Mountains” (<i>fide</i> White and Morse 1973, also listed in Needham et al. 2000). Given the species’ subarctic distribution, this record probably represents a misidentification (possibly of <i>A. sitchensis</i> , below), and it is not believed to occur in NH.
<i>Aeshna sitchensis</i> (Zigzag Darner)	Not recorded	Single record from White Mountains (possibly Hermit Lake, Tuckerman’s Ravine) in 1860s (P. Brunelle, pers. comm., probably the <i>A. septentrionalis</i> listed in White and Morse 1973). Still needs verification, but not uncommon in northern Maine (Brunelle and deMaynadier 2005).
<i>Anax longipes</i> (Comet Darner)	New for state	Found at Brentwood (2007-10), Seabrook (2010) and Lee (2011). Breeding suspected at Lee.
<i>Ophiogomphus columbrinus</i> * (Boreal Snaketail)	Not recorded	Undated record from “White Mountains” (<i>fide</i> White and Morse 1973). Does occur in northern Maine, but may not actually occur in NH pending verification of this record.
<i>Epitheca semiaquea</i> (Mantled Baskettail)	Not recorded	Three records (historic, 2003, and 2005), but identification difficult and no voucher specimens available.
<i>Somatochlora kennedyi</i> (Kennedy’s Emerald)	Not recorded	Several records, most recently from Bethlehem and Milan (both in 2006).
<i>Celithemis fasciata</i> (Banded Pennant)	New for state	Sites in Hooksett (2008-09) and Strafford (2011).
<i>Libellula vibrans</i> (Great Blue Skimmer)	Possible (report by credible observer in 2011)	Old records from Durham (1946) and Lee (2005). 2011 record included in Figure 4 but still considered unverified. Species should be considered a vagrant from farther south.
<i>Sympetrum rubicundulum</i> * (Ruby Meadowhawk)	Not recorded	May not occur in state at all. All NH specimens identified as this species in the UNH collection appear to be <i>S. internum</i> , and <i>S. rubicundulum</i> may not occur north of Cape Cod (although hybrids do, <i>fide</i> T. Donnelly).
<i>Tamea calverti</i> (Striped Saddlebags)	New for state	Single record of vagrant from Chichester (2010). This is a species of Central America and the Caribbean, and does not regularly occur north of Texas. In 2010 the species appeared across a large portion of the northeastern and north-central US, and the NH record may represent the northernmost occurrence on the planet.
<i>Tamea carolina</i> (Carolina Saddlebags)	New for state	Recorded from several locations in southeastern NH in 2010-11, and likely now breeds in the state.

Table 2. State list of New Hampshire damselflies and dragonflies, including distribution by county. X = species recorded in county since 1987, including NHDS records. H = species represented solely by records before 1987. Scientific and common names follow Paulson and Dunkle 2012.

Scientific Name	Common Name	NH	Belknap	Carroll	Cheshire	Coos	Grafton	Hillsborough	Merrimack	Rockingham	Strafford	Sullivan
CALOPTERYGIDAE (BROAD-WINGED DAMSELS)												
<i>Calopteryx aequabilis</i>	River Jewelwing	X	X	X	X	X	X	X	X	X	X	X
<i>Calopteryx amata</i>	Superb Jewelwing	X	X	X	X	X	X	X	X	X	X	X
<i>Calopteryx dimidiata</i>	Sparkling Jewelwing	X						X		X		
<i>Calopteryx maculata</i>	Ebony Jewelwing	X	X	X	X	X	X	X	X	X	X	X
<i>Hetaerina americana</i>	American Rubyspot	X	X		X			X	X	X	X	
LESTIDAE (SPREADWINGS)												
<i>Lestes congener</i>	Spotted Spreadwing	X	X	X	X	X	X	X	X	X	X	X
<i>Lestes disjunctus</i>	Northern Spreadwing	X	X	X	X	X	X	X	X	X	X	X
<i>Lestes dryas</i>	Emerald Spreadwing	X	X	X	X	X	X	X	X	X	X	X
<i>Lestes eurinus</i>	Amber-winged Spreadwing	X	X	X	X	X	X	X	X	X	X	X
<i>Lestes forcipatus</i>	Sweetflag Spreadwing	X	X	X	X	X	X	X	X	X	X	X
<i>Lestes inaequalis</i>	Elegant Spreadwing	X	X	X	X	X	X	X	X	X	X	X
<i>Lestes rectangularis</i>	Slender Spreadwing	X	X	X	X	X	X	X	X	X	X	X
<i>Lestes unguiculatus</i>	Lyre-tipped Spreadwing	X		H		X	H			X	H	
<i>Lestes vigilax</i>	Swamp Spreadwing	X	X	X	X	X	X	X	X	X	X	X
COENAGRIONIDAE (POND DAMSELS)												
<i>Amphiagrion saucium</i>	Eastern Red Damsel	X	X	X	X	X	X	X	X		X	
<i>Argia apicalis</i>	Blue-fronted Dancer	X			X			X	X	X		
<i>Argia fumipennis</i>	Variable Dancer	X	X	X	X	X	X	X	X	X	X	X
<i>Argia moesta</i>	Powdered Dancer	X	X	X	X	X	X	X	X	X	X	X
<i>Chromagrion conditum</i>	Aurora Damsel	X	X	X	X	X	X	X	X	X	X	X
<i>Coenagrion interrogatum</i>	Subarctic Bluet	X				X	X					
<i>Coenagrion resolutum</i>	Taiga Bluet	X				X	X		X	X	H	X
<i>Enallagma annexum</i>	Northern Bluet	X		X		X	X	X		X	X	
<i>Enallagma antennatum</i>	Rainbow Bluet	X					X					
<i>Enallagma aspersum</i>	Azure Bluet	X	X	X	X	X	X	X	X	X	X	X
<i>Enallagma boreale</i>	Boreal Bluet	X	X	X	X	X	X	X	X	X	X	X
<i>Enallagma carunculatum</i>	Tule Bluet	X	X		X		X		X			
<i>Enallagma civile</i>	Familiar Bluet	X	X	X	X	X	X	X	X	X	X	X
<i>Enallagma divagans</i>	Turquoise Bluet	X	X	X	X		H	X	X	X	X	X
<i>Enallagma durum</i>	Big Bluet	X			X						X	
<i>Enallagma ebrium</i>	Marsh Bluet	X	X	X	X	X	X	X	X	X	X	X
<i>Enallagma exsulans</i>	Stream Bluet	X	X	X	X	X	X	X	X	X	X	X
<i>Enallagma geminatum</i>	Skimming Bluet	X	X	X	X	X	X	X	X	X	X	X
<i>Enallagma hageni</i>	Hagen's Bluet	X	X	X	X	X	X	X	X	X	X	X
<i>Enallagma laterale</i>	New England Bluet	X	X	X	X			X	X	X	X	X

Table 2. continued

Scientific Name	Common Name	NH	Belknap	Carroll	Cheshire	Coos	Grafton	Hillsborough	Merrimack	Rockingham	Strafford	Sullivan
<i>Enallagma minusculum</i>	Little Bluet	X	X	X	X		X	X	X	X	X	X
<i>Enallagma pictum</i>	Scarlet Bluet	X	X	X	X	X		X	X	X		X
<i>Enallagma recurvatum</i>	Pine Barrens Bluet	X						X				
<i>Enallagma signatum</i>	Orange Bluet	X	X	X	X	X	X	X	X	X	X	X
<i>Enallagma traviatum</i>	Slender Bluet	X	X	X	X			X	X	X	X	
<i>Enallagma vernale</i>	Vernal Bluet	X	X	X	X	X	X	X	X	X	X	X
<i>Enallagma vesperum</i>	Vesper Bluet	X	X	X	X	X	X	X	X	X	X	X
<i>Ischnura hastata</i>	Citrine Forktail	X	X		X		X	X	X	X	X	
<i>Ischnura kellicotti</i>	Lilypad Forktail	X	X	X	X		X	X	X	X	X	
<i>Ischnura posita</i>	Fragile Forktail	X	X	X	X	X	X	X	X	X	X	X
<i>Ischnura verticalis</i>	Eastern Forktail	X	X	X	X	X	X	X	X	X	X	X
<i>Nehalennia gracilis</i>	Sphagnum Sprite	X	X	X	X	X	X	X	X	X	X	X
<i>Nehalennia irene</i>	Sedge Sprite	X	X	X	X	X	X	X	X	X	X	X
AESHNIDAE (DARNERS)												
<i>Aeshna canadensis</i>	Canada Darner	X	X	X	X	X	X	X	X	X	X	X
<i>Aeshna clepsydra</i>	Mottled Darner	X	X	X	X	H	X	X	X	X	X	X
<i>Aeshna constricta</i>	Lance-tipped Darner	X	X	X	X	X	X	X	X	X	X	X
<i>Aeshna eremita</i>	Lake Darner	X	X	X	X	X	X	X	X		X	X
<i>Aeshna interrupta</i>	Variable Darner	X	X	X	X	X	X	X	X		X	X
<i>Aeshna juncea</i>	Sedge Darner	X				H	X					
<i>Aeshna sitchensis</i>	Zigzag Darner	H				H						
<i>Aeshna subarctica</i>	Subarctic Darner	X		X		X	X	X				X
<i>Aeshna tuberculifera</i>	Black-tipped Darner	X	X	X	X	X	X	X	X	X	X	X
<i>Aeshna umbrosa</i>	Shadow Darner	X	X	X	X	X	X	X	X	X	X	X
<i>Aeshna verticalis</i>	Green-striped Darner	X	X	X	X	X	X	X	X	X	X	X
<i>Anax junius</i>	Common Green Darner	X	X	X	X	X	X	X	X	X	X	X
<i>Anax longipes</i>	Comet Darner	X								X	X	
<i>Basiaeschna janata</i>	Springtime Darner	X	X	X	X	X	X	X	X	X	X	X
<i>Boyeria grafiana</i>	Ocellated Darner	X		X		X	X					X
<i>Boyeria vinosa</i>	Fawn Darner	X	X	X	X	X	X	X	X	X	X	X
<i>Epiaeschna heros</i>	Swamp Darner	X			H			X	X	X	X	X
<i>Gomphaeschna furcillata</i>	Harlequin Darner	X	X	X	X	X	X	X	X	X	X	X
<i>Nasiaeschna pentacantha</i>	Cyrano Darner	X		X	X			X	X	X	X	X
<i>Rhioaeschna mutata</i>	Spatterdock Darner	X	X		X			X	X	X	X	
GOMPHIDAE (CLUBTAILS)												
<i>Arigomphus furcifer</i>	Lilypad Clubtail	X	X	X	X	X	X	X	X	X	X	X
<i>Arigomphus villosipes</i>	Unicorn Clubtail	X	X		X		X	X	X	X	X	X
<i>Dromogomphus spinosus</i>	Black-shouldered Spinylegs	X	X	X	X	X	X	X	X	X	X	X
<i>Gomphus abbreviatus</i>	Spine-crowned Clubtail	X	X	X	X			X	X	X	X	
<i>Gomphus adelphus</i>	Mustached Clubtail	X	X	X	X	X	X	X	X	X	X	X

Table 2. continued

Scientific Name	Common Name	NH	Belknap	Carroll	Cheshire	Coos	Grafton	Hillsborough	Merrimack	Rockingham	Strafford	Sullivan
<i>Gomphus borealis</i>	Beaverpond Clubtail	X	X	X	X	X	X	X	X	X	X	X
<i>Gomphus descriptus</i>	Harpoon Clubtail	X	X	X	X	X	X	X	X		X	X
<i>Gomphus exilis</i>	Lancet Clubtail	X	X	X	X	X	X	X	X	X	X	X
<i>Gomphus lividus</i>	Ashy Clubtail	X	X		X			X	X	X		
<i>Gomphus quadricolor</i>	Rapids Clubtail	X			X			X	X			
<i>Gomphus spicatus</i>	Dusky Clubtail	X	X	X	X	X	X	X	X	X	X	X
<i>Gomphus vastus</i>	Cobra Clubtail	X	X		X		X	X	X			X
<i>Gomphus ventricosus</i>	Skillet Clubtail	X			X			X	X			
<i>Hagenius brevistylus</i>	Dragonhunter	X	X	X	X	X	X	X	X	X	X	X
<i>Lanthus parvulus</i>	Northern Pygmy Clubtail	X		X		X	X	H?	H?			
<i>Lanthus vernalis</i>	Southern Pygmy Clubtail	X	X	X		X		X			X	X
<i>Ophiogomphus aspersus</i>	Brook Snaketail	X	X	X	X	X	X	X	X	X	X	X
<i>Ophiogomphus carolus</i>	Riffle Snaketail	X		X		X	X	X	X		X	X
<i>Ophiogomphus colubrinus</i>	Boreal Snaketail	H	No locality available, see Table 1									
<i>Ophiogomphus howeii</i>	Pygmy Snaketail	X		X				X	X			
<i>Ophiogomphus mainensis</i>	Maine Snaketail	X	X	X		X	X	X	X		X	X
<i>Ophiogomphus rupinsulensis</i>	Rusty Snaketail	X	X		X	X	X	X	X	X	X	X
<i>Progomphus obscurus</i>	Common Sanddragon	X		X				X	X	X	X	X
<i>Stylogomphus albistylus</i>	Eastern Least Clubtail	X	X	X	X	X	X	X	X	X	X	X
<i>Stylurus amnicola</i>	Riverine Clubtail	X			X	X	X	X	X			X
<i>Stylurus scudleri</i>	Zebra Clubtail	X	X	X	X	X	X	X	X	X	X	X
<i>Stylurus spiniceps</i>	Arrow Clubtail	X	X		X	X	X	X	X		X	X
CORDULEGASTRIDAE (SPIKETAILS)												
<i>Cordulegaster diastatops</i>	Delta-spotted Spiketail	X	X	X	X	X	X	X	X	X	X	X
<i>Cordulegaster maculata</i>	Twin-spotted Spiketail	X	X	X	X	X	X	X	X	X	X	X
<i>Cordulegaster obliqua</i>	Arrowhead Spiketail	X	H		X		X		X	X	X	X
MACROMIIDAE (CRUISERS)												
<i>Didymops transversa</i>	Stream Cruiser	X	X	X	X	X	X	X	X	X	X	X
<i>Macromia illinoensis</i>	Swift River Cruiser	X	X	X	X	X	X	X	X	X	X	X
CORDULIDAE (EMERALDS)												
<i>Cordulia shurtleffi</i>	American Emerald	X	X	X	X	X	X	X	X	X	X	X
<i>Dorocordulia lepida</i>	Petite Emerald	X	X	X	X	X	X	X	X	X	X	X
<i>Dorocordulia libera</i>	Racket-tailed Emerald	X	X	X	X	X	X	X	X	X	X	X
<i>Epithea canis</i>	Beaverpond Baskettail	X	X	X	X	X	X	X	X	X	X	X
<i>Epithea cynosura</i>	Common Baskettail	X	X	X	X	X	X	X	X	X	X	X
<i>Epithea princeps</i>	Prince Baskettail	X	X	X	X	X	X	X	X	X	X	X
<i>Epithea semiaquea</i>	Mantled Baskettail	X						X				
<i>Epithea spinigera</i>	Spiny Baskettail	X	X	X	X	X	X	X	X	X	X	X
<i>Helocordulia uhleri</i>	Uhler's Sundragon	X	X	X	X	X	X	X	X	X	X	X
<i>Neurocordulia obsoleta</i>	Umber Shadowdragon	X	X	X			X	X	X	X	X	X

Table 2. continued

Scientific Name	Common Name	NH	Belknap	Carroll	Cheshire	Coos	Grafton	Hillsborough	Merrimack	Rockingham	Strafford	Sullivan
<i>Neurocordulia yamaskanensis</i>	Stygian Shadowdragon	X	X	X	X	X	X	X	X			X
<i>Somatochlora albicincta</i>	Ringed Emerald	X		H		X	X					
<i>Somatochlora cingulata</i>	Lake Emerald	X		X		X	X					X
<i>Somatochlora elongata</i>	Ski-tipped Emerald	X	X	X	X	X	X	X	X		H	X
<i>Somatochlora forcipata</i>	Forcipate Emerald	X		X	H	X	X		X			X
<i>Somatochlora franklini</i>	Delicate Emerald	X		X		X						
<i>Somatochlora georgiana</i>	Coppery Emerald	X								X		
<i>Somatochlora incurvata</i>	Incurvate Emerald	X	X	X	X	X				X		
<i>Somatochlora kennedyi</i>	Kennedy's Emerald	X	H	X		X	X		H	H	H	
<i>Somatochlora linearis</i>	Mocha Emerald	X								X		
<i>Somatochlora minor</i>	Ocellated Emerald	X		H		X	X					
<i>Somatochlora tenebrosa</i>	Clamp-tipped Emerald	X	X	X	X	X	X	X	X	X	X	X
<i>Somatochlora walshii</i>	Brush-tipped Emerald	X	X	X	X	X	X	X	X	X	X	X
<i>Somatochlora williamsoni</i>	Williamson's Emerald	X	X	H	X	X	X	X	X	X	H	X
<i>Williamsonia fletcheri</i>	Ebony Boghaunter	X	X	X	X	X		X	X	X	X	X
<i>Williamsonia lintneri</i>	Ringed Boghaunter	X						X	X	X	X	
LIBELLULIDAE (SKIMMERS)												
<i>Celithemis elisa</i>	Calico Pennant	X	X	X	X	X	X	X	X	X	X	X
<i>Celithemis eponina</i>	Halloween Pennant	X	X	X	X			X	X	X	X	X
<i>Calithemis fasciata</i>	Banded Pennant	X							X		X	
<i>Celithemis martha</i>	Martha's Pennant	X	X	X	X			X	X	X	X	X
<i>Erythemis simplicicollis</i>	Eastern Pondhawk	X	X	X	X		X	X	X	X	X	X
<i>Erythrodiplax berenice</i>	Seaside Dragonlet	X								X	X	
<i>Ladona deplanata</i>	Blue Corporal	X						X		X		
<i>Ladona exusta</i>	White Corporal	X	X	X	X		X	X	X	X	X	X
<i>Ladona julia</i>	Chalk-fronted Corporal	X	X	X	X	X	X	X	X	X	X	X
<i>Leucorrhinia frigida</i>	Frosted Whiteface	X	X	X	X	X	X	X	X	X	X	X
<i>Leucorrhinia glacialis</i>	Crimson-ringed Whiteface	X	X	X	X	X	X	X	X	X	X	X
<i>Leucorrhinia hudsonica</i>	Hudsonian Whiteface	X	X	X	X	X	X	X	X	X	X	X
<i>Leucorrhinia intacta</i>	Dot-tailed Whiteface	X	X	X	X	X	X	X	X	X	X	X
<i>Leucorrhinia proxima</i>	Belted Whiteface	X	X	X	X	X	X	X	X	X	X	X
<i>Libellula cyanea</i>	Spangled Skimmer	X	X	X	X	X	X	X	X	X	X	X
<i>Libellula incesta</i>	Slaty Skimmer	X	X	X	X	X	X	X	X	X	X	X
<i>Libellula luctuosa</i>	Widow Skimmer	X	X	X	X	X	X	X	X	X	X	X
<i>Libellula needhami</i>	Needham's Skimmer	X								X		
<i>Libellula pulchella</i>	Twelve-spotted Skimmer	X	X	X	X	X	X	X	X	X	X	X
<i>Libellula quadrimaculata</i>	Four-spotted Skimmer	X	X	X	X	X	X	X	X	X	X	X
<i>Libellula semifasciata</i>	Painted Skimmer	X			X		X	X	X	X	X	X
<i>Libellula vibrans</i>	Great Blue Skimmer	X								X	X	
<i>Nannothemis bella</i>	Elfin Skimmer	X	X	X	X	X	X	X	X	X	X	X

Table 2. continued

Scientific Name	Common Name	NH	Belknap	Carroll	Cheshire	Coos	Grafton	Hillsborough	Merrimack	Rockingham	Strafford	Sullivan
<i>Pachydiplax longipennis</i>	Blue Dasher	X	X	X	X	X	X	X	X	X	X	X
<i>Pantala flavescens</i>	Wandering Glider	X	X	X	X	X	X	X	X	X	X	X
<i>Pantala hymenaea</i>	Spot-winged Glider	X	X		X		X	X	X	X	X	X
<i>Perithemis tenera</i>	Eastern Amberwing	X	X	X	X		X	X	X	X	X	X
<i>Plathemis lydia</i>	Common Whitetail	X	X	X	X	X	X	X	X	X	X	X
<i>Sympetrum costiferum</i>	Saffron-winged Meadowhawk	X	X	X	X	X	X	X	X	X	X	X
<i>Sympetrum danae</i>	Black Meadowhawk	X				X	H					
<i>Sympetrum internum</i>	Cherry-faced Meadowhawk	X	X	X	X	X	X	X	X	X	X	X
<i>Sympetrum obtrusum</i>	White-faced Meadowhawk	X	X	X	X	X	X	X	X	X	H	X
<i>Sympetrum semicinctum</i>	Band-winged Meadowhawk	X	X	X	X	X	X	X	X	X	X	X
<i>Sympetrum vicinum</i>	Autumn Meadowhawk	X	X	X	X	X	X	X	X	X	X	X
<i>Tamea calverti</i>	Striped Saddlebags	X							X			
<i>Tamea carolina</i>	Carolina Saddlebags	X								X	X	
<i>Tamea lacerata</i>	Black Saddlebags	X	X	X	X		X	X	X	X	X	X
	Number of species	162	120	123	125	115	125	134	134	127	129	120

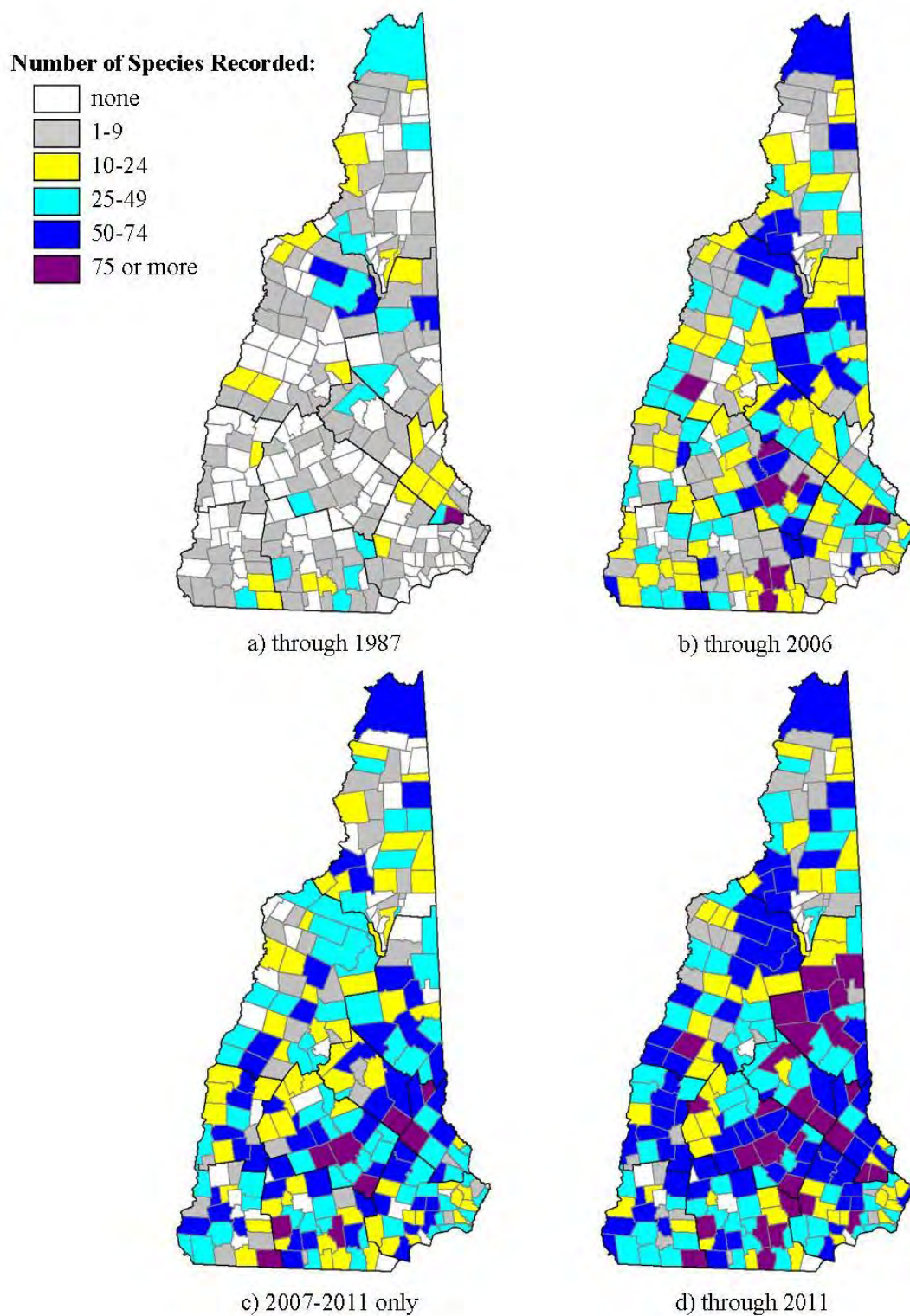


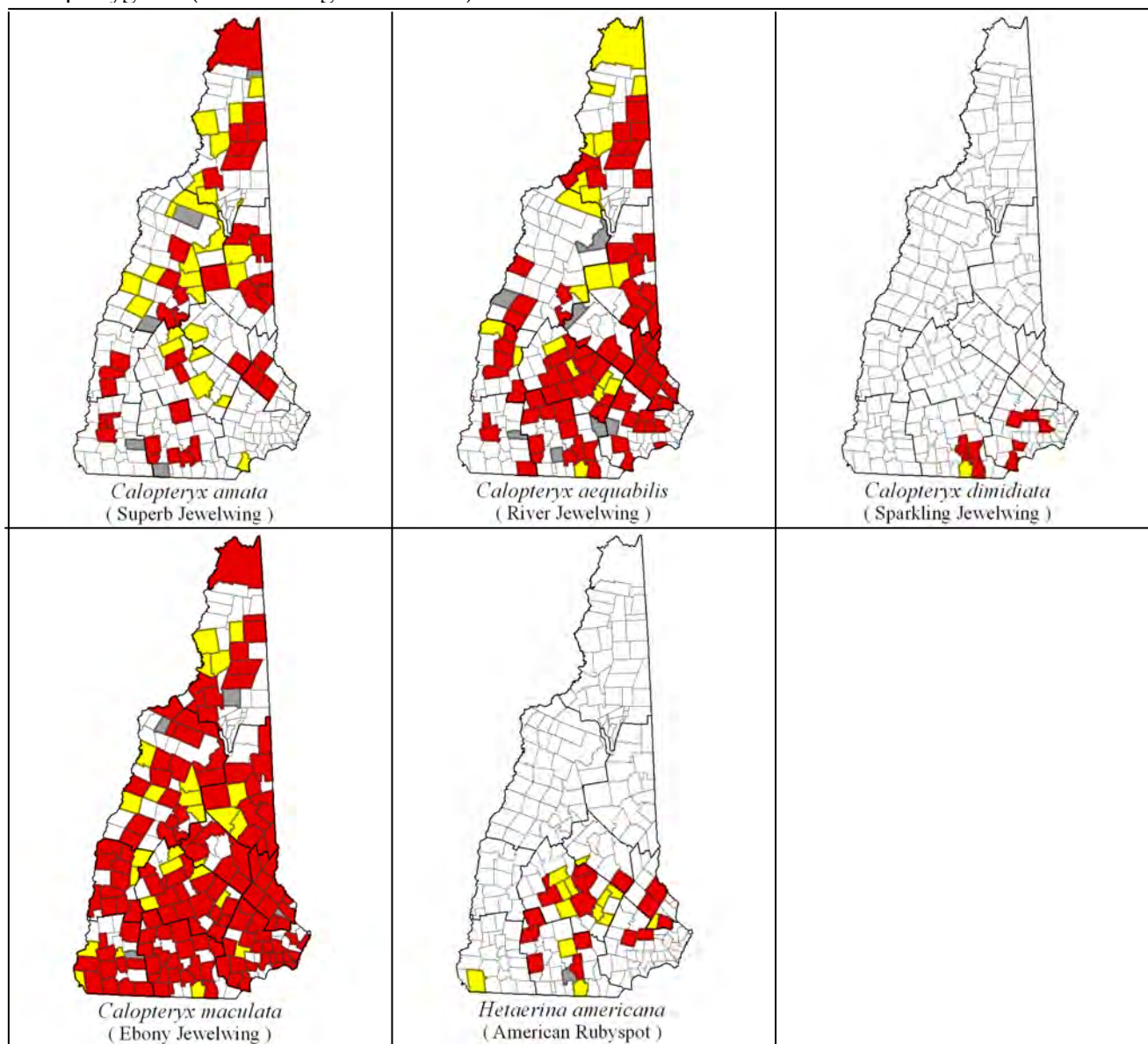
Figure 3. Species richness of Odonata by town for four time periods: a) based on data prior to 1987 (historic data), b) based on all data collected prior to initiation of the NHDS (e.g., through 2006), c) during the NHDS 2007-2011, and d) overall (all available data through the end of 2011). Legend for all figures as per (a). See Appendix E for town and county names.

Figure 4. Species distribution maps. The following maps indicate the towns where each of 161 species (and three additional forms, see below) has been recorded in New Hampshire through 2011. Red towns indicate where a species was documented during the NHDS, yellow towns indicate where a species was documented 1987-2006, but NOT during the NHDS, and gray towns indicate records prior to 1987. Note that not all records prior to the NHDS have been fully verified, and some identifications or locations may be in error. Town lines in gray, county lines in black (see Appendix E). *Ophiogomphus colubrinus* is not mapped because the only record has no locality data (see Table 1).

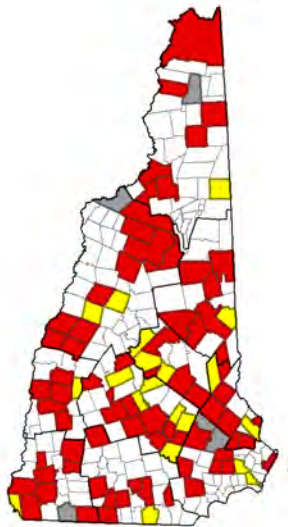
In addition to species maps, distributions are provided for three additional taxa, as follows:

- Enallagma annexum/vernale*. This species pair is extremely difficult to separate in the hand, and in the absence of specimens many records could not be assigned to species. The map is provided to show the potential range of either species.
- Hybrids between *Sympetrum internum* and *S. obscurum*. This hybrid is rare but widespread, and certainly underreported as it requires careful expert examination. It was reported 12 times and from widely scattered locations in New York (White et al. 2006). A single specimen showing characteristics of a hybrid *S. internum* x *S. rubicundulum* was collected in Concord in 2006, but this hybrid is not mapped.
- Unidentified *Sympetrum*. A map is provided for unidentified *Sympetrum* because most such records are probably *internum* (or less commonly, *obscurum*, if in the north). These towns are also indicated by cross-hatching on the *S. internum* map.

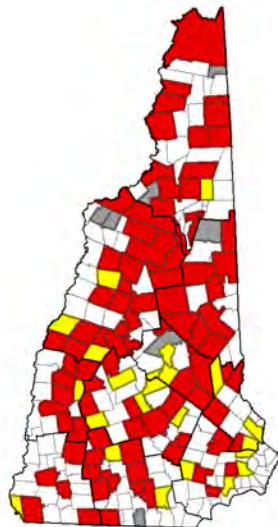
Calopterygidae (Broad-winged Damselflies)



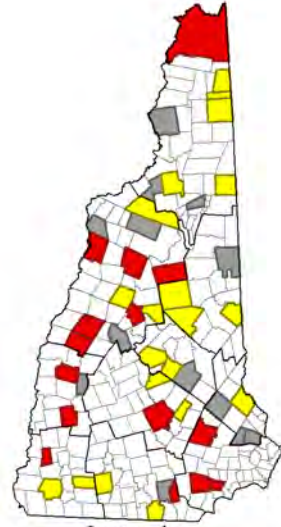
Lestidae (Spreadwings)



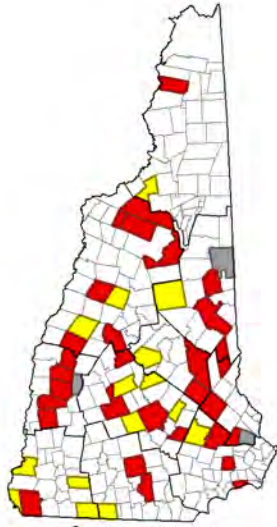
Lestes congener
(Spotted Spreadwing)



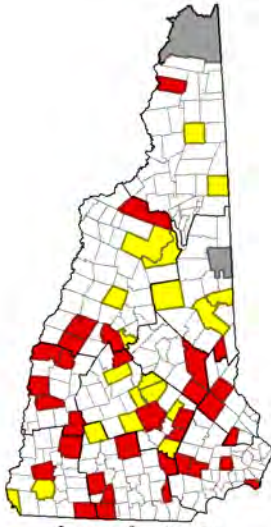
Lestes disjunctus
(Northern Spreadwing)



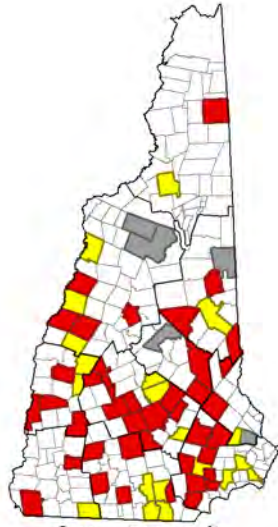
Lestes dryas
(Emerald Spreadwing)



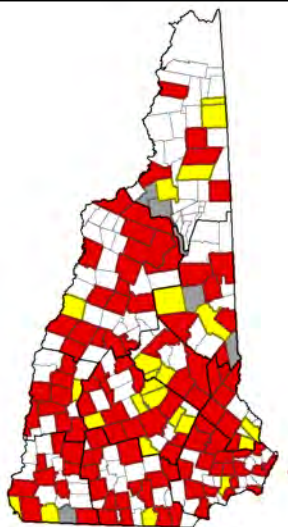
Lestes eurinus
(Amber-winged Spreadwing)



Lestes forcipatus
(Sweetflag Spreadwing)



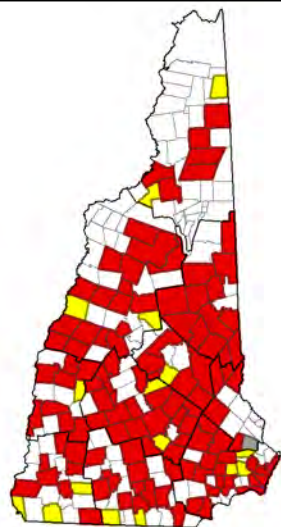
Lestes inaequalis
(Elegant Spreadwing)



Lestes rectangularis
(Slender Spreadwing)

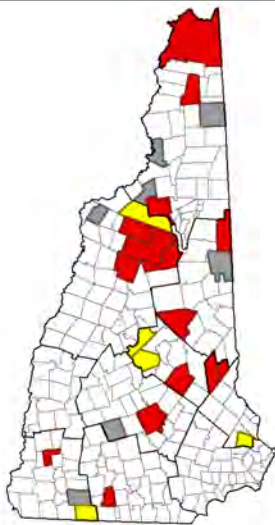


Lestes unguiculatus
(Lyre-tipped Spreadwing)



Lestes vigilax
(Swamp Spreadwing)

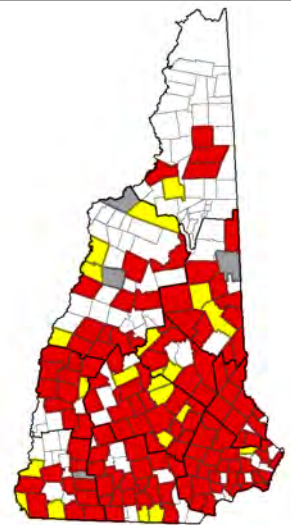
Coenagrionidae (Pond Damsels)



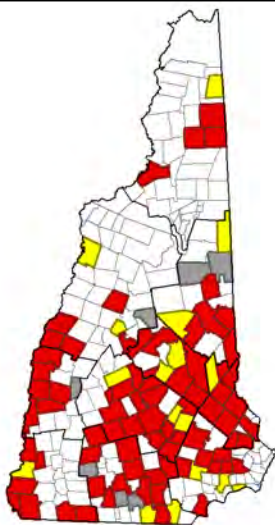
Amphiagrion saucium
(Eastern Red Damselfly)



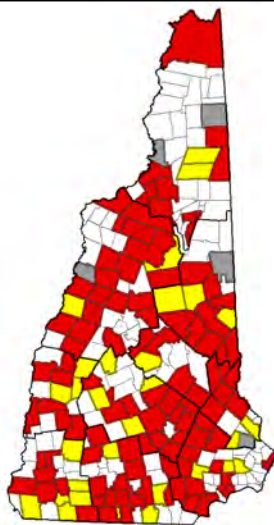
Argia apicalis
(Blue-fronted Dancer)



Argia fumipennis
(Variable Dancer)



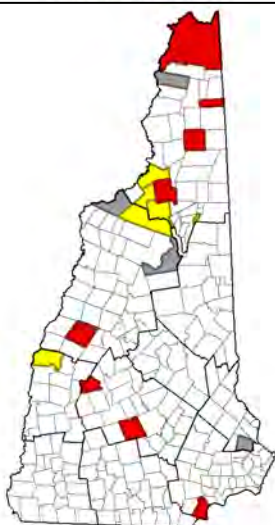
Argia moesta
(Powdered Dancer)



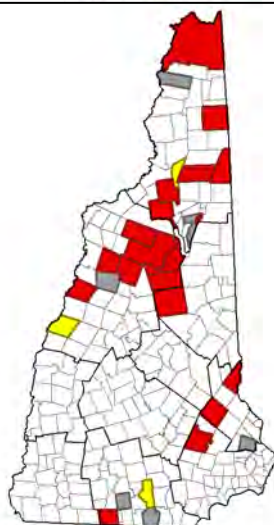
Chromagrion conditum
(Aurora Damselfly)



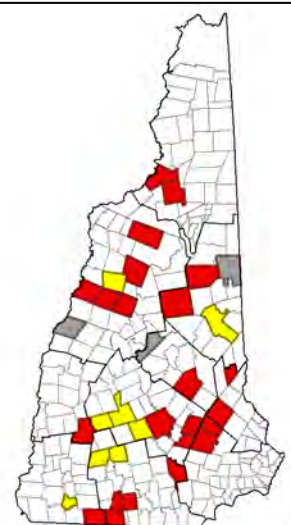
Coenagrion interrogatum
(Subarctic Bluet)



Coenagrion resolutum
(Taiga Bluet)



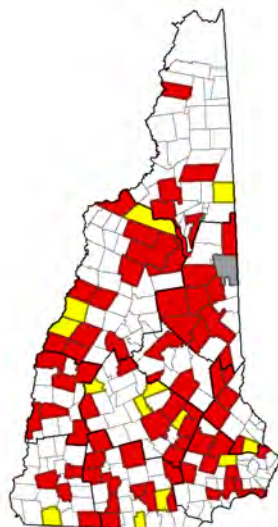
Enallagma annexum
(Northern Bluet)



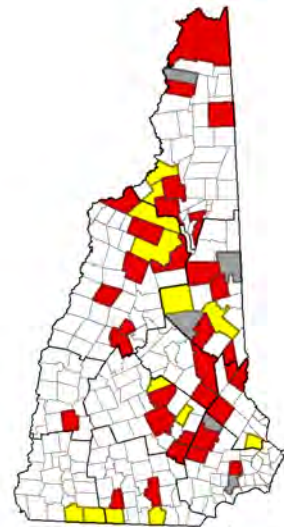
Enallagma annexum vernale
(Northern/Vernal Bluet)



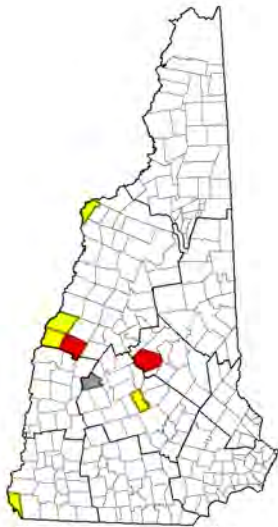
Enallagma antennatum
(Rainbow Bluet)



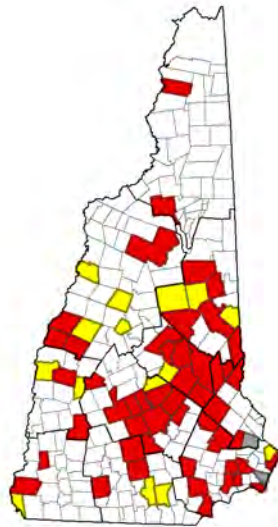
Enallagma aspersum
(Azure Bluet)



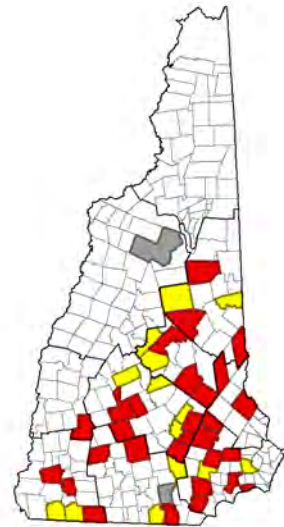
Enallagma boreale
(Boreal Bluet)



Enallagma carunculatum
(Tule Bluet)



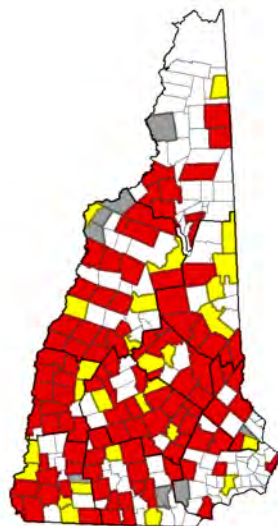
Enallagma civile
(Familiar Bluet)



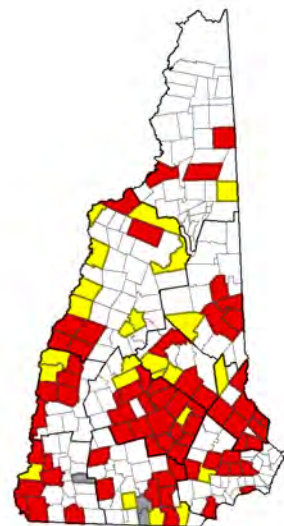
Enallagma divagans
(Turquoise Bluet)



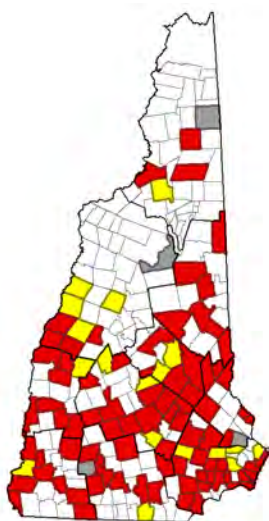
Enallagma durum
(Big Bluet)



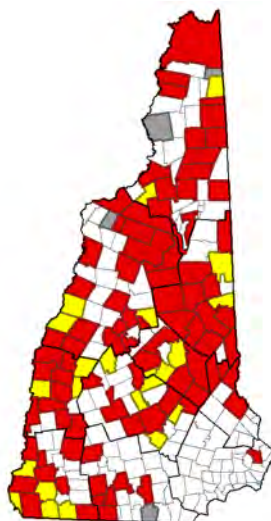
Enallagma ebrium
(Marsh Bluet)



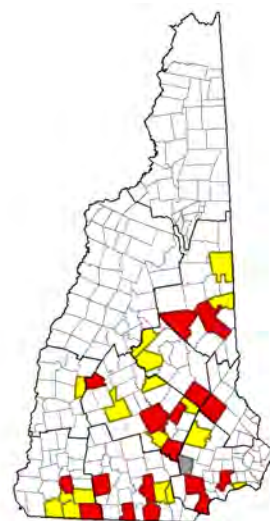
Enallagma exsulans
(Stream Bluet)



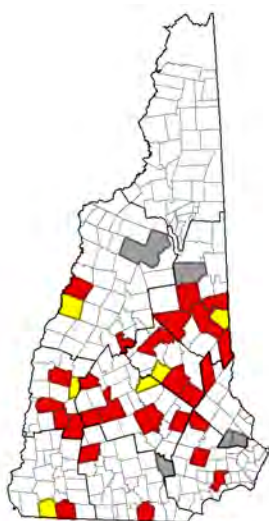
Enallagma geminatum
(Skimming Bluet)



Enallagma hageni
(Hagen's Bluet)



Enallagma laterale
(New England Bluet)



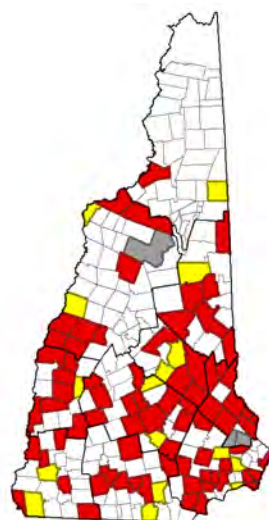
Enallagma mimasculum
(Little Bluet)



Enallagma pictum
(Scarlet Bluet)



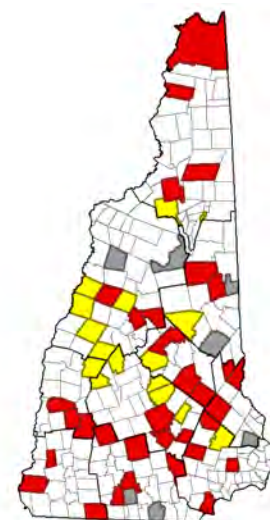
Enallagma recurvatum
(Pine Barrens Bluet)



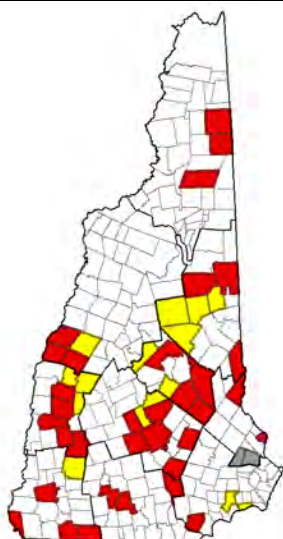
Enallagma signatum
(Orange Bluet)



Enallagma traviatum
(Slender Bluet)



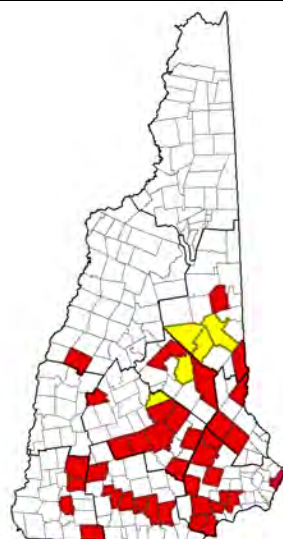
Enallagma vernale
(Vernal Bluet)



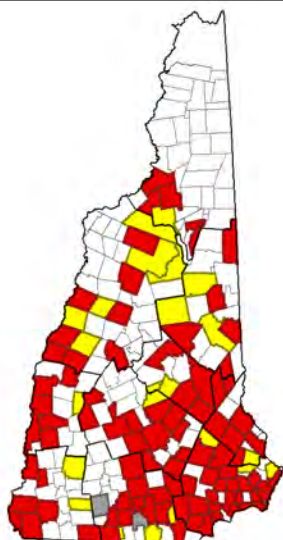
Enallagma vesperum
(Vesper Bluet)



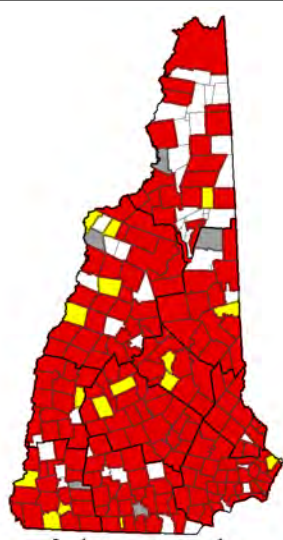
Ischnura hastata
(Citrine Forktail)



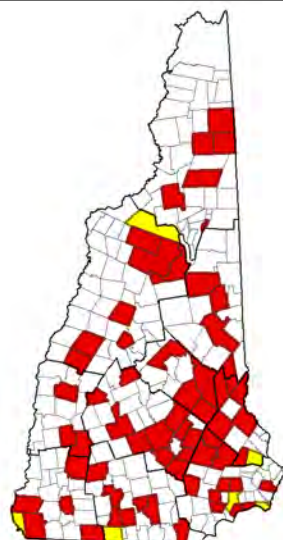
Ischnura kellicotti
(Lilypad Forktail)



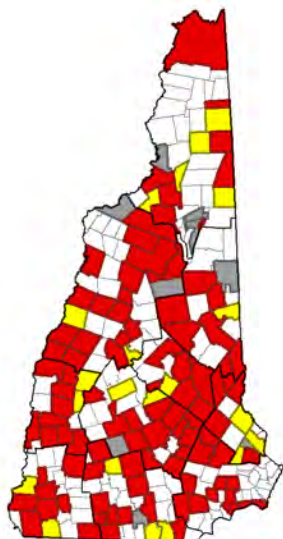
Ischnura posita
(Fragile Forktail)



Ischnura verticalis
(Eastern Forktail)

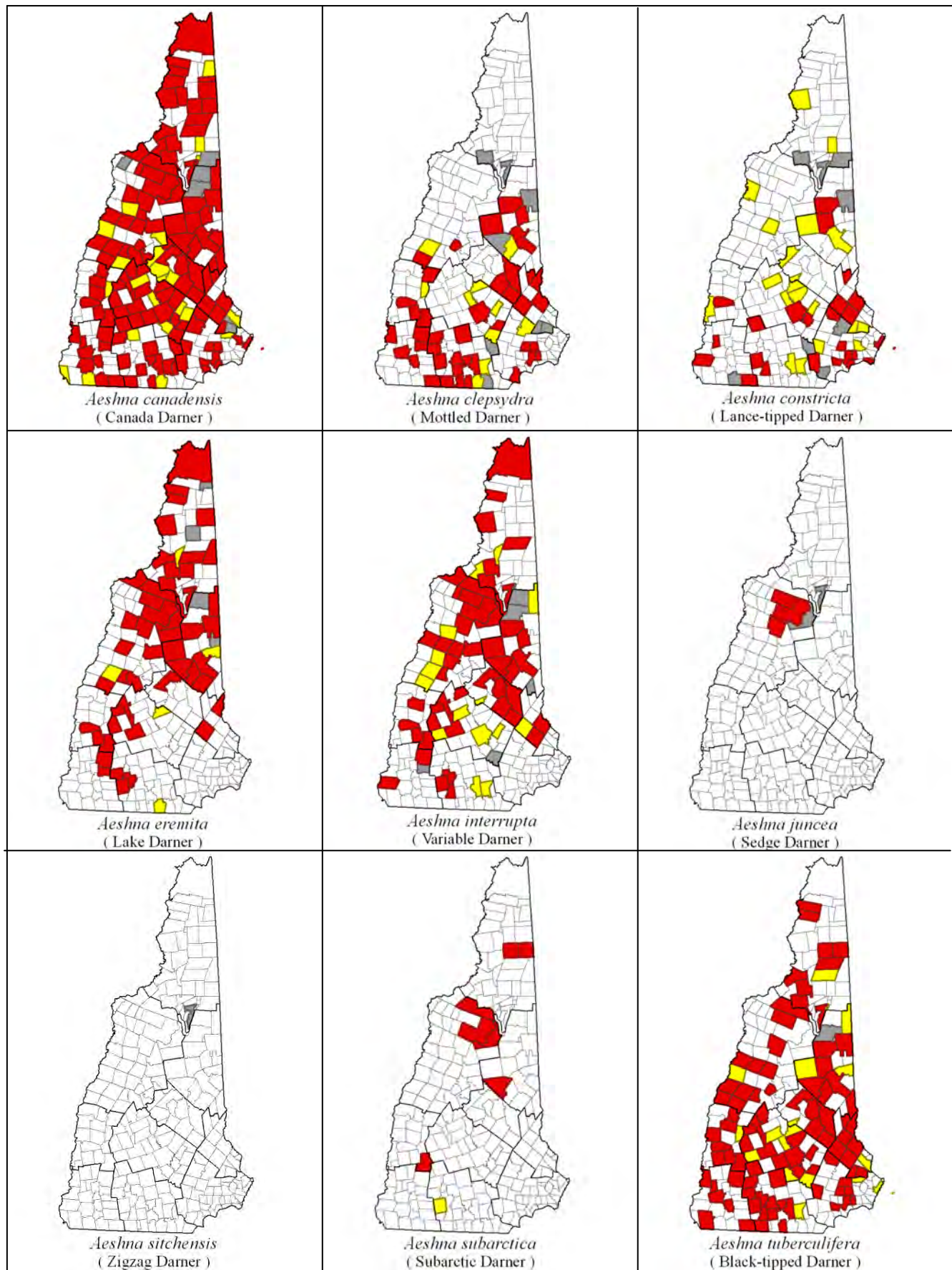


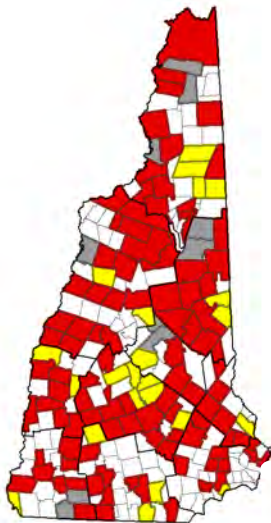
Nehalennia gracilis
(Sphagnum Sprite)



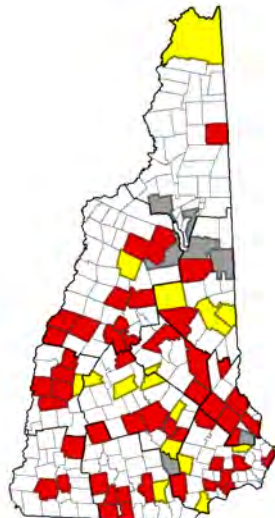
Nehalennia irene
(Sedge Sprite)

Aeshnidae (Darners)

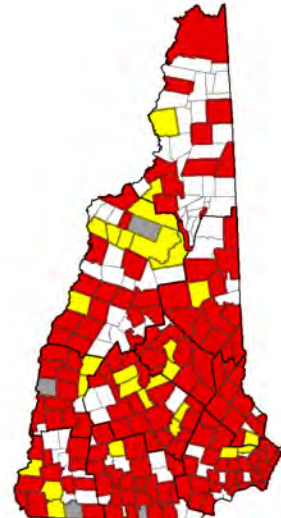




Aeshna umbrosa
(Shadow Darner)



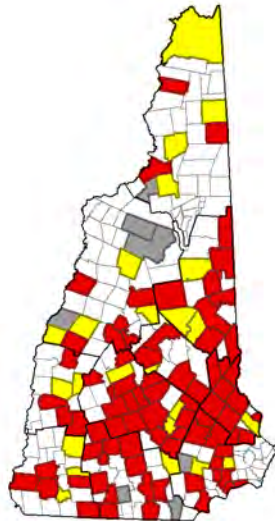
Aeshna verticalis
(Green-striped Darner)



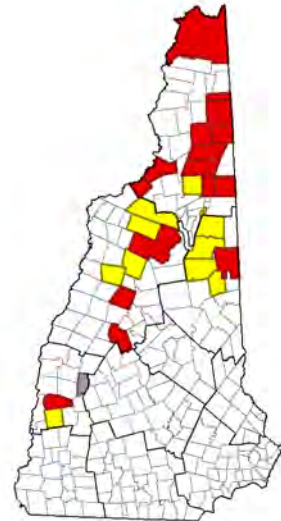
Anax junius
(Common Green Darner)



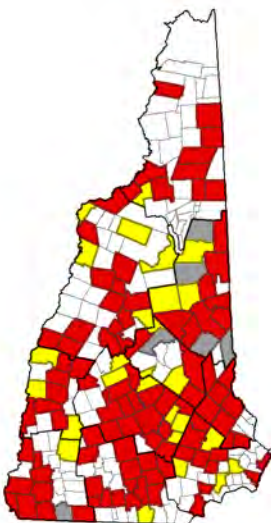
Anax longipes
(Comet Darner)



Basiaeschna janata
(Springtime Darner)



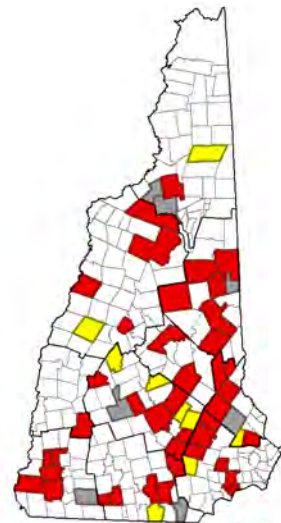
Boyeria grafiana
(Ocellated Darner)



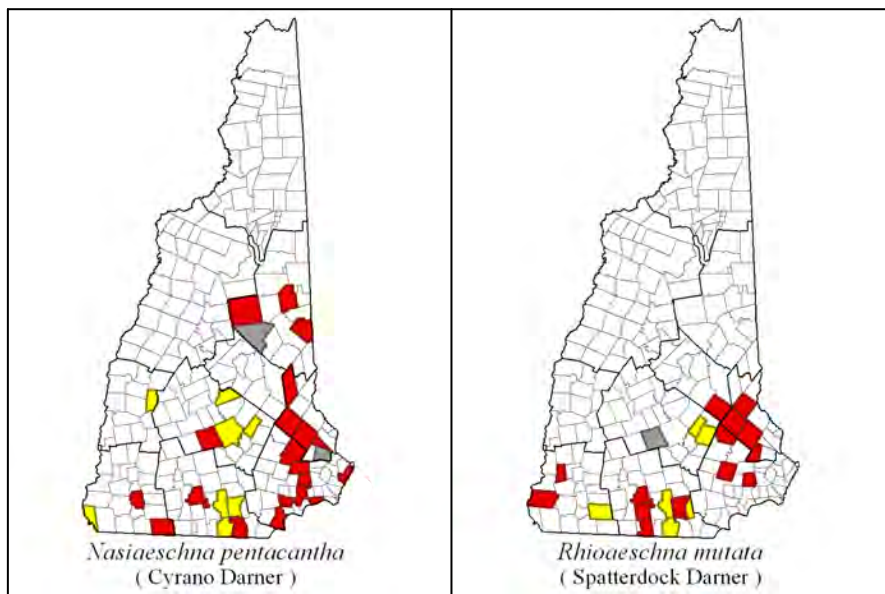
Boyeria vinosa
(Fawn Darner)



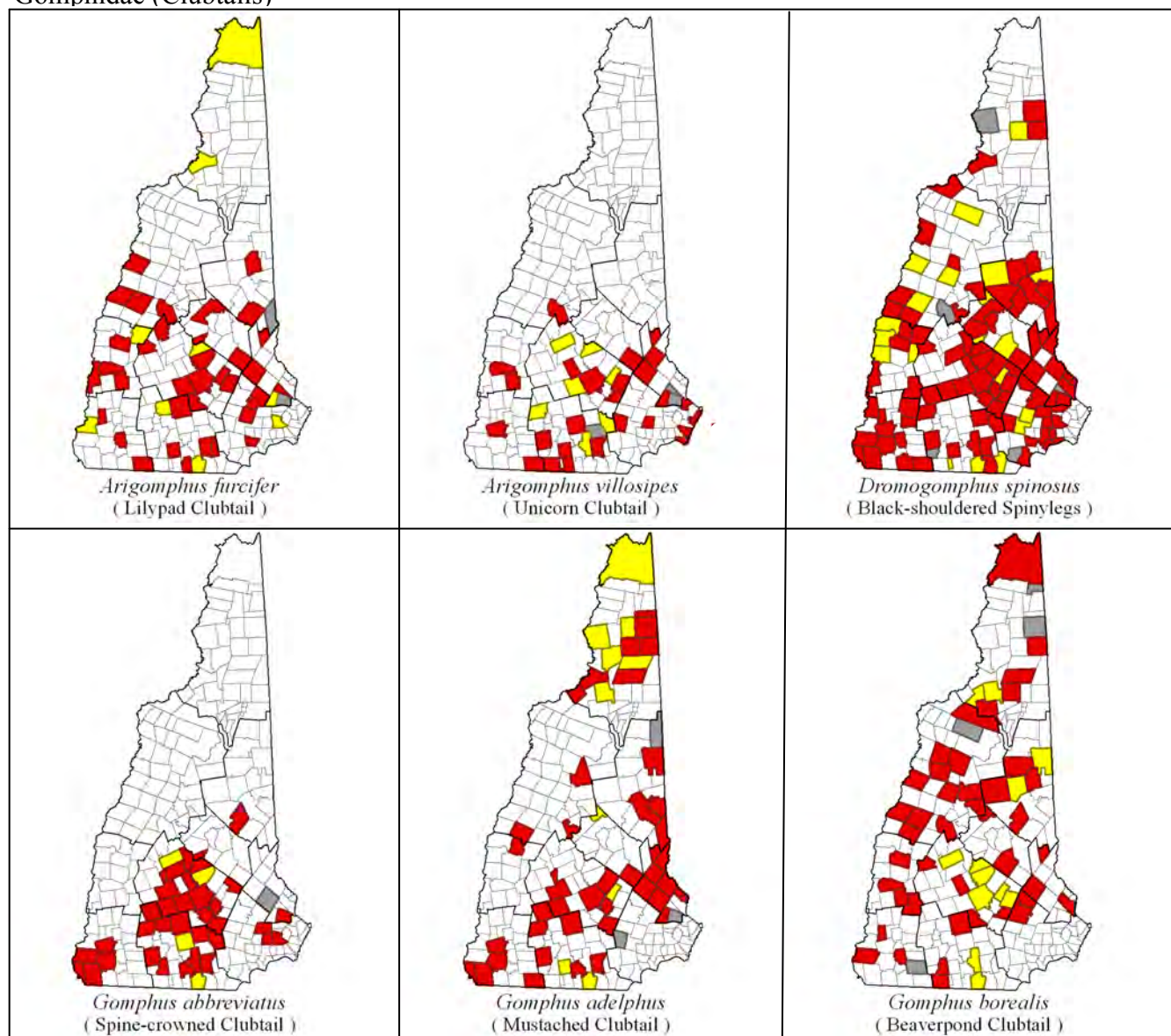
Epiaeschna heros
(Swamp Darner)

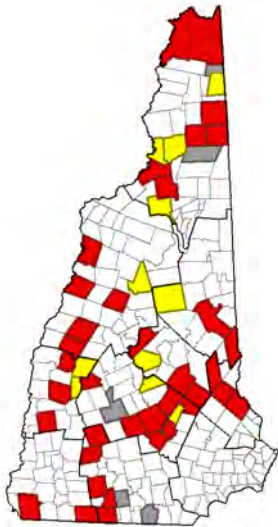


Gomphaeschna furcillata
(Harlequin Darner)

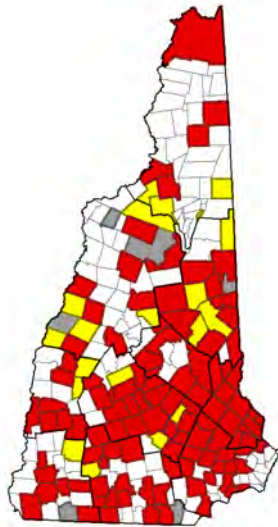


Gomphidae (Clubtails)





Gomphus descriptus
(Harpoon Clubtail)



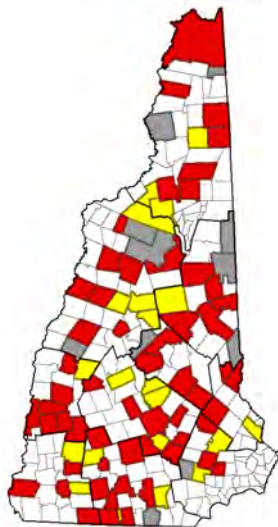
Gomphus exilis
(Lancet Clubtail)



Gomphus lividus
(Ashy Clubtail)



Gomphus quadricolor
(Rapids Clubtail)



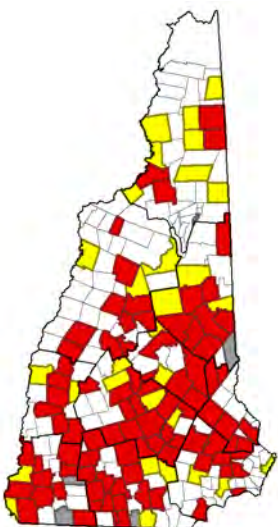
Gomphus spicatus
(Dusky Clubtail)



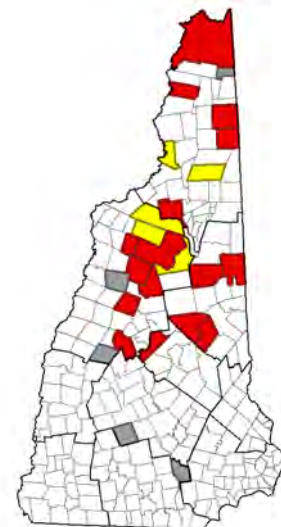
Gomphus vastus
(Cobra Clubtail)



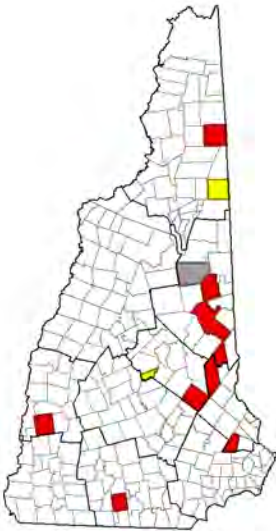
Gomphus ventricosus
(Skillet Clubtail)



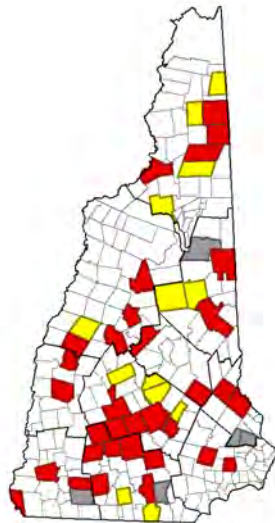
Hagenius brevistylus
(Dragonhunter)



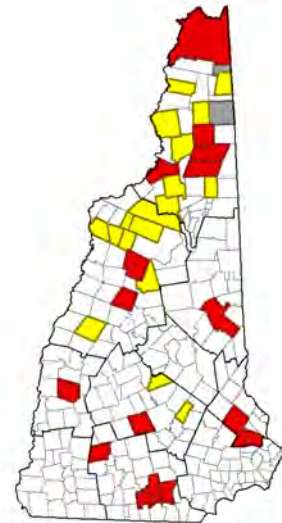
Lanthus parvulus
(Northern Pygmy Clubtail)



Lanthus vernalis
(Southern Pygmy Clubtail)



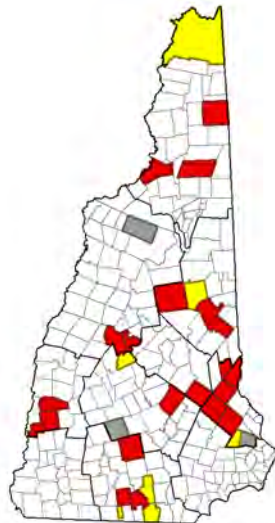
Ophiogomphus aspersus
(Brook Snaketail)



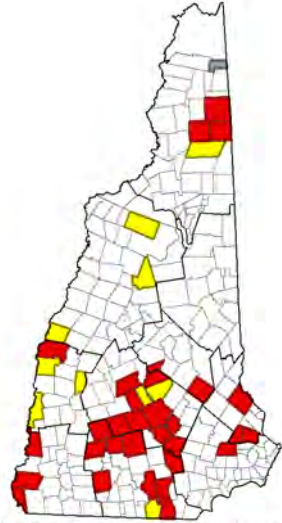
Ophiogomphus carolus
(Riffle Snaketail)



Ophiogomphus howeii
(Pygmy Snaketail)



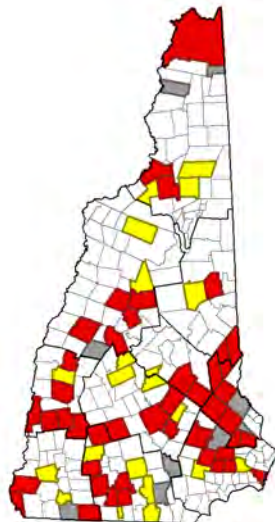
Ophiogomphus mainensis
(Maine Snaketail)



Ophiogomphus rupinsulensis
(Rusty Snaketail)



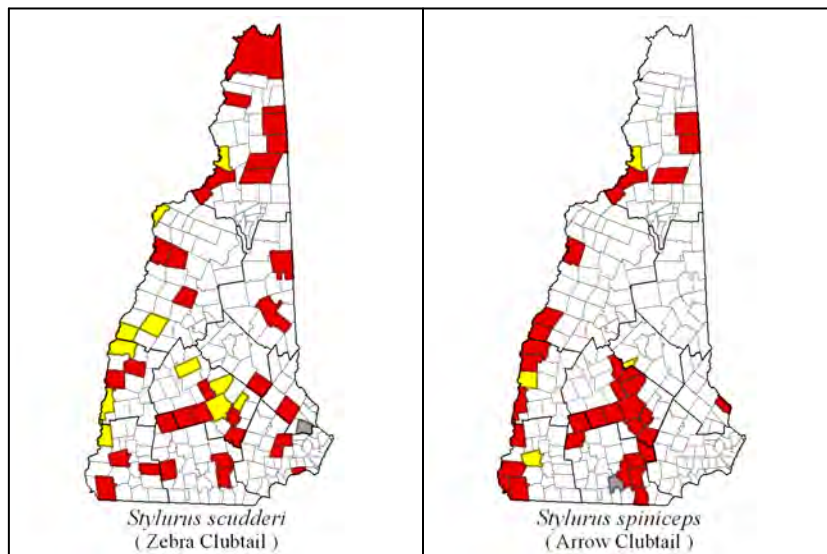
Progomphus obscurus
(Common Sanddragon)



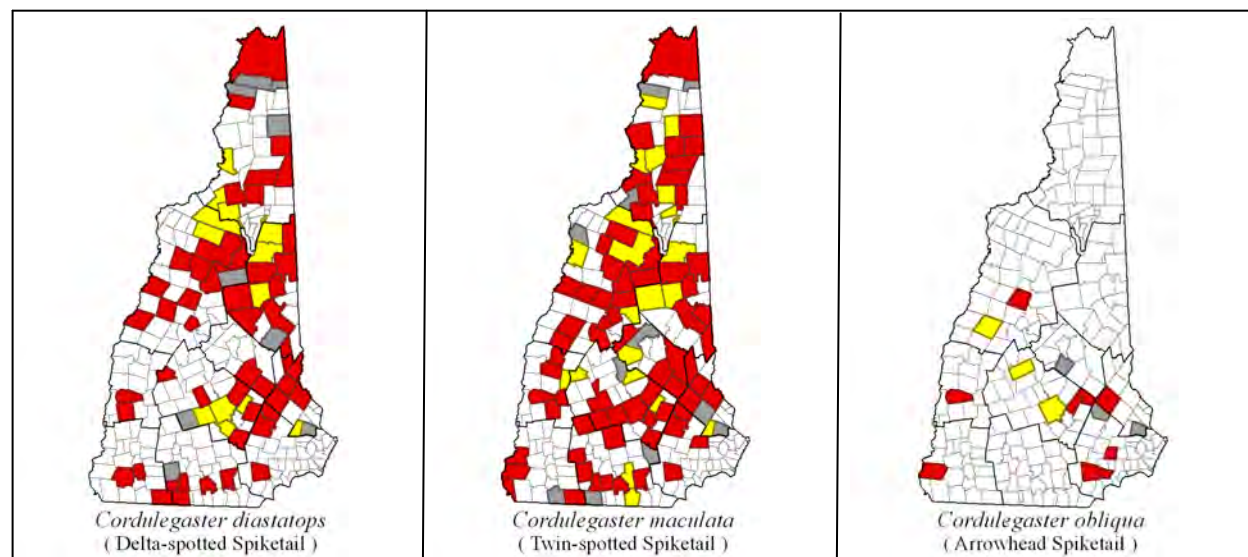
Stylogomphus albistylus
(Eastern Least Clubtail)



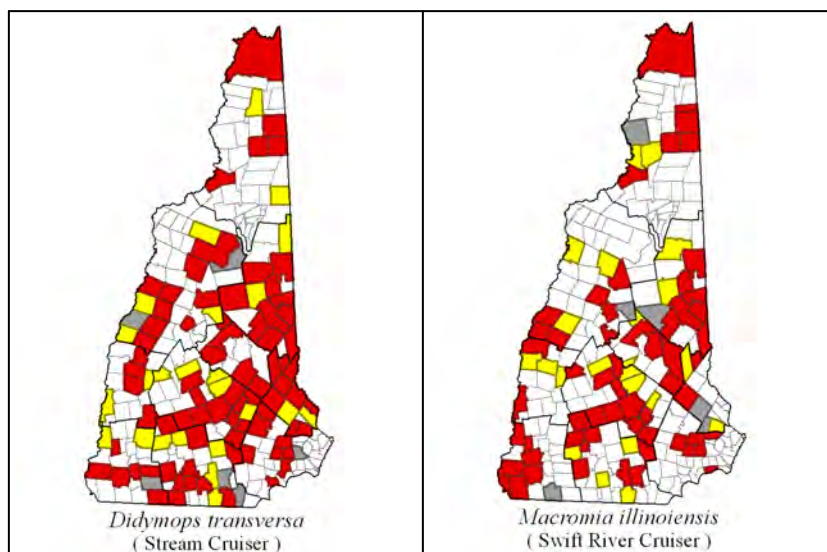
Stylurus amnicola
(Riverine Clubtail)



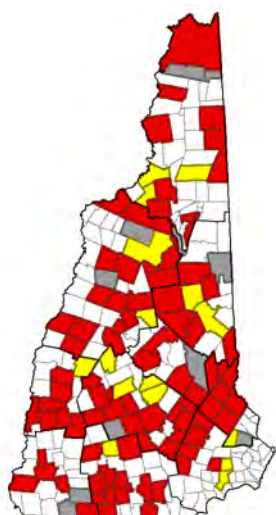
Cordulegastridae (Spiketails)



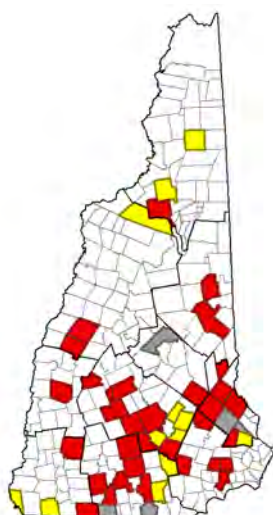
Macromidae (Cruisers)



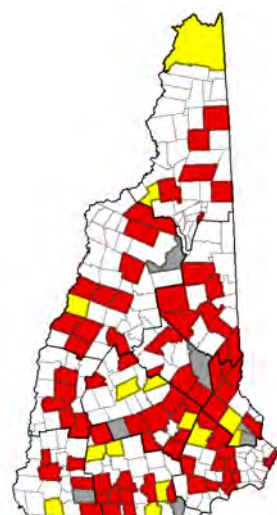
Cordulidae (Emeralds)



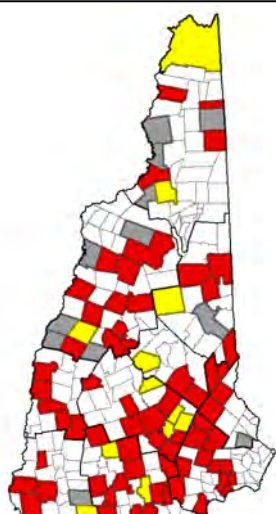
Cordulia shurtleffi
(American Emerald)



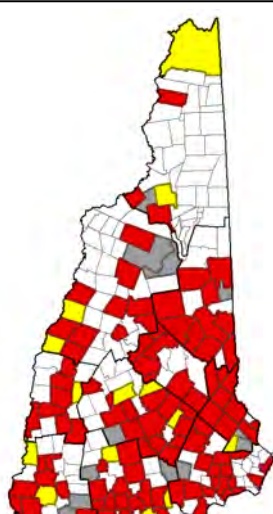
Dorocordulia lepida
(Petite Emerald)



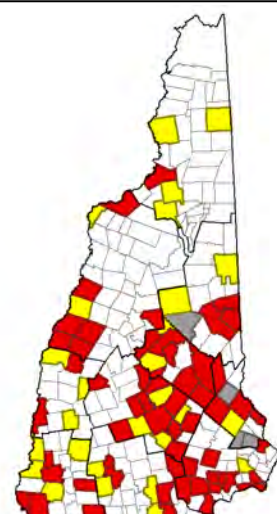
Dorocordulia libera
(Racket-tailed Emerald)



Epitheca canis
(Beaverpond Baskettail)



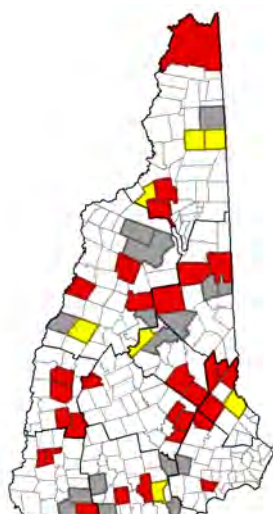
Epitheca cynosura
(Common Baskettail)



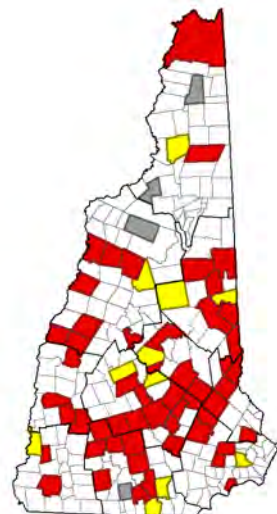
Epitheca princeps
(Prince Baskettail)



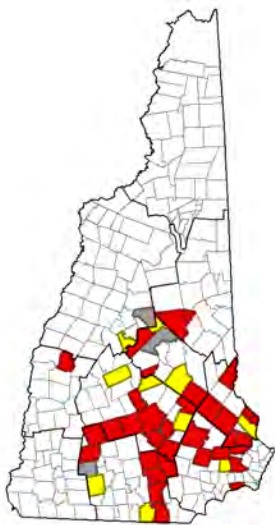
Epitheca semiaquea
(Mantled Baskettail)



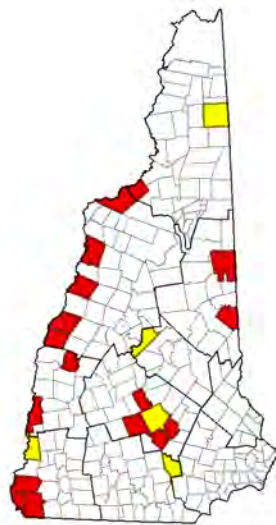
Epitheca spinigera
(Spiny Baskettail)



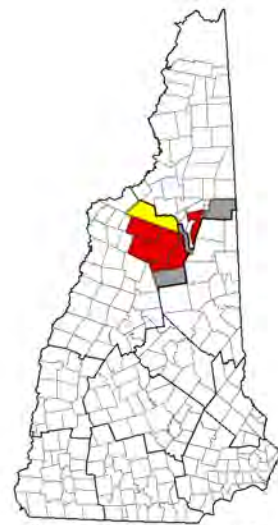
Helocordulia uhleri
(Uhler's Sundragon)



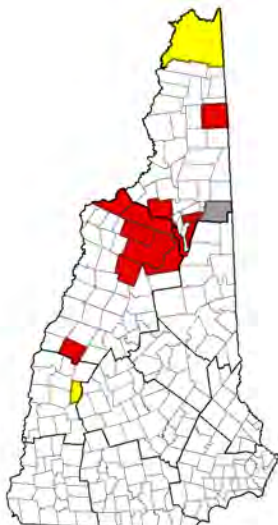
Neurocordulia obsoleta
(Umber Shadowdragon)



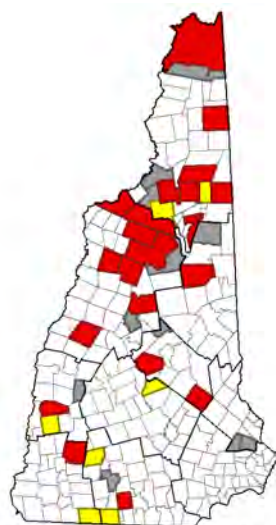
Neurocordulia yamaskanensis
(Stygian Shadowdragon)



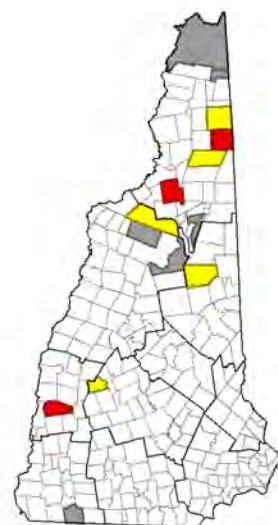
Somatochlora albicincta
(Ringed Emerald)



Somatochlora cingulata
(Lake Emerald)



Somatochlora elongata
(Ski-tipped Emerald)



Somatochlora forcipata
(Forecipate Emerald)



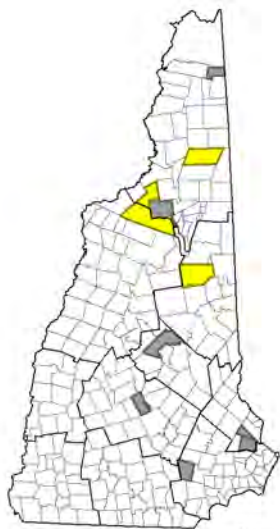
Somatochlora franklini
(Delicate Emerald)



Somatochlora georgiana
(Coppery Emerald)



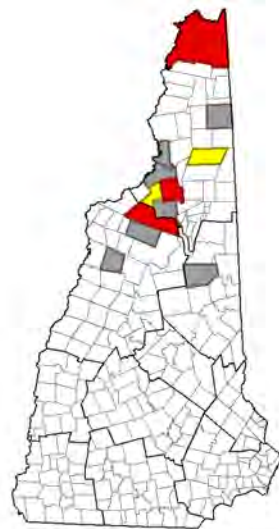
Somatochlora incurvata
(Incurvate Emerald)



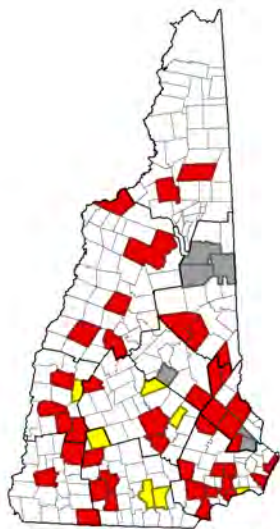
Somatochlora kennedyi
(Kennedy's Emerald)



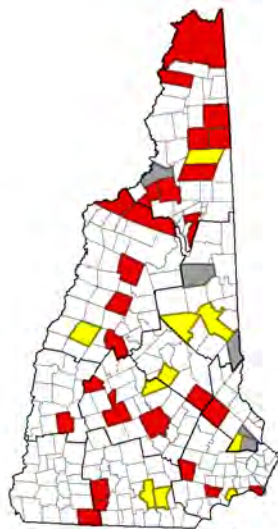
Somatochlora linearis
(Mocha Emerald)



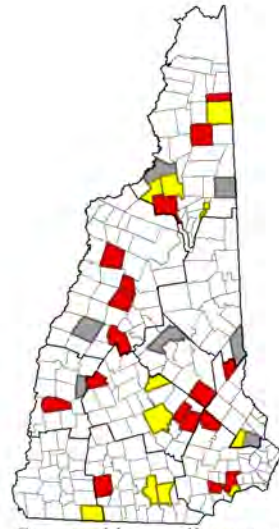
Somatochlora minor
(Ocellated Emerald)



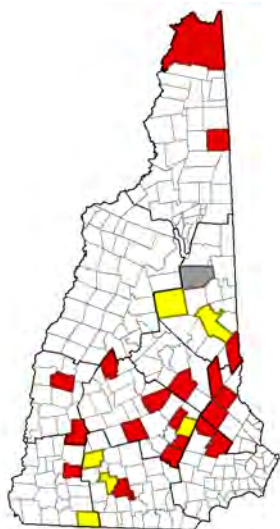
Somatochlora tenebrosa
(Clamp-tipped Emerald)



Somatochlora walshii
(Brush-tipped Emerald)



Somatochlora williamsoni
(Williamson's Emerald)

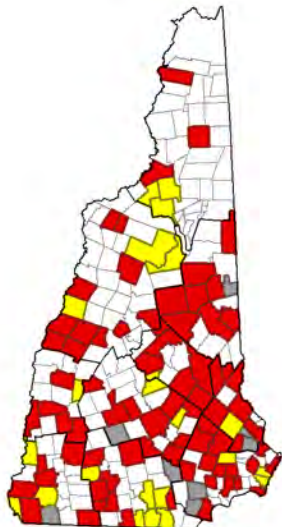


Williamsoma fletcheri
(Ebony Boghaunter)

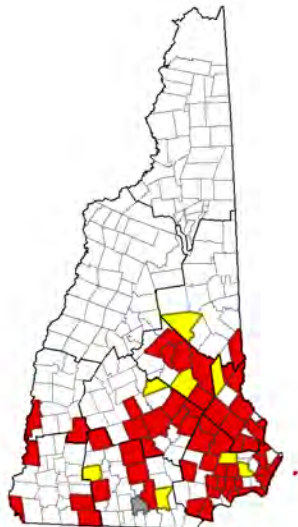


Williamsoma lintneri
(Ringed Boghaunter)

Libellulidae (Skimmers)



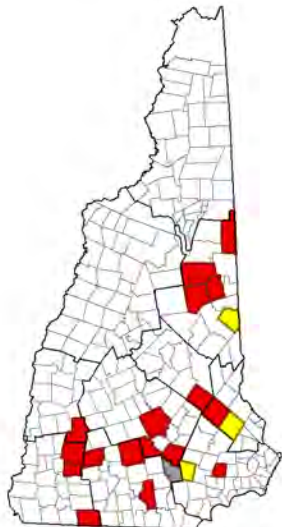
Celithemis elisa
(Calico Pennant)



Celithemis eponina
(Halloween Pennant)



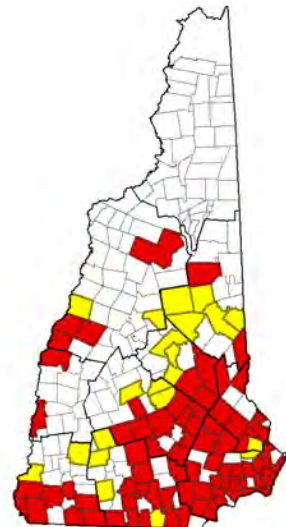
Celithemis fasciata
(Banded Pennant)



Celithemis martha
(Martha's Pennant)



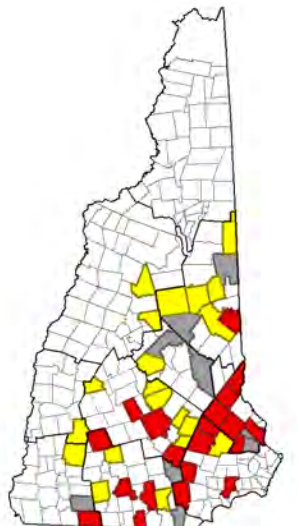
Erythrodiplax berenice
(Seaside Dragonlet)



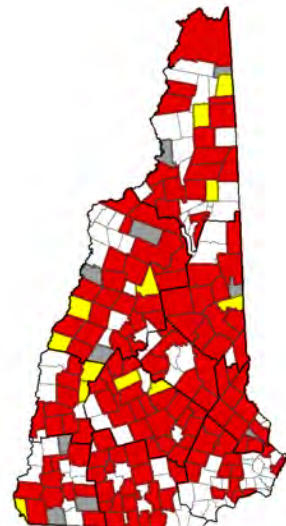
Erythemis simplicicollis
(Eastern Pondhawk)



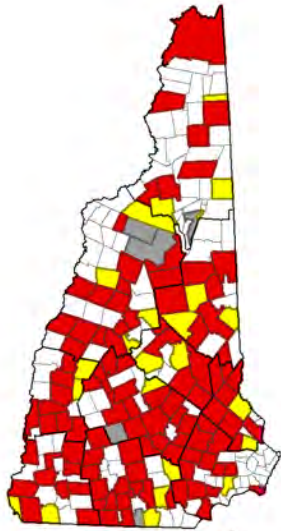
Ladona deplanata
(Blue Corporal)



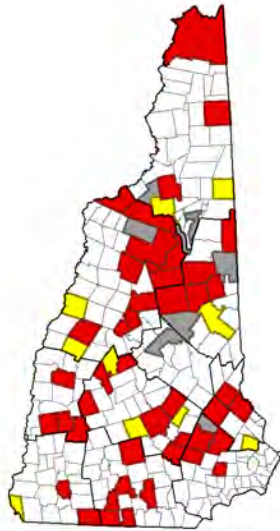
Ladona exusta
(White Corporal)



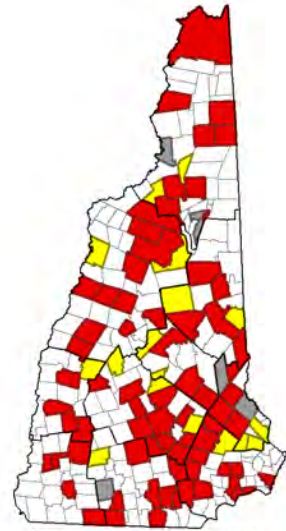
Ladona julia
(Chalk-fronted Corporal)



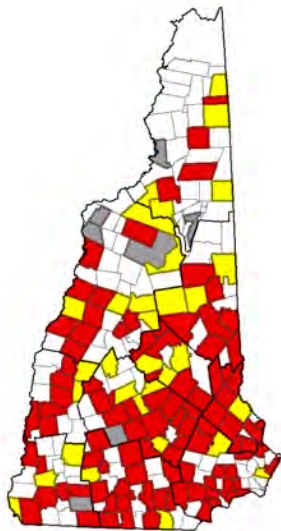
Leucorrhinia frigida
(Frosted Whiteface)



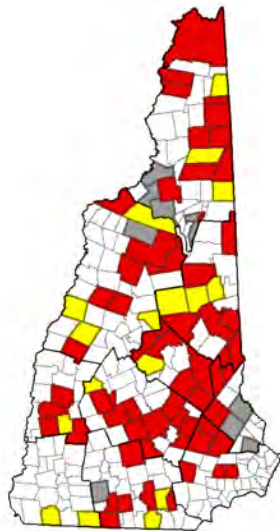
Leucorrhinia glacialis
(Crimson-ringed Whiteface)



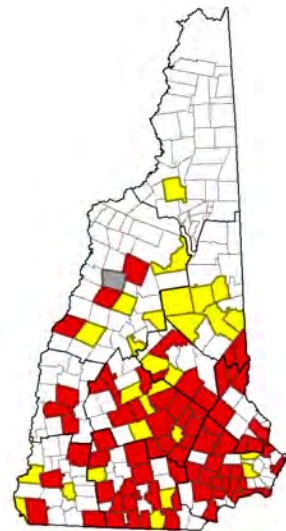
Leucorrhinia hudsonica
(Hudsonian Whiteface)



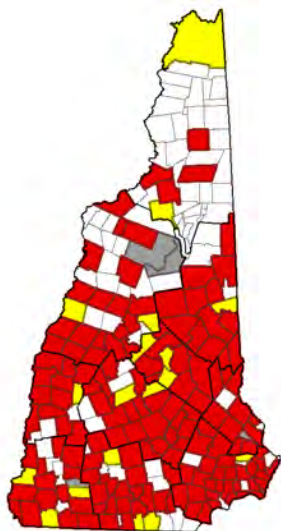
Leucorrhinia intacta
(Dot-tailed Whiteface)



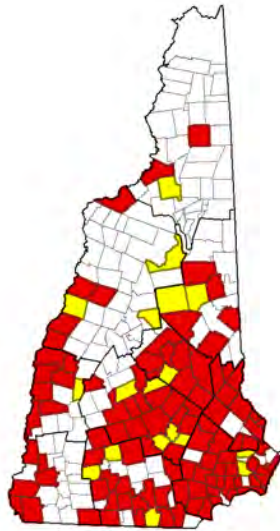
Leucorrhinia proxima
(Belted Whiteface)



Libellula cyanea
(Spangled Skimmer)



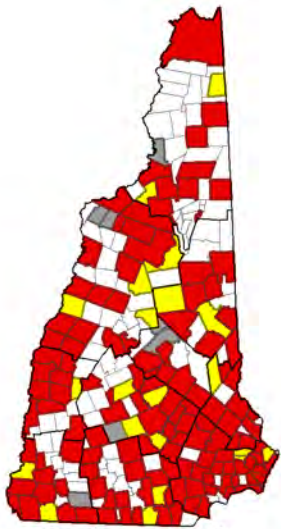
Libellula incesta
(Slaty Skimmer)



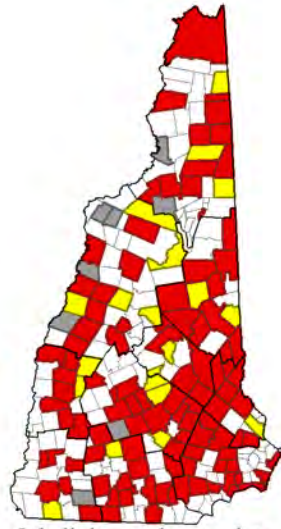
Libellula luctuosa
(Widow Skimmer)



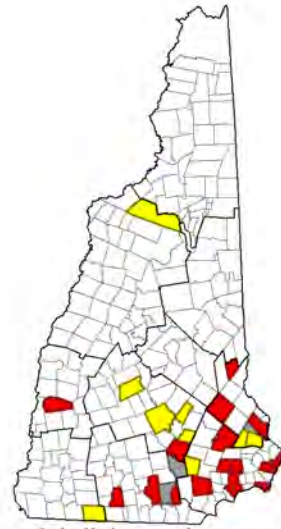
Libellula needhami
(Needham's Skimmer)



Libellula pulchella
(Twelve-spotted Skimmer)



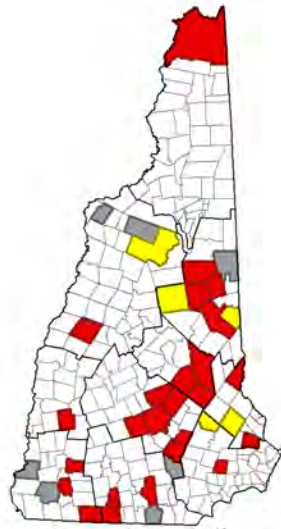
Libellula quadrimaculata
(Four-spotted Skimmer)



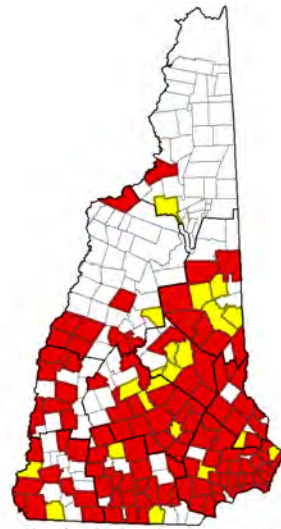
Libellula semifasciata
(Painted Skimmer)



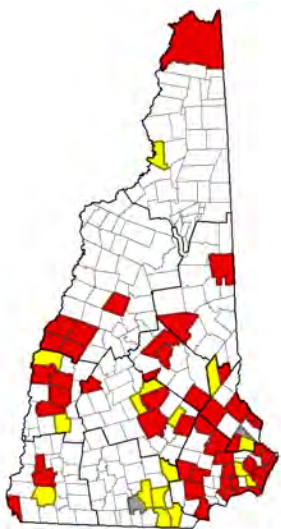
Libellula vibrans
(Great Blue Skimmer)



Nannothemis bella
(Elfin Skimmer)



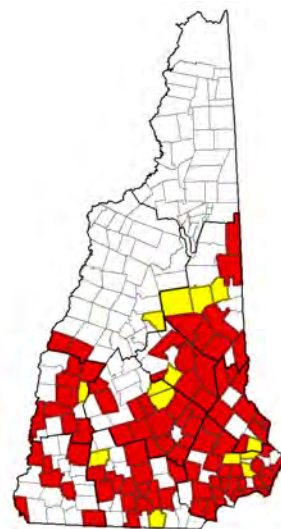
Pachydiplax longipennis
(Blue Dasher)



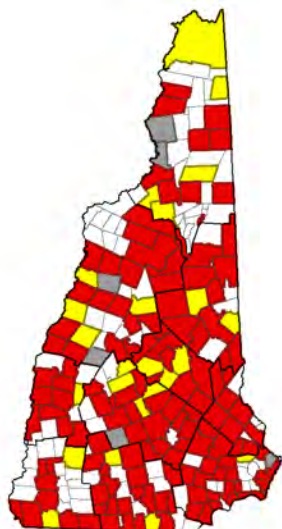
Pantala flavescens
(Wandering Glider)



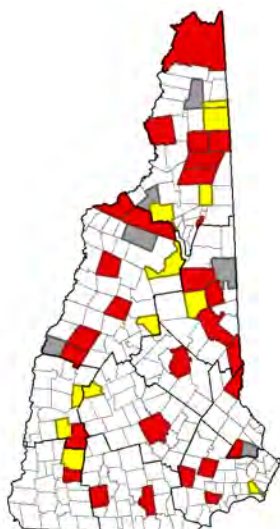
Pantala hymenaea
(Spot-winged Glider)



Perithemis tenera
(Eastern Amberwing)



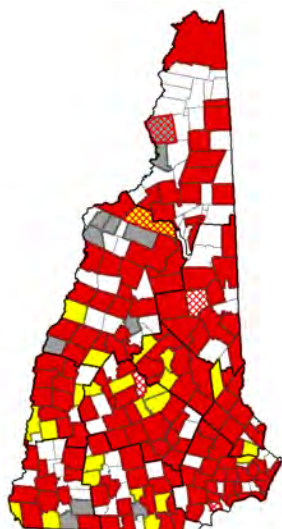
Plathemis lydia
(Common Whitetail)



Sympetrum costiferum
(Saffron-winged Meadowhawk)



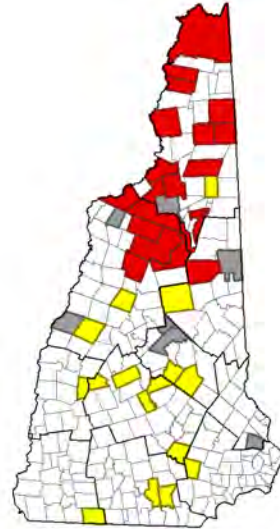
Sympetrum danae
(Black Meadowhawk)



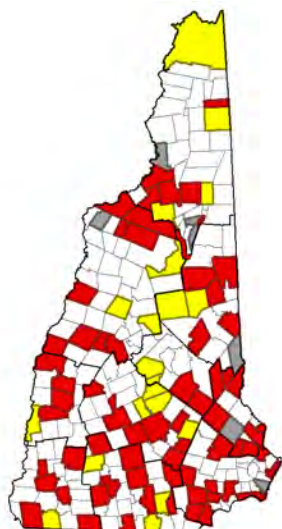
Sympetrum internum
(Cherry-faced Meadowhawk)



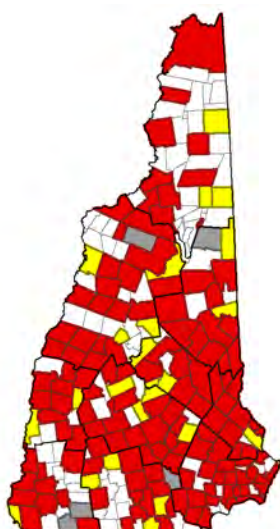
Sympetrum internum x obtrusum
hybrid Meadowhawk (Cherry-faced/White-faced)



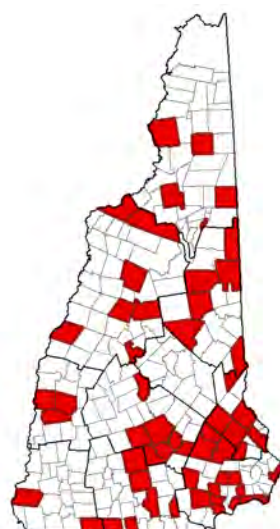
Sympetrum obtrusum
(White-faced Meadowhawk)



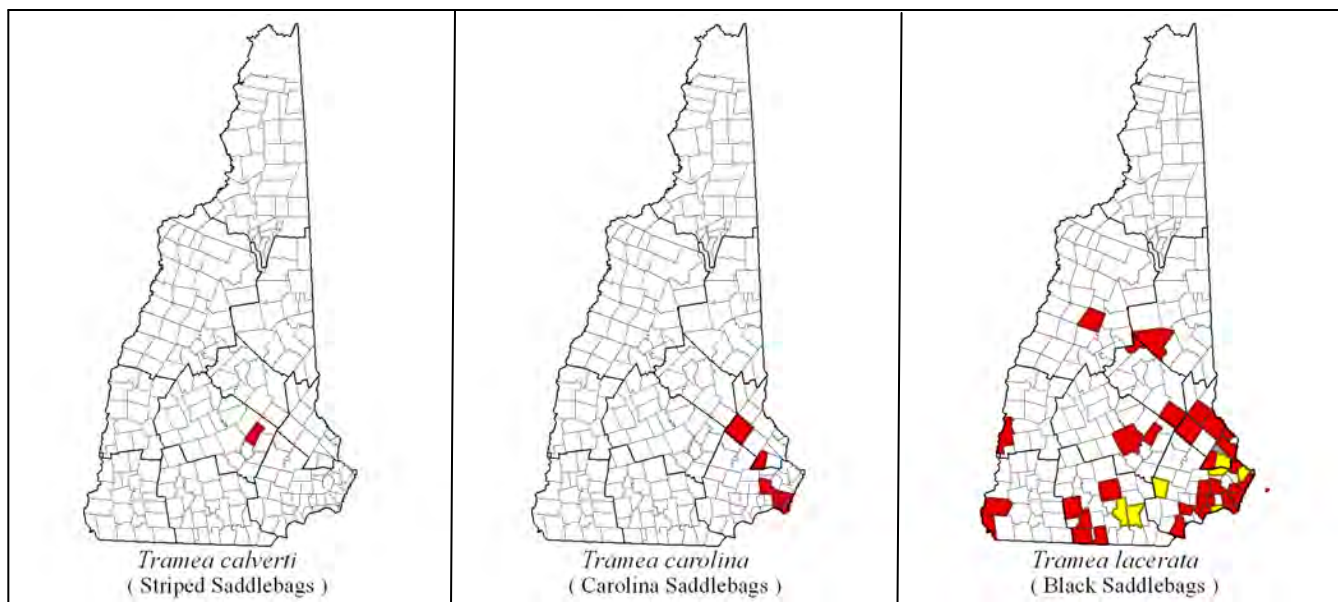
Sympetrum semicinctum
(Band-winged Meadowhawk)



Sympetrum vicinum
(Autumn Meadowhawk)



Sympetrum sp.
(unidentified meadowhawk)



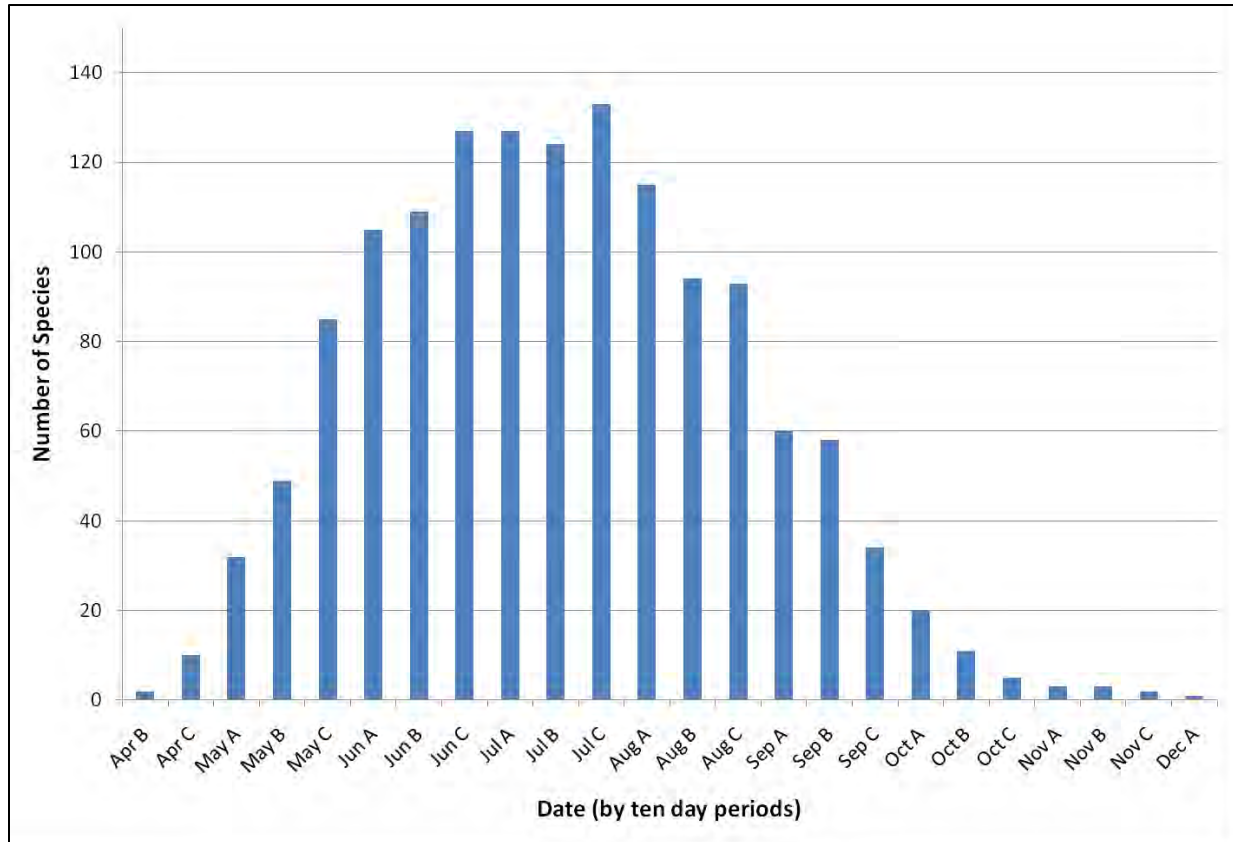


Figure 5. Seasonal variation in odonate species richness during the NHDS, 2007-2011. Dates are grouped in to ten day periods (e.g., May A = 1-10 May, May B = 11-20 May, and May C = 21-31 May). Figure includes all exuviae records but no larvae: see Table 3 for more details.

Table 3. Flight periods of NH Odonata by ten day period (e.g., May A = 1-10 May, May B = 11-20 May, and May C = 21-31 May). Numbers represent the total number of records in the NHDS database for each period, *not* including larvae. These totals *do* include exuviae, which under certain conditions can persist until after a species' normal flight period is over. A red number in a column indicates that all records for that time period were of exuviae, *and* that the period in question was *later* than any recorded date for flying adults. Early dates in this table apply to either adults or early-season exuviae (e.g., records that pre-date detection of flying adults), while late dates are restricted to adults. In cases where older data extend a species flight period beyond that detected during the NHDS, these early/late dates are shown in red, but actual numbers of records are not included in the table. Species not recorded during the NHDS, but for which flight period data are available, are indicated in red. No dates are available for *Aeshna sitchensis* or *Ophiogomphus colubrinus*, so these species are omitted from the table.

			APRIL		MAY			JUNE			JULY			AUGUST			SEPTEMBER			OCTOBER			NOVEMBER			DEC	Σ ²
Scientific Name ¹	Early	Late	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	
CALOPTERYGIDAE (BROAD-WINGED DAMSELS)																											
<i>Calopteryx aequabilis</i>	05/20	09/12					24	26	40	12	12	9	5	1	1	1		1									132
<i>Calopteryx amata</i>	05/29	08/09					6	12	12	17	6	7	8	5													73
<i>Calopteryx dimidiata</i>	06/09	08/18						1		1	3	10	2	5	1												23
<i>Calopteryx maculata</i>	05/20	09/13				2	39	48	52	39	59	61	54	44	32	14	2	2									449
<i>Hetaerina americana</i>	07/30	09/23												3	7	1	4	6	1								23
LESTIDAE (SPREADWINGS)																											
<i>Lestes congener</i>	07/10	10/28									1	5	7	7	13	24	18	21	18	4	3						122
<i>Lestes disjunctus</i>	05/28	10/18					1	1	3	4	6	26	39	27	34	46	15	10	10								222
<i>Lestes dryas</i>	06/01	08/20						5	3	2	1	2	1		1												15
<i>Lestes eurinus</i>	05/25	08/23					3	3	9	8	16	10	6	2	5	1											63
<i>Lestes forcipatus</i>	06/11	09/26							1		1	3	7	7	7	8	4	2									40
<i>Lestes inaequalis</i>	05/22	08/01					5	7	10	7	14	4	3	1													52
<i>Lestes rectangularis</i>	06/02	10/23						2	6	4	13	19	30	34	46	36	19	20	10								240
<i>Lestes unguiculatus</i>	06/16	09/20												1				1									2
<i>Lestes vigilax</i>	05/28	10/6					1	5	10	13	41	47	57	48	27	26	4	2									281
COENAGRIONIDAE (POND DAMSELS)																											
<i>Amphiagrion saucium</i>	05/27	08/02					4	7	4	3	4	3	1														26
<i>Argia apicalis</i>	06/16	08/17							1		2	2	2		3												10
<i>Argia fumipennis</i>	05/18	10/02				1	2	14	13	19	53	74	68	53	65	34	13	11									423
<i>Argia moesta</i>	05/20	10/02				1	2	6	20	14	24	37	29	17	23	8	7	5									193
<i>Chromagrion conditum</i>	05/04	08/27			6	26	59	62	32	21	27	13	6	1	1	1											256
<i>Coenagrion interrogatum</i>	06/13	06/27								1																	1
<i>Coenagrion resolutum</i>	05/20	07/04				1		1	3	3																	8
<i>Enallagma annexum</i>	05/20	08/26				1	2	2	2	7	3	1	3	3		1											25
<i>Enallagma antennatum</i>	07/08	07/30																									0
<i>Enallagma aspersum</i>	05/16	09/30				1	2	4	10	5	13	28	36	21	21	19	9	6	7								182
<i>Enallagma boreale</i>	05/11	08/16				5	13	8	8	6	3	7	5	3													58
<i>Enallagma carunculatum</i>	07/06	08/23												1		1											2

Table 3. continued

Scientific Name ¹	Early	Late	APRIL		MAY			JUNE			JULY			AUGUST			SEPTEMBER			OCTOBER			NOVEMBER			DEC	Σ^2
			B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	
<i>Enallagma civile</i>	06/01	10/21						2	3	2	7	8	16	8	5	8	7	8	6	4	1	1					87
<i>Enallagma divagans</i>	05/30	08/14					2	10	10	7	6	1	3		1												41
<i>Enallagma durum</i>	07/21	07/30											2														2
<i>Enallagma ebrium</i>	05/15	09/14				1	4	19	24	22	63	44	42	18	13	9	2	1									262
<i>Enallagma exsulans</i>	06/03	09/13						2	7	10	23	42	24	15	21	7	6	2									159
<i>Enallagma geminatum</i>	05/29	09/27					1	6	3	7	23	37	41	33	17	15	4	2	1								190
<i>Enallagma hageni</i>	05/23	09/06					3	8	16	27	39	49	32	17	8	5	1										205
<i>Enallagma laterale</i>	05/05	07/08				3	6	9	5	3	1																27
<i>Enallagma minusculum</i>	05/27	08/23					1	1		1	8	10	10	8	1	2											43
<i>Enallagma pictum</i>	06/28	08/26								2	3	5	12	7	9	2											48
<i>Enallagma recurvatum</i>	06/07	06/28						1		1																	2
<i>Enallagma signatum</i>	06/08	09/19								3	18	31	34	20	14	11	1	1									134
<i>Enallagma traviatum</i>	07/02	08/23									10	3	5	5	2	1											26
<i>Enallagma vernale</i>	05/02	07/13			2	10	10	11	6	4	2																46
<i>Enallagma vesperum</i>	05/28	09/19					1		3	1	10	8	10	4	3	7		1									49
<i>Ischnura hastata</i>	07/22	10/06											2	3	3	3	1										12
<i>Ischnura kellicotti</i>	06/15	09/06							2	6	10	15	4	13	11	10											72
<i>Ischnura posita</i>	05/07	09/17			3	9	23	24	21	16	27	17	29	24	28	10	6	1									240
<i>Ischnura verticalis</i>	04/20	10/14	1	2	19	36	91	88	88	63	116	112	104	89	90	83	33	25	10	2							1054
<i>Nehalennia gracilis</i>	05/07	09/13			1	1	5	12	12	14	17	23	15	14	6	4	2	1									127
<i>Nehalennia irene</i>	05/20	09/25					11	16	25	21	36	35	18	18	6	6	1		1								194
AESHNIDAE (DARNERS)																											
<i>Aeshna canadensis</i>	06/08	10/11						1		2	11	16	28	39	51	63	33	24	15	4	1						288
<i>Aeshna clepsydra</i>	07/09	10/11									1	4	6	5	7	16	7	7	7	2							62
<i>Aeshna constricta</i>	07/08	10/10									1	1	10	6	4	3	5	4	2	1							37
<i>Aeshna eremita</i>	06/29	10/07								2		11	16	16	10	22	12	10	6								106
<i>Aeshna interrupta</i>	06/27	10/12								1		9	8	11	11	19	8	3	8		1						79
<i>Aeshna juncea</i>	07/11	08/25										1		1		1											3
<i>Aeshna subarctica</i>	07/26	09/25											1			6			1								8
<i>Aeshna tuberculifera</i>	06/16	10/12							2	2	3	10	21	36	24	26	15	18	9	4	2						173
<i>Aeshna umbrosa</i>	06/07	11/16						1	1	2	7	19	23	30	28	37	24	26	24	7	6	5	5	3			249
<i>Aeshna verticalis</i>	07/03	09/28									1	4	8	13	14	14	11	12	8								85
<i>Anax junius</i>	04/26	11/26		3	12	12	46	49	43	42	67	64	69	47	50	41	21	25	10	5	2	3	3	1	3		619
<i>Anax longipes</i>	06/15	07/27							2	2		1	5														10
<i>Basiaeschna janata</i>	04/24	07/20		1	6	21	51	33	24	18	6	3	3	3													170
<i>Boyeria grafiana</i>	06/19	09/03							1	4	2	1	4	1	2	5	2										22
<i>Boyeria vinosa</i>	06/02	09/26						4	9	15	30	47	27	22	28	26	15	14	5								250
<i>Epiaeschna heros</i>	06/03	08/22								2		1	4	2	3	1											13

Table 3. continued

Scientific Name ¹	Early	Late	APRIL		MAY			JUNE			JULY			AUGUST			SEPTEMBER			OCTOBER			NOVEMBER			DEC	Σ^2
			B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	
<i>Gomphaeschna furcillata</i>	05/07	07/08			6	17	10	22	11	3	1																70
<i>Nasiaeschna pentacantha</i>	05/07	07/21			1		2	8	8	1	1																21
<i>Rhioaeschna mutata</i>	05/20	07/07				1	3	8	5	2	2																21
GOMPHIDAE (CLUBTAILS)																											
<i>Arigomphus furcifer</i>	05/22	08/23					3	7	18	6	10	3	3			1											51
<i>Arigomphus villosipes</i>	05/13	08/15				1	3	2	6	3	11	4	5	3	1												40
<i>Dromogomphus spinosus</i>	06/05	09/30						7	13	21	33	35	38	19	33	17	8	4	1								230
<i>Gomphus abbreviatus</i>	05/20	07/27				1	17	26	24	10	9	12	4	1	1			1									106
<i>Gomphus adelphus</i>	05/21	07/26					15	8	18	9	4	6	7		1												69
<i>Gomphus borealis</i>	05/07	08/06			2	4	9	23	15	9	4	2	1	2													71
<i>Gomphus descriptus</i>	05/20	07/22				1	10	10	16	4	2	3															46
<i>Gomphus exilis</i>	05/05	08/09			3	11	60	66	51	26	35	31	10	1													295
<i>Gomphus lividus</i>	05/17	07/03				1	11	5	2	1																	21
<i>Gomphus quadricolor</i>	05/30	06/30					3	3	1		1		1														9
<i>Gomphus spicatus</i>	05/05	08/14			1	9	31	23	19	7	4	8	2														104
<i>Gomphus vastus</i>	05/28	07/22					3	17	17	11	18	8	9	2	1	1											87
<i>Gomphus ventricosus</i>	06/01	06/22						2		1																	3
<i>Hagenius brevistylus</i>	06/03	09/20						4	19	24	28	31	19	21	26	13	3	3									192
<i>Lanthus parvulus</i>	05/20	07/23				1	2	6	10	7	1	2	3	1													33
<i>Lanthus vernalis</i>	05/24	08/06					3	4	2	1	1																12
<i>Ophiogomphus aspersus</i>	05/23	08/22					9	8	10	8	6	4	5	1				1									52
<i>Ophiogomphus carolus</i>	05/29	08/03					4	2	3	2		6	2	1													21
<i>Ophiogomphus howeii</i>	05/26	06/04					5	13		3	2	3	1					1									28
<i>Ophiogomphus mainensis</i>	05/09	07/30			1	1	4	5	4	5	2		3														26
<i>Ophiogomphus rupinsulensis</i>	05/29	08/28					7	18	16	8	4	4	3	2	1	1											64
<i>Progomphus obscurus</i>	06/10	08/21						1	7	6	3	9	2					1									29
<i>Stylogomphus albistylus</i>	06/07	08/28						3	17	11	12	12	5	4	3	1											70
<i>Stylurus amnicola</i>	06/14	07/01							1	3	17	13	2	2													38
<i>Stylurus scudleri</i>	07/01	09/20									7	19	9	7	5	3	3	1									55
<i>Stylurus spiniceps</i>	06/30	10/06								1	20	25	19	10	11	3	3	3									95
CORDULEGASTRIDAE (SPIKETAILS)																											
<i>Cordulegaster diastatops</i>	05/21	08/19					12	21	17	12	9	6	1	1													79
<i>Cordulegaster maculata</i>	05/21	07/26					20	14	29	13	11	10	8	1													113
<i>Cordulegaster obliqua</i>	05/23	08/04					2	1	2		1	1	2	1													10
MACROMIIDAE (CRUISERS)																											
<i>Didymops transversa</i>	05/09	07/31			1	9	46	34	25	12	4	5	3														140
<i>Macromia illinoensis</i>	05/30	09/20					3	3	12	17	14	17	20	6	7	3	1	2									107

Table 3. continued

Table 3. continued			APRIL		MAY			JUNE			JULY			AUGUST			SEPTEMBER			OCTOBER			NOVEMBER			DEC	Σ ²
Scientific Name ¹	Early	Late	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	
CORDULIDAE (EMERALDS)																											
<i>Cordulia shurtleffi</i>	04/30	08/06		1	4	15	48	34	24	21	10	10	8	3		2										181	
<i>Dorocordulia lepida</i>	05/07	09/08			1		5	19	13	8	9	7	6	1		1	1									71	
<i>Dorocordulia libera</i>	05/20	08/27				1	25	42	37	16	13	11	10	4		2										162	
<i>Epitheca canis</i>	04/30	07/13		1	11	27	44	22	9	6	2	1														123	
<i>Epitheca cynosura</i>	04/29	08/19		1	4	12	56	58	32	13	15	7	4	1	3	1										209	
<i>Epitheca princeps</i>	05/20	09/01				1	2	4	18	15	22	15	9	10	2	1	1									100	
<i>Epitheca semiaquea</i>	06/17	06/23																								0	
<i>Epitheca spinigera</i>	05/09	07/17			1	4	22	8	6	2		4	1													48	
<i>Helocordulia uhleri</i>	05/07	08/03			2	7	22	22	15	6	6	2	2	1												85	
<i>Neurocordulia obsoleta</i>	05/28	08/02					4	16	16	15	12	9	8	6	1	3		1								93	
<i>Neurocordulia yamaskanensis</i>	05/31	07/04					2	3	13	3	5	4	2		1											33	
<i>Somatochlora albicincta</i>	07/03	08/27											2	2		2										6	
<i>Somatochlora cingulata</i>	06/15	09/25								1		1	4	4	1	3	1	1	1							17	
<i>Somatochlora elongata</i>	06/05	09/11						1	2	2	1	2	5	8	6	5		1								33	
<i>Somatochlora forcipata</i>	06/16	08/12							1		1			1												3	
<i>Somatochlora franklini</i>	06/23	08/26								1	2	1	1			1										6	
<i>Somatochlora georgiana</i>	07/30	08/05											1	1												2	
<i>Somatochlora incurvata</i>	07/10	09/02													2	3	1									6	
<i>Somatochlora kennedyi</i>	05/29	07/04																								0	
<i>Somatochlora linearis</i>	07/21	08/08											2	5												7	
<i>Somatochlora minor</i>	06/23	08/19								3				1												4	
<i>Somatochlora tenebrosa</i>	06/25	09/10								1	7	6	15	16	10	4	3									62	
<i>Somatochlora walshii</i>	06/06	08/29						1	1	3	2	4	9	3	3	6										32	
<i>Somatochlora williamsoni</i>	06/17	09/01							1		4	3	4	7	4	3										26	
<i>Williamsonia fletcheri</i>	05/05	07/08			4	9	14	3		3																33	
<i>Williamsonia lintneri</i>	04/30	06/15		2	12	10	5	2																		31	
LIBELLULIDAE (SKIMMERS)																											
<i>Celithemis elisa</i>	05/09	09/23			1	1	6	15	23	20	30	35	44	29	21	9	6	1	1							242	
<i>Celithemis eponina</i>	06/21	08/29								1	16	22	36	26	12	4										118	
<i>Celithemis fasciata</i>	06/21	07/24								1	1	1	1													4	
<i>Celithemis martha</i>	06/17	08/27								2	4	9	3	7	12	3										40	
<i>Erythemis simplicicollis</i>	05/29	09/10					2	10	7	11	29	30	48	37	27	13	4									218	
<i>Erythrodiplax berenice</i>	05/29	08/30							1		2		5	6		1										15	
<i>Ladona deplanata</i>	05/20	06/15				2		1	1																	4	
<i>Ladona exusta</i>	04/29	07/17			1	3	14	17	9	2	3															49	
<i>Ladona julia</i>	04/29	08/23		2	7	37	102	113	84	62	61	33	22	7	1	1										533	
<i>Leucorrhinia frigida</i>	05/09	09/06			1	7	27	50	39	28	51	41	41	20	16	7										328	

Table 3. continued

Scientific Name ¹	Early	Late	APRIL		MAY			JUNE			JULY			AUGUST			SEPTEMBER			OCTOBER			NOVEMBER			DEC	Σ^2
			B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	
<i>Leucorrhinia glacialis</i>	05/05	08/19			3	10	12	15	16	11	8	6	3	2	3												89
<i>Leucorrhinia hudsonica</i>	04/14	08/14	3	4	23	33	50	30	14	9	8	6	6		1												187
<i>Leucorrhinia intacta</i>	04/30	08/08		1	7	15	53	68	44	28	30	24	19	5													295
<i>Leucorrhinia proxima</i>	05/07	08/23			2	1	5	17	18	11	18	10	9	6	1	1											99
<i>Libellula cyanea</i>	05/25	09/26					10	19	22	21	37	30	37	21	12	5	3										217
<i>Libellula incesta</i>	05/25	10/02					6	14	36	27	80	100	117	85	87	49	14	8	4								628
<i>Libellula luctuosa</i>	05/29	09/23					3	4	11	12	45	51	66	54	33	18	13	1									313
<i>Libellula needhami</i>	07/04	08/10									2		5	1													8
<i>Libellula pulchella</i>	05/28	10/12					2	19	20	16	41	59	77	61	50	24	18	6	1	2	1						399
<i>Libellula quadrimaculata</i>	05/02	08/27			8	23	56	67	44	20	15	12	16	3	1												265
<i>Libellula semifasciata</i>	05/27	08/18					3	5	4	1	2	2	6		1												24
<i>Libellula vibrans</i>	06/14	08/21											1														1
<i>Nannothemis bella</i>	05/20	08/20				1	5	5	6	7	10	12	3		2												51
<i>Pachydiplax longipennis</i>	06/10	10/06						2	12	8	42	73	82	62	55	29	13	6	2	1							390
<i>Pantala flavescens</i>	06/01	10/23							1	1	3	4	10	16	15	10	11	5	4	4		1					85
<i>Pantala hymenaea</i>	05/21	09/07					1	2		1	4	2	3	1	1		1										16
<i>Perithemis tenera</i>	06/04	09/13								4	28	38	54	47	38	24	6	1									242
<i>Plathemis lydia</i>	05/05	10/08			1	12	35	56	45	30	41	47	51	32	31	18	10	3	6	1							422
<i>Sympetrum costiferum</i>	06/30	10/06								1	2	3	4	5	8	13	6	4	5	1							52
<i>Sympetrum danae</i>	08/06	09/21												1		2	1										4
<i>Sympetrum internum</i>	06/05	10/18						1	3	2	17	21	41	46	46	46	24	25	12	3	1						288
<i>Sympetrum internum x obtrusum</i>																1	2	1			1						5
<i>Sympetrum obtrusum</i>	07/10	10/09									1	3	6	7	2	21	3	2	2	3							50
<i>Sympetrum semicinctum</i>	06/18	10/20							1	1	5	6	11	20	19	19	12	10	5	1	1						111
<i>Sympetrum vicinum</i>	06/23	12/04								2	3	18	33	35	55	72	49	50	30	16	8	15	11	11	8	3	420
<i>Tramea calverti</i>	08/31	08/31														1											1
<i>Tramea carolina</i>	06/01	10/06						2	2	2		2	7	1	3	1		1		1							22
<i>Tramea lacerata</i>	05/26	10/09					2	2	5	3	4	4	26	3	7	4	10	6	4	3							84

¹ Common names in Table 2² Sum of all records in NHDS database

Discussion

Completion of the NHDs allows for evaluation of the project with respect to its three original goals:

- 1) Obtain better information on the distribution and abundance of Odonata of potential conservation concern in New Hampshire,
- 2) Collect data from poorly surveyed parts of the state, and
- 3) Increase public awareness of dragonfly diversity and conservation.

In addition to these goals, the following sections will address future uses of NHDS data, and future survey needs in terms of habitats and/or regions of New Hampshire. An additional use of the NHDS data, and not one explicitly outlined at the project's inception, is in scientific research. Already there is interest in this significant data set from researchers working on community ecology, habitat modeling, and evolutionary genetics.

Conservation

Hunt (2006) identified 56 species and three habitats (Rivers and Streams, Southern Peatlands, and Northern Lakes/Peatlands) of potential conservation concern in a preliminary conservation assessment of the Odonata of New Hampshire. Based on data collected during the NHDS, a significant majority of these species appear more common and/or widespread than previously believed, with well over a thousand records of all but four of the 56 species. Perhaps only 10-12 species from a smaller list of 26 highest priority species warrant careful consideration. A more detailed overview of NHDS coverage with respect to the three priority habitat groups is presented in the next section.

It is not within the scope of this report to carefully evaluate NHDS data with respect to species S-ranks or listing status, but an immediate outcome of the project's completion will be to work with the New Hampshire Natural Heritage Bureau to update S-ranks and revise the Bureau's list of tracked species. As part of this process, the list of species considered "special concern" in 2009 will be revisited with the NH Fish and Game Department. In addition, data from the NHDS will be used in a recently-initiated Northeast Region conservation assessment being led by the New York Heritage Program and funded through a Northeast Regional Conservation Needs grant, with funds provided by State Wildlife Grants.

From a conservation standpoint, it will be important to consider repeating the NHDS at some point in the future, probably in the 20-30 year range. Current efforts have resulted in a strong baseline data set on Odonata distributions in the state, against which future changes – be they due to climate change, habitat loss, or other factors – can be measured.

Survey Coverage

By all measures, Goal 2 was met more successfully than ever imagined, and New Hampshire is now one of the best surveyed states in the Northeast, if not the country. A minimum of 115 species have been recorded in all ten counties, and data of some sort exist for 244 of the state's 259 towns. 37% of towns are known to contain a minimum of 50 species, and

the average species richness across all towns is 38 species (41 if only towns with data are included). Looking broadly at the cumulative data, only a handful of locations could be considered in need of additional surveys. These are 1) the central highlands of northern Coos County (e.g., Kilkenny to Dixville), 2) northwest Grafton County, 3) eastern White Mountains (e.g., Bean's Purchase to Bartlett, northern Presidential Range), 4) northwest Merrimack County (Danbury to Newbury) 5) northern Cheshire County (e.g., Alstead to Sullivan), and, to a lesser extent, 6) eastern Rockingham County away from the immediate coast. These areas tend to appear as concentrations of gray- or yellow-shaded towns in Figure 3d.

However, none of these “gaps” are probably significant at a larger scale, and a more important measure of coverage is likely to be habitat related. Although a detailed analysis of habitat is not part of this report, consideration of both the geographic gaps listed above and species priorities identified prior to the survey allows for finer scale identification of priority survey areas in the future. The following three paragraphs provide an overview of both existing coverage and future needs with respect to three priority habitats: 1) rivers and streams, 2) southern peatlands, and 3) northern lakes and peatlands.

Although riverine species were generally found more common and widespread than previously believed, a number of major rivers (primarily in the north) were poorly surveyed, and should be considered priorities for future work. These include the Ammonoosuc, Mohawk, Israel, and Swift/Dead Diamond Rivers, the Connecticut River above Lancaster, and much of the Upper Ammonoosuc system (including Nash Stream and Phillips Brook). Many of these rivers fall within geographic priority areas (1) and (2) as listed above. More work on southern rivers (e.g., upper Ashuelot, Pemigewasset, Cold, Sugar, and Mascoma) may also yield significant records, but data on riverine species is generally quite good in the south, and the added value of additional surveys is likely lower except in a more local context.

Southern peatlands are generally defined as those south of the White Mountains, and from a conservation perspective are further restricted to those in the southeastern portion of the state. The generally high level of coverage in this habitat is illustrated by the number of new records for *Williamsonia lintneri* during the NHDS, along with other species regularly associated with peatlands. The most significant gap in coverage is seasonal in nature, and pertains to peatlands suitable for *W. lintneri* in central and southern Carroll County. Such areas (e.g., Effingham, Ossipee) should be surveyed in late May so as to determine the northern extent of *W. lintneri* range in New Hampshire (the species is found at this latitude in Maine, Brunelle and deMaynadier 2005). Other priority species of southern peatlands were also usually found to be more common than previously believed, with exceptions to be considered during the S-rank process.

The sheer number of lakes and peatlands in northern New Hampshire (White Mountains and Coos County), combined with a relatively small number of survey visits to the north, makes a thorough assessment of coverage difficult. Such an assessment is further complicated because the priority species in these habitats are often difficult to capture or occur in naturally low abundance. Despite these limitations, available data show that many species are fairly widespread, and extrapolation would suggest they occur at many more locations than where they

were detected. Such a prediction could be tested with further work in regions (1) and (3) as listed above, as well as in the Sandwich Range and the area around Lake Umbagog.

Outreach

In addition to reaching 242 people through the training workshops, information on Odonata and the NHDS was presented through a number of slide presentations to NH Audubon Chapters, garden clubs, and similar groups. NH Audubon's Massabesic Center held three introductory workshops modeled on the NHDS training workshop, and one of the NHDS volunteers led a dragonfly workshop for BearPaw Regional Greenways. The collaboration with Amoskeag Fishways not only resulted in data for the Merrimack River, but also introduced middle school girls and Fishways volunteers to dragonflies. A second collaboration with the Fishways in 2011 included a dragonfly session as part of a week-long teacher training workshop.

The NHDS also received a significant amount of attention in the popular press and in partner publications. No fewer than 10 newspaper articles focused on the project from 2007 to 2011, with five additional stories mentioning the project in passing. Updates on the NHDS were published regularly in NH Audubon electronic and print media, and four times in "Wildlines," the quarterly newsletter of the NH Nongame and Endangered Species Program. A full story on the project, and dragonflies in general, appeared in NH Fish and Game's "Wildlife Journal."

Acknowledgments

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This project would not have been possible without an enthusiastic and dedicated corps of volunteers. All people who submitted data are listed below, with two subgroups deserving of special mention highlighted as follows. Volunteers who documented over 100 hours are boldfaced, while those who participated in one of the five "Coos County OdoBlitzes" are underlined. Together, these two groups of (often overlapping) people are responsible for the majority of data collected by the NHDS, and without their efforts we'd still know significantly less about the status of these organisms in the state. Special thanks are also due to Christina Emery, who created the NHDS database, and to Betsy Hamlin-Morin and Carol Lowden for tireless hours of data entry. Nick Donnelly and Ken Tennessen graciously looked at several specimens to verify problematic identifications.

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References

- Bried, J.T., B.J. Hager, P.D. Hunt, J.N. Fox, H.J. Jensen, and K.M. Vowels. 2011. Bias of reduced-effort community surveys for adult Odonata of lentic waters. *Insect Conservation and Diversity*. Published online: 9 June 2011; DOI: 10.1111/j.1752-4598.2011.00156.x
- Brunelle, P.-M. and P.G. deMaynadier. 2005. The Maine Damselfly and Dragonfly Survey: A Final Report. Prepared for the Maine Department of Inland Fisheries and Wildlife.
- Hunt, P.D. 2006. Assessment of the Conservation Status of Odonata in New Hampshire. Report to the NH Fish and Game Department. Audubon Society of NH, Concord.
- Hunt, P.D., M. Blust, and F. Morrison. 2010. Lotic Odonata of the Connecticut River in New Hampshire and Vermont. *Northeastern Naturalist* 17: 175-188.
- Needham, J.G., M.J. Westfall, and M.L. May. 2000. Dragonflies of North America: revised edition. Scientific Publishers, Gainesville, FL.
- Olcott, S. 2011. Final Report for the West Virginia Dragonfly and Damselfly Atlas. West Virginia Division of Natural Resources, Farmington.
- Paulson, D.R. 2002. New state records of *Enallagma* from Minnesota and New Hampshire. *Argia* 14(3): 12.
- Paulson, D.R., and S.W. Dunkle. 2011. A checklist of North American Odonata, including English name, etymology, type locality, and distribution. Originally published as Occasional Paper No. 56, Slater Museum of Natural History, University of Puget Sound, June 1999; completely revised March 2009; updated February 2011 and February 2012. Available online at: http://odonata.bogfoot.net/docs/NA_Odonata_Checklist_2012.pdf
- Westfall, M.J., and M.L. May. 2006. Damselflies of North America: revised edition. Scientific Publishers, Gainesville, FL.
- White, E.L., J.D. Corser, and M.D. Schlesinger. 2006. The New York Dragonfly and Damselfly Survey 2005-2009: Distribution and Status of the Odonates of New York. NY Natural Heritage Program, Albany.
- White, H.B., III and W.J. Morse. 1973. Odonata (Dragonflies) of New Hampshire: An Annotated List. NH Agricultural Experiment Station, Durham.

Appendices

Appendix A. Locations and attendance at NHDS volunteer training workshops, 2007-2010.

Date	Location	Attendees	Year Total
May 19, 2007	Massabesic Audubon Center, Auburn	26	64
May 21, 2007	Peabody Mill Nature Center, Amherst	18	
May 31, 2007	Rockingham County Offices, Brentwood	20	
May 23, 2008	Harris Center, Hancock	15	42
June 2, 2008	Tin Mountain Conservation Center, Albany	10	
June 9, 2008	Epping Town Hall, Epping	17	
May 28, 2009	McLane Center (Audubon), Concord	20	50
June 12, 2009	Paradise Point Nature Center, Hebron	22	
June 27, 2009	AMC Pinkham Notch Visitor Center	8	
May 28, 2010	McLane Center (Audubon), Concord	36	86
June 5, 2010	Grafton County Offices, Haverhill	24	
June 18, 2010	St. Paul’s Episcopal Church, Lancaster	26	
		Grand Total = 242	

Appendix B. Rough agenda for training workshops.

This agenda applies to workshops in 2009 and 2010. In 2007 and 2008 they were indoor only with an optional and separate field component.

10-11:30 a.m. Introductory slide show with information on

- a) Basic odonate biology (anatomy, life cycle, habitat)
- b) Introduction to odonate identification (families, common species)
- c) Background on the state of knowledge of NH odonates
- d) Brief overview of odonate conservation
- e) Overview of NHDS

11:30 a.m.–1:00 p.m. Overview of NHDS manual, identification resources, and collecting equipment

Break for lunch

1 to 4 p.m. Field component. Group visited a nearby wetland and practiced capture and identification.

Appendix C. Funding sources for the NH Dragonfly Survey, 2007-2011.

Source	Amount (approx.)
NH Fish and Game Department, Nongame and Endangered Species Program (through State Wildlife Grants)	\$40,000
Amoskeag Fishways (grant from Minnesota Public Television, Dragonfly TV)	\$3,400
Lamprey River Advisory Commission (grant from National Park Service, Wild and Scenic Rivers Program)	\$3,000
Individual contributions (includes workshop fees)	\$7,400
New Hampshire Audubon sanctuary endowments (breakdown below)	\$12,500
Dahl (Conway)	(\$1,400)
Foskett (Rindge)	(\$1,500)
Hoyt (Madison)	(\$700)
Kensan Devan (Marlborough)	(\$1,200)
Lovejoy Marsh (Albany)	(\$1,400)
Nye Meadow (Stoddard)	(\$500)
Ponemah Bog (Amherst)	(\$5,200)
Smith Pond Bog (Hopkinton)	(\$600)
Total	\$64,300

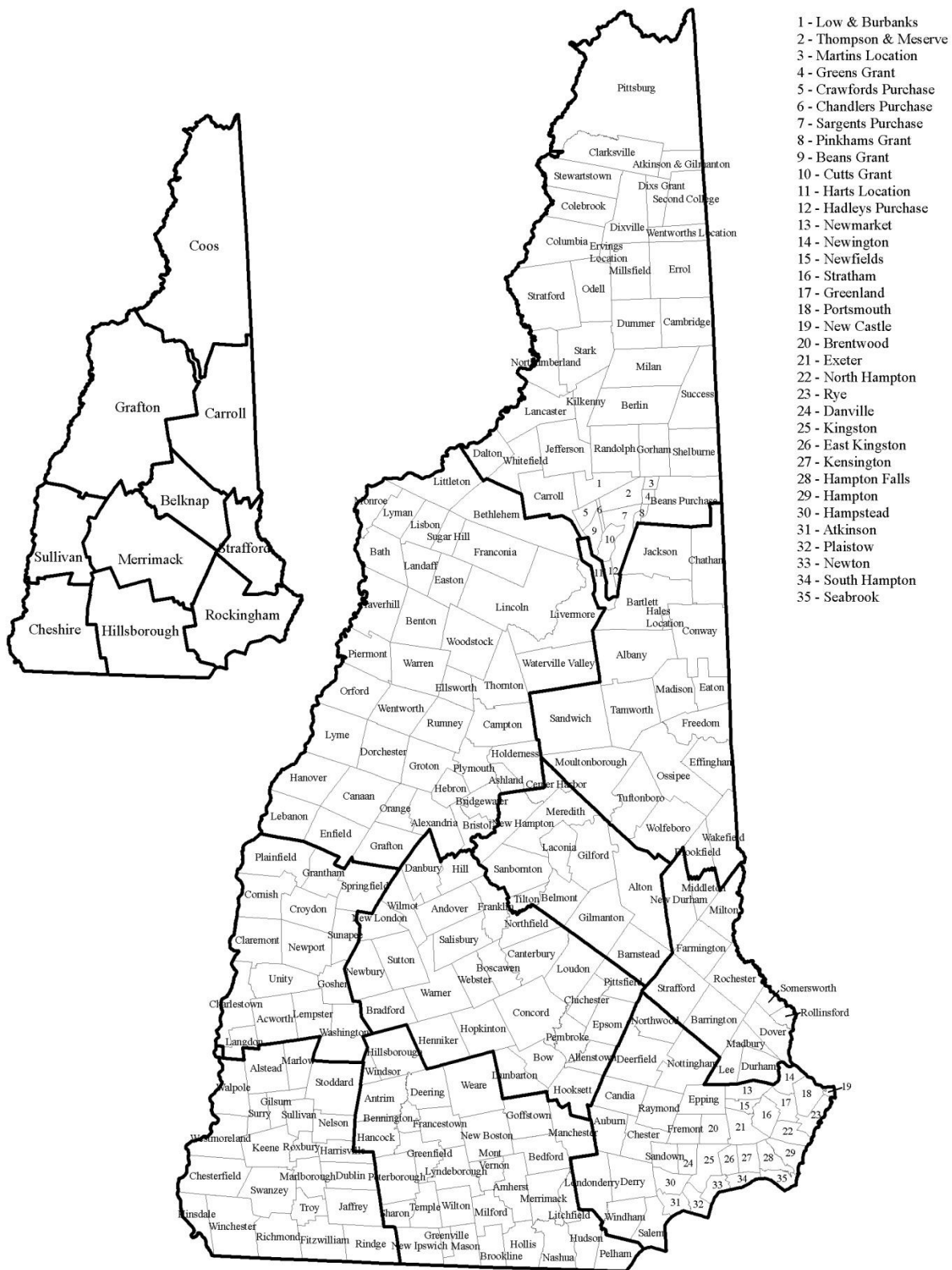
Appendix D. Annual summary of volunteer effort and contributions to the NHDS, 2007-2011.
Some site totals (e.g., by habitat) unavailable pending further querying of database.

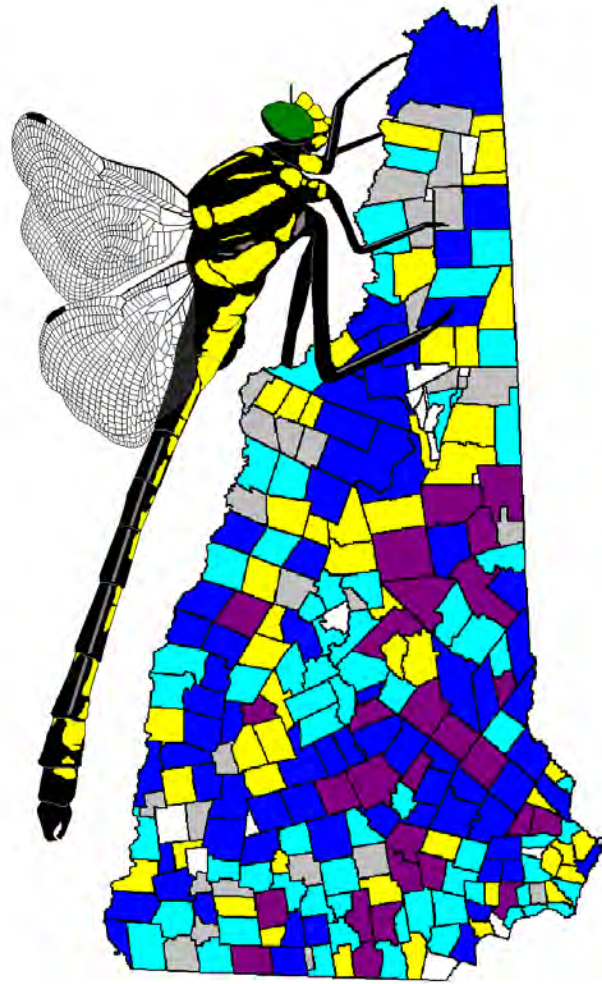
	2007	2008	2009	2010	2011	Overall
Number of Volunteers submitting data	35	23	47	48	38	145
Number of volunteer field hours *	247	380	830	1905	2039	5400
Number of volunteer miles *	n/a	339	n/a	13,967	13,152	27,458
Number of towns with data	74	97	118	157	163	221
Number of towns with regularly surveyed sites	28	27	37	60	72	~150
Number of sites with data (excluding incidentals)	90	49	167	250	320	~1000
Sites with regular data	48	38	63	97	100	n/a
Sites meeting survey criteria	21	17	28	54	66	~130
Sites on large rivers	21	8	18	19†	11†	n/a
Sites on small rivers	13	4	29	9†	10†	n/a
Sites at peatlands	17	15	19	21†	15†	n/a
Sites at marshes or ponds	34	23	92	51†	50†	n/a
Sites at high elevation lakes				12†	14†	n/a
Total number of records (approximate)	1800	1200	3000	6000	6000	18,250
Total species represented (164 known from state)	127	135	137	150	151	157
Number of priority species detected (of 56)	31	33	34	43	46	50
Number of records of priority species	224	162	139	266	290	~1080
New town records	500	650	850	1150	1350	~4500
New county records	13	30	22	27	41	133
New recent county records (first since 1973)	8	9	15	15	2	49

* Hours and miles not accurately recorded in 2007-2009, so numbers for these years are minimums. Hours spent by volunteers at training workshops not included here.

† These totals only reflect sites among the sites with “regular data,” not all sites visited in 2010-11.

Appendix E. Counties and towns of New Hampshire.





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COOPERATIVE EXTENSION

