County-level Richness Patterns

Spangled Skimmer (*Libellula cyanea*), Alan W. Wells 2005

New York's odonate biodiversity is strongly influenced by the state's varied geology, hydrology, climate, vegetation, history of glaciation, and land use (see Edinger & Howard 2008 for a summary of ecoregions and habitats of New York). With boreal ecosystems in the Adirondacks and scattered locations elsewhere, and ecosystems typical of more southern locales on Long Island and in the Hudson Valley, New York is the northern or southern range limit for a great many species. With large rivers like the Hudson, Delaware, Susquehanna, and Allegheny draining the state's watersheds in all directions, linking New York to large bodies of water like the Great Lakes, Chesapeake Bay, and Hudson Bay, a high diversity of aquatic life is to be expected. Sure enough, New York has one of the highest odonate diversities of any U.S. state (Donnelly pers. Comm.).

A full treatment of patterns of diversity in New York's odonate fauna is beyond the scope of this report. Here we present a simple depiction of odonate diversity by county, a basic political division that divides the state neatly into 62 blocks and a scale at which summaries of odonate fauna before the NYDDS were available (Donnelly 1992, 1999, 2004a). Further analysis of these data by more ecologically meaningful units (i.e., watershed, ecoregion) will yield additional insight into mechanisms underlying the state's odonate diversity.

NYDDS participants added five species to the fauna of New York, and 1,111 new county records for known species. Note that the totals reported in this section include verified records only. On average, each county's documented odonate richness was increased by 18 species! This shows the enormous progress that a focused, five-year effort can bring to even a relatively well known group like dragonflies and damselflies. The increases varied widely among counties, however, with some counties (Rensselaer, Warren, Washington, Schenectady, Onondaga) having more than 40 new species added and others (Erie, New York, Tompkins, Yates) having none or just a few new species added. These increases appeared strongly, but not perfectly, related to the survey effort allocated to the county. Additional data analysis can allow us to understand for future, similar atlas efforts how to allocate survey effort among different areas of the state.

From Figure 10, it is clear that odonate diversity in New York was highest in the southeast along the border with Pennsylvania and New Jersey (Orange, Ulster, Broome, Tompkins, Schuyler, and Suffolk) and in northern counties with boreal ecosystems (St. Lawrence, Essex, Lewis, Franklin, Warren, and Rensselaer). Richness was lowest in the New York City metropolitan area and in western New York. These diversity patterns roughly match those yielded by the analysis of estimated species richness in the Survey Effort section (page 17). We documented at least 75 species in 66% of the counties. For the remainder of the counties, final tallies increased to numbers in the 60s for seven of those counties, the 50s for another seven, the 40s for four, and the 20s for four of the NYC counties. Overall, the Survey clarified and strengthened existing patterns that await further exploration and ongoing analyses of these data should prove fruitful. For example, we currently have funding by State Wildlife Grants to assess the factors influencing the patterns of distribution of odonates throughout the state and relate them to issues of regional water quality and land use in concert with data on habitat preference, phylogeny, and range-wide biogeography.

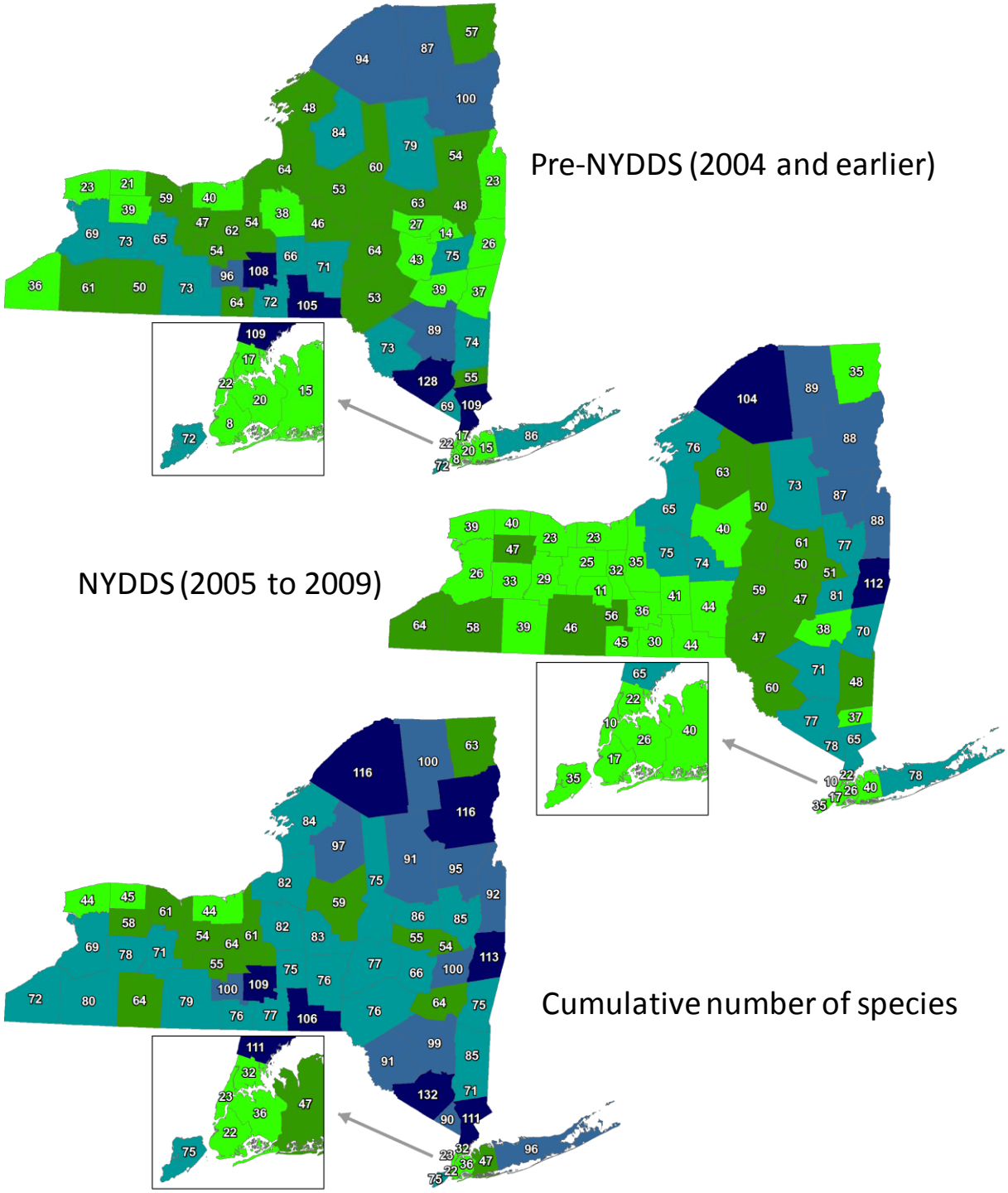

Figure 10. Number of species of dragonflies and damselflies recorded in each New York county before the NYDDS (based on Donnelly 1999, 2004a), during the NYDDS, and the total number of species as of 2009. Counties are colored by richness, from light green to dark blue. NYDDS numbers include verified records only.

Special Efforts

Secondary goals of the NYDDS included special efforts for the state historical Ringed Boghaunter (*Williamsonia lintneri*), the Federally Endangered Hine's Emerald (*Somatochlora hineana*), and New York's three state threatened damselflies.

Ringed Boghaunter (*Williamsonia lintneri*)

During the NYDDS, we devoted a significant amount of effort, especially in spring 2006 to 2008, in searching for this species and potential habitats in New York. Virginia Brown, Paul Novak, Erin White, and NYDDS participants visited locations in Albany, Columbia, Rensselaer, Oneida, Oswego, and Franklin counties to assess habitats for their suitability for harboring *W. lintneri* populations. Throughout their range, Ringed Boghaunters are known to occur in acidic sedge fens and sphagnum bogs that contain "soupy" sphagnum pools and are surrounded by wooded uplands (Massachusetts NHESP 2003). For more detailed information on habitat, see the species account above (page 232). The species is known historically (1874) from "a sandy pine woods region", which is now Colonie in the Albany area (Howe Jr 1923, Donnelly 1999). Previous survey work in the Albany Pine Bush in 1998 had not revealed the species, although potential habitats were found (Novak & Gifford 1998). In 2007, NYDDS contractor Virginia Brown, who has done extensive work with *W. lintneri* in Rhode Island, assessed habitats at the Wilton Wildlife Preserve in Saratoga county, the Rome Sand Plains in Oneida county, and fen habitats in Oswego county.

Of the areas surveyed, Huckleberry Swamp of Rome received the most favorable review from Brown (2007d). She considered the habitat to be ideal for the species, with areas of soupy sphagnum, emergent graminoids including *Dulichium arundinaceum*, and shrubs. She suggested repeated visits with reverence for the fragility of the habitat, but cautioned that it is unknown if the species' range ever extended that far west of Albany (Brown 2007d). In 2008, the most promising site with ideal habitat for *W. lintneri* was identified in Grafton near Dyken Pond Environmental Center. Two wetland habitats in this area had the above habitat characteristics and the location is much closer to Albany, the site of the original record. Future survey work and repeat visits to the Grafton sites is needed to assess if a population may exist in New York. This species has been recommended for federal listing (Carpenter 1993) and finding locations in New York would be remarkable after a near 100-year period of nondetection. However, there are extant populations in New Jersey and Massachusetts, and a New York occurrence is within the realm of possibility. This species is rare globally, however, with a brief and early flight season in the spring. Odonate surveyors will continue the search for suitable habitats and populations of Ringed Boghaunters in New York.

Hine's Emerald (*Somatochlora hineana*)

The Federally Endangered Hine's Emerald (*Somatochlora hineana*) was a focus of special effort in the summers of 2007 and 2008 for the NYDDS. Known to inhabit calcareous spring-fed marshes, sedge meadows, and fens, overlaying dolomitic bedrock in midwestern states, this dragonfly was sought in western New York which contains appropriate geology and habitat to support the species, although none have ever been found here. A workshop was held on July 9 and 10, 2007, at the Buffalo State College Field Station in Buffalo**.** The workshop was organized and sponsored by the USFWS Cortland Office and the NY Natural Heritage to train

professionals with an introduction to the genus *Somatochlora*, and to the Hine's Emerald in particular. Under contract to the NYNHP, Tim Vogt, a Hine's Emerald expert and a member of the Hine's Emerald Recovery Team, attended the workshop and provided much of the background information, as well as reference specimens for identification practice.

The second day of the workshop was spent in the field surveying two sites in western New York for habitat and *Somatochlora* species. Vogt determined that one of the sites (privately-owned) had an extensive fen habitat with the potential to support Hine's Emerald, as well as the known population of Clamp-tipped Emerald (*Somatochlora tenebrosa*). One male *Somatochlora* observed by Vogt was tentatively identified as Hine's Emerald, but could not be captured for confirmation. This led to a site revisit in late July of 2007, when NYDDS participants were able to capture 21 *Somatochlora* of three species (*Somatochlora tenebrosa, Somatochlora walshii, and Somatochlora williamsoni*). Survey work at the site continued in 2008 with repeated visits earlier in the season, timed with the known flight season for Hine's in the midwest.

Three females appeared to have "Hine's-like" characteristics, as the position of the ovipositor did not seem quite right for *S. tenebrosa* in comparison to others that were captured. These three were sent to Dr. Everett Cashatt at the Illinois State Museum for identification and DNA analysis and all were later identified as *S. tenebrosa*. One of the females was analyzed and appeared not to have any introgression with Hine's and was similar to a cluster of *S. tenebrosa* from Wisconsin. In addition, a male was observed hovering about 4 feet from the ground, a behavior not typical of the other *Somatochlora* we observed, and similar to Hine's behavior that has been observed in the Midwest (Ailsa Donnelly pers. Comm). We cannot conclude, based on the initial visit and the follow-up surveys, that Hine's Emerald does not occur at this property or in western New York, although it seems unlikely at this point. Multiple surveys have often been required before the presence of Hine's Emerald was confirmed at new sites discovered in Wisconsin and other states, and the observations of Hine's-like behaviors from *Somatochlora* were intruiging, so future survey work may yet prove fruitful. However, we devoted at least five group surveys to this effort during the NYDDS and the nearest known population occurs in Michigan, so its presence is not necessarily probable. Should the search for Hine's continue here, recommendations for future survey work in fen habitats of western New York include repeated visits to sites with appropriate habitat and evening surveys to coincide with higher activity of *Somatochlora*. All currently known sites for the Hine's Emerald also support the burrowing crayfish, *Cambarus diogenes*, and the dragonfly nymphs or larvae are known to live in, and over winter in, the crayfish burrows (Vogt pers. Comm.). Further surveys at known and new locations of these crayfish is also recommended.

Three State Threatened Bluet Damselflies

At the inception of the NYDDS, relatively little was known about the status of the previously documented New York State populations of three damselflies that are the only State-listed odonate species: the Pine Barrens Bluet (*Enallagma recurvatum*), the Scarlet Bluet (*Enallagma pictum*), and the Little Bluet (*Enallagma minusculum*). All three are listed as Threatened. At the time, Pine Barrens Bluet was known from 9 separate ponds, all in eastern Suffolk County. Scarlet Bluet was known from just 3 separate ponds, with all three of these ponds also supporting Pine Barrens Bluet. The Little Bluet was known from two small lakes in eastern Suffolk County, neither of which was known to support the other two species. Understanding the relative abundance of these three state Threatened damselfly species in their

respective occurrences was one objective of the NYDDS. Specifically, relative abundance was to be estimated by conducting counts and making an estimate of the number of individuals present, in at least seven sites for the Pine Barrens Bluet, three sites for Scarlet Bluet, and one site for Little Bluet. This work was completed through contract work by Virginia "Ginger" Brown (nee Carpenter), who is amongst the country's most knowledgeable biologists with respect to these three species.

Two new sites were documented for Pine Barrens Bluet, both in 2005 (one of which was identified by the collection of a specimen by a Brookhaven Lab intern); while seven new sites for Scarlet Bluet were documented: two in 2005, two in 2006, and one each in 2007, 2008, and 2009. Two of the new Scarlet Bluet sites were surveyed during a subsequent year as well. No new sites for Little Bluet were documented by Brown during her surveys despite searches of a number of sites with at least some suitable habitat. While some new sites were added, there were some sites visited where bluet populations for one of the three species had been previously noted, but were not observed during this study.

Recommendations for future inventory of these species include surveys in pond complexes where they are known to occur when water levels are not extremely high, as this factor limited work during the NYDDS in some cases. Investigating new areas may prove fruitful as well. Future monitoring should include continued counts of threatened bluets at known sites, especially those with imminent threats, and detection probability should be investigated. These damsels are known to associate with specific native emergent rushes and floating plants that are required for successful reproduction (Gibbons *et al.* 2002). Considerations for the management of these species should include addressing the following threats: *Phragmites*, which appears to be eliminating those plants required for egg laying and Canada Goose browse, which appears to have the same effect and may also increase egg mortality by overgrazing (New York Natural Heritage Program 2010). Vehicle use on pond shoreline vegetation and reduction in native shoreline vegetation and surrounding wooded upland habitat should also be considered as threats. Another consideration is that these damsels have dispersing capabilities and study shows that they may undergo metapopulation dynamics (Gibbons *et al.* 2002), relying on a source population and\or several small populations within a pond complex. These recommendations, and the development of a Recovery Plan and monitoring plan is suggested for these three *Enallagma*, and the current information relating to the odonates of coastal plain ponds should be reviewed and updated in the NYSDEC CWCS.

Inventory Needs

Inventory and research needs for all SGCN were addressed in the species accounts section. From these accounts and the county richness analysis (Table 3, Figure 10), it is clear that the Odonate fauna of New York is very dynamic, and species' populations are actively changing their ranges within the state as well as moving into and out of different political boundaries. This high level of population flux is well known for this group of mobile insects (Beatty & Beatty 1968), and many recent studies have examined the effects that climate change is having on the distribution of Odonates worldwide (see Bried & Mazzacano 2010), and in New York in particular (Corser 2010). Thus, our five-year snapshot of the Odonata fauna in New York is affected by this flux as well as the amount of survey effort and area effects. We feel that our adherement to a protocol for specimen verification (White 2007) greatly reduced our potential for mis-identification which can confound an understanding of true patterns. An important

Rainbow Bluet (*Enallagma antennatum*), Jeremy Martin 2006

question that often arises is whether the patterns revealed in Figure 10 and the individual species dot maps are real, or are more an artifact of survey effort, or a result of area or scale effects. The Odonate fauna of a particular area (i.e., a County) is a function of the available habitats, and the species- area rule in ecology states that larger areas will have, on average, more different types of habitats than smaller areas, and thus greater potential for more odonate species (Kalkman *et al.* 2008). So all things being equal, larger counties like St. Lawrence would be expected to have more species than smaller counties like Putnam. Nevertheless, size alone does not dictate the amount of suitable habitat; for instance, if a large area is rather homogenous (i.e., agricultural lands), fewer species would be expected to find successful breeding sites, and so habitat diversity is an important driver of species diversity (Kalkman *et al.* 2008).

Survey effort also has important effects on the number of species known to a particular area and the survey effort section and Figure 7 shows clearly that more survey effort invariably turns up more species. Areas with particularly active and skilled surveyors have higher percentages of expected species detected (Figure 7). Therefore, area, effort, distributional flux, and the true species richness at any point in time are all confounded with one another. This makes answering important questions like "are there really fewer Odonate species in western New York compared to eastern New York, or is it just under-surveyed?" very complicated, and the answer is probably yes—both are true. Yet, it is desirable to know where to focus additional inventory efforts to get the highest return for survey effort. What areas of the state have the highest potential for harboring undiscovered and rarer species? Focusing survey efforts in a particular county simply because it currently has relatively lower numbers of species could be misguided because it may be that there are fewer odonate species for purely ecological and/or biogeographical reasons (Kalkman *et al.* 2008).

Figure 11 is a graphical summary to help sort out these confounded variables and to aid in determining which counties might benefit most from additional inventory effort. It displays the relationship between numbers of species detected, and survey effort, controlled for the size of the sample unit (in this case, a County). We used the data in Table 3 in a least squares linear regression analysis to control for the effects of county size by creating scatterplots of residuals. In other words, large and small counties have an equal chance of harboring a given number of species that depends on its true richness and the level of survey effort. Figure 11 shows that even with area effects removed, counties with more survey effort had significantly ($R^2 = 0.64$; $p < 0.0001$) more species detected partially because bigger counties did tend to have somewhat more survey effort ($R^2 = 0.1$; $p = 0.02$). Those counties that fall along or near the regression line have about the expected number of species for a given level of survey effort, while those that fall below the line have fewer species than expected. The graph can be broken down into four quadrants. The upper right quadrant consists of counties whose Odonate fauna is both quite well surveyed and that have high richness, so that additional survey efforts in these counties would not be expected to turn up lots of new species. Many of these counties contain, or are near the residences of very active and skilled surveyors. The lower right quadrant consists of counties that have had a relatively high number of surveys, but the number of species is lower than would be expected given the higher survey effort. Additional survey efforts here would also not be

expected to turn up many new species. Several of these counties are around the New York City area where much of the natural habitat has been destroyed.

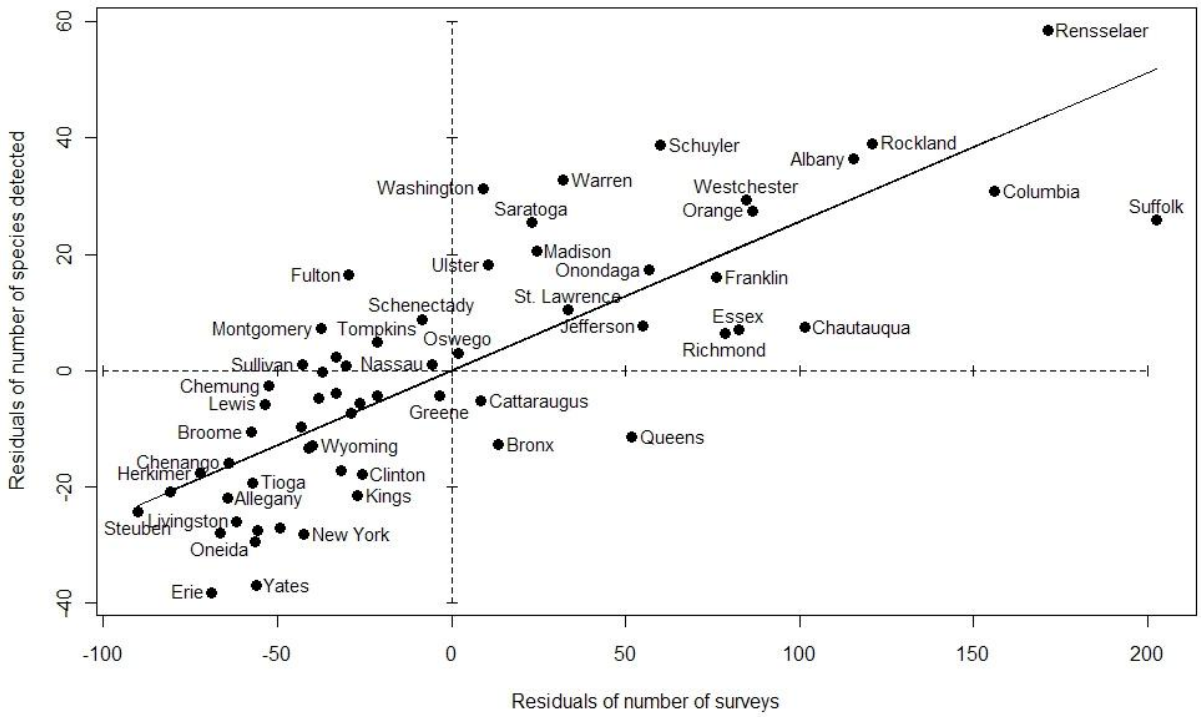

Figure 11. A residual scatterplot statistically controlling for the effect of the size of each county. The graph can be interpreted as a typical scatterplot (the axis numbers are arbitrary) that shows how NYDDS survey effort related to the numbers of species (verified and unvouchered) that were detected in each county. For example Rensselaer County had large numbers of species and effort, while Steuben had the lowest. Bronx and Washington Counties had about the same level of effort (# surveys), but Washington had approximately two times as many species per area. Not all of the counties are labeled; see text for additional details.

The lower left quadrant consists of counties that have lower than expected numbers of species, and although the survey effort in these counties has been relatively light, more species would have been expected given the observed level of survey effort. Additional survey efforts in these counties would be expected to turn up marginally more species, but not at highly efficient rates. Many of these counties are in western New York and the Finger Lakes region, and this analysis suggests that comparatively lower richness levels in this part of the state (Figure 10) is not solely due to it being under-surveyed, but that there are ecological and/or biogeographical explanations. Because similar patterns are also found in other well studied animals such as birds (McGowan & Corwin 2008) and herpetofauna (NYSDEC 2009), it could be due to lower habitat diversity, possibly owing to the large amount of acreage that has been cleared for agriculture. Biogeographical explanations are also a factor in a state that is both on the northern range margin for numerous southern species, as well as on the southern range margin for numerous boreal

species (Beatty & Beatty 1968, Corser 2010, Bried & Mazzacano 2010). Finally, the upper left quadrant consists of the counties where we feel additional inventory efforts would be most fruitful. These counties had relatively low levels of survey effort but accumulated more species than would have been expected given the modest number of surveys. This suggests that additional species, especially the rarer ones, are waiting to be discovered in these counties. Many of them are in the transition area between western and eastern New York where a potential contact zone exists between Atlantic coastal and Midwestern forms (Beatty & Beatty 1968). We expect that the Odonate fauna of New York will continue to be dynamic into the future and many of those more southern and midwestern species now found near the borders of New York will eventually be found here. At the same time it appears that the many of the boreal species are retreating northward. Interested parties should consult White **(**2007) as well as Donnelly (2004b,c,d) for specific examples.

Conservation and Monitoring

Odonates appeal to many, as they are charismatic insects with incredible flight capabilities and consume large numbers of insects humans consider pests, like mosquitoes. People like to observe them for the same reasons they enjoy bird-watching (although many will tell you it is difficult to focus on both groups at the same time): The adults have remarkable color patterns and interesting behaviors, and many species are distinguishable with close-focusing binoculars. These creatures spark the interest of people of all age groups and are excellent animals to highlight in freshwater education programs (Ramsay & Cannings 2004). We can look to these insects to tell us how we are doing as stewards of the natural ecosystems they inhabit through study and inventory (Bried & Mazzacano 2010).

Student at Dragonfly Day on Long Island, Annette Oliveira 2008

Odonates are found in nearly every aquatic habitat in New York, from ponds, bogs, and marshes to rivers, streams, and seeps. Adults breed and oviposit and larvae develop in these aqueous environments for as long as several years. However, adults also use surrounding uplands to fulfill other requirements such as feeding, roosting, thermoregulation, and maturation of teneral (newly emerged) adults. For example, many odonates, such as *Williamsonia lintneri* in the northeast (Carpenter 1993, Massachusetts NHESP 2003b), forage for insect prey in fields and woodlands. Deforestation is thus a threat to odonate diversity globally, especially in the tropics (Corbet 2006) where there is a high density of aquatic habitats (Kalkman *et al.* 2008). In New York, the forested surroundings around breeding habitats are essential for maintaining viable populations. Even more important is protecting larval and breeding habitats since odonates spend most of their lives in the water and these environments are essential to their development. A high diversity of odonates generally indicates good water quality, especially if larvae are present (Corbet 2004). The tolerance of individual species to pollution and other environmental stressors varies, as do habitat requirements. Some are generalists found in a variety of habitats, others are specialists, with more specific habitat requirements (Barbour *et al.* 1999, Kalkman *et al.* 2008).

Globally, odonate species that occupy lotic habitats such as rivers and streams have a greater risk of extinction (when looking at the percentages of IUCN listed species) than those

occupying lentic habitats (Clausnitzer *et al.* 2009). A decline in the biodiversity of freshwater lotic habitats has been attributed to alterations of flow, pollution, deforestation in riparian areas, and increased road construction and impoundments (SaintOurs 2002). Any activity that might lead to water contamination, eutrophication, or the alteration of natural hydrology could affect odonate populations (NYSDEC 2005). Such threats might include agricultural run-off (i.e., pesticides) and other pollutants, shoreline modifications, increases in the sediment load of rivers, and changes in dissolved oxygen content (SaintOurs 2002, NYSDEC 2005). River impoundment is known to cause sediment coarsening downstream, which is an obstacle for burrowing invertebrates (Donnelly 1993). Several of the above threats also apply to lentic habitats, as well as groundwater withdrawal and invasive plant species replacing native plants required for oviposition (New York Natural Heritage Program 2010).

Some species appear to be showing effects of climate change. At the local level, drought could strand nymphs in breeding habitats (Biber 2002) and flooding could render emergence substrates unavailable. Effects have been seen at the rangewide level as well. Southern species of dragonflies in Europe are expanding their ranges while others in temperate climates are shifting flight seasons, leading to distributional changes (Kalkman *et al.* 2008). Corser (2010) provides some evidence that *S. plagiatus*, a more southerly distributed dragonfly, has recently expanded its range in New York. Corbet (2003) hypothesized that individuals at the northern portion of their range may emerge earlier than southern ones, responding to temperature and photoperiod, which is longer in northern latitudes. He further suggests that odonates adapted to cold climates may have increased their development rate (provided conditions are right, like ample prey availability) in northern habitats with shorter summers. Both emergence rates and\or species ranges may shift for odonate species as a result of global warming. Kalkman *et al.* (2008) state that there are currently no known northern species in which populations are decreasing due to climate change; however, researchers are on the lookout for these patterns as odonates gain attention in climate change studies (Ott 2008).

Clausnitzer et al. (2009) found that one in 10 species of odonates is threatened with extinction worldwide, which is a low proportion compared with other taxa that have been similarly assessed using IUCN criteria (birds, mammals, and amphibians). While management considerations should address all habitat requirements to maintain odonate diversity and rare species on a local scale, these insects may be better able to sustain viable populations due to their unique life history and reproductive strategy than some other taxa. We found (Table 5) that 26% of New York's odonate fauna are potentially imperiled or critically imperiled. New York also had a higher percentage (42%) of species likely to be ranked as vulnerable (S3) or higher (S1,S2) than the national percentage of vulnerable odonates (18%) (Bried & Mazzacano 2010). While New York appears to have higher proportions of rare species than national and global averages, it also has one of the highest diversity of odonates in the United States (Abbott 2010, Donnelly pers. comm.) and we added five species to the list during the Survey. At the same time, we were unable to confirm the presence of 15 of the 189 Odonata species ever documented in New York by Donnelly 2004a) (Table 1), and every one of these species was rare in the state to begin with. It is quite likely that some of these rare and/or elusive species were missed by our sampling protocol, and some were never represented by established breeding populations. However, there is some reason to believe that this flux is a result of active range changes by Odonata species in response to climate (Ott 2008) and habitat changes (Kalkman *et al.* 2008). Flenner and Sahlen (2008) discuss the high turnover of Odonata populations at their range margins; 12 of our 15

undocumented species were near their northern distributional limits in New York, while the remainder were near their southern limits.

Our knowledge of the distribution and habitats utilized by these species in New York will help inform conservation. As odonates are noted as indicators of water quality (Barbour *et al.* 1999), biodiversity, and ecological change, these data will help inform future conservation efforts in freshwater habitats for many other species as well (Bried & Mazzacano 2010).

NYDDS information will add to Donnelly's (2004d) effort, providing excellent baseline information on the distribution and status of odonates in New York. Much like the 2000-2005 Breeding Bird Atlas (McGowan & Corwin 2008) followed up on the 1980-1985 Atlas (Andrle & Carroll 1988), leading to some fascinating analyses of distributional change over those 20 years (e.g., Zuckerberg *et al.* 2010), we hope that in the future this survey effort will be similarly revisited to assess changes in odonate distributions. Monitoring of this sort may be the only way to know whether we are maintaining New York's dragonfly and damselfly biodiversity in the face of continuing global change.

Twelve-spotted Skimmer (*Libellula pulchella*), Alan W. Wells 2008

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Appendix I. Odonate list for volunteers. The table below contains all dragonfly and damselfly species recorded to date in New York State, as well as a few additional species whose range extends into states or provinces very close to New York which could be expected to occur in New York. Bolded species = species of "Greatest Conservation Need" and/or on the NY Natural Heritage Program "Active Inventory List". Species with an asterisk = species not yet recorded in NEW YORK, but could occur here based on records in nearby states and provinces.
Identification Level: Identification level refers to the type of verification that will generally be required in order for us to be fully confident of and make maximum use of the submitted records. Codes are as follows: SPEC = collected specimen, PHOT = photograph, OBS = site record. In the case of photographs, in many cases very close up images of particular body parts will be necessary to confirm identification and these parts are listed in parentheses after PHOT. Lateral = a side view shot of the body; term app = both dorsal and lateral views of the male terminal appendages; lateral thoracic = the lateral thoracic stripes; wings = a dorsal shot of the wings to show a particular spot or pattern; abdomen – dorsal = a dorsal view of the abdomen; top of head = the top of the head in front of the eyes. NOTE that in many cases different levels of verification are needed for males vs. females.

Family	**Common Name**	**Scientific Name**	**Identification Level**	**Habitat**
Calopterygidae	River Jewelwing	Calopteryx aequabilis	OBS	
Calopterygidae	Superb Jewelwing	Calopteryx amata	PHOT	
Calopterygidae	**Appalachian Jewelwing**	**Calopteryx angustipennis**	**M – PHOT, F SPEC**	**rivers**
Calopterygidae	**Sparkling Jewelwing**	**Calopteryx dimidiata**	**PHOT**	**brooks, rivers**
Calopterygidae	Ebony Jewelwing	Calopteryx maculata	OBS	
Calopterygidae	**American Rubyspot**	**Hetaerina americana**	**PHOT**	**streams, rivers**
Lestidae	Great Spreadwing	Archilestes grandis	PHOT	
Lestidae	Spotted Spreadwing	Lestes congener	SPEC	
Lestidae	Common Spreadwing	Lestes disjunctus	SPEC	
Lestidae	Common Spreadwing	Lestes australis	SPEC	
Lestidae	Emerald Spreadwing	Lestes dryas	M – OBS, F - SPEC	
Lestidae	Amber-winged Spreadwing	Lestes eurinus	M – PHOT (term app), F - SPEC	
Lestidae	Sweetflag Spreadwing	Lestes forcipatus	SPEC	
Lestidae	Elegant Spreadwing	Lestes inaequalis	M – PHOT (term app), F - SPEC	

Family	Common Name	Scientific Name	Identification Level	Habitat
Lestidae	Slender Spreadwing	Lestes rectangularis	M – PHOT (term app), F - SPEC	
Lestidae	Lyre-tipped Spreadwing	Lestes unguiculatus	M – PHOT (term app), F - SPEC	
Lestidae	Swamp Spreadwing	Lestes vigilax	M – PHOT (term app), F - SPEC	
Coenagrionidae	Eastern Red Damsel	Amphiagrion saucium	PHOT (lateral)	
Coenagrionidae	Blue-fronted Dancer	Argia apicalis	M - PHOT (lateral), F - SPEC	
Coenagrionidae	**Seepage Dancer**	**Argia bipunctulata**	**SPEC**	**seeps, rivulets, bogs**
Coenagrionidae	Variable Dancer	Argia fumipennis violacea	OBS	
Coenagrionidae	Powdered Dancer	Argia moesta	OBS	
Coenagrionidae	**Blue-tipped Dancer**	**Argia tibialis**	**M - PHOT (lateral), F - SPEC**	**rivers, brooks**
Coenagrionidae	Dusky Dancer	Argia translata	M - PHOT (lateral, term app), F - SPEC	
Coenagrionidae	Aurora Damsel	Chromagrion conditum	M - PHOT (lateral, term app), F - SPEC	
Coenagrionidae	**Subarctic Bluet**	**Coenagrion interrogatum**	**SPEC**	**ponds, bogs**
Coenagrionidae	Taiga Bluet	Coenagrion resolutum	M - PHOT (term app), F - SPEC	
Coenagrionidae	Rainbow Bluet	Enallagma antennatum	M - PHOT (term app), F - SPEC	
Coenagrionidae	Azure Bluet	Enallagma aspersum	M - PHOT (term app), F - SPEC	
Coenagrionidae	Double-striped Bluet	Enallagma basidens	M - PHOT (term app), F - SPEC	
Coenagrionidae	Boreal Bluet	Enallagma boreale	SPEC	

Family	Common Name	Scientific Name	Identification Level	Habitat
Coenagrionidae	Tule Bluet	Enallagma carunculatum	SPEC	
Coenagrionidae	Familiar Bluet	Enallagma civile	M - PHOT (term app), F - SPEC	
Coenagrionidae	Northern Bluet	Enallagma annexum	SPEC	
Coenagrionidae	Attenuated Bluet *	Enallagma daeckii	SPEC	
Coenagrionidae	Turquoise Bluet	Enallagma divagans	M - PHOT (term app), F - SPEC	
Coenagrionidae	Atlantic Bluet	Enallagma doubledayi	SPEC	
Coenagrionidae	Big Bluet	Enallagma durum	M - PHOT (term app), F - SPEC	
Coenagrionidae	Marsh Bluet	Enallagma ebrium	M - PHOT (term app), F - SPEC	
Coenagrionidae	Stream Bluet	Enallagma exsulans	M - PHOT (term app), F - SPEC	
Coenagrionidae	Skimming Bluet	Enallagma geminatum	M - PHOT (term app), F - SPEC	
Coenagrionidae	Hagen's Bluet	Enallagma hageni	M - PHOT (term app), F - SPEC	
Coenagrionidae	**New England Bluet**	**Enallagma laterale**	**M - PHOT (term app), F - SPEC**	**ponds, lakes**
Coenagrionidae	**Little Bluet**	**Enallagma minusculum**	**M - PHOT (term app), F - SPEC**	**coastal plain ponds, lakes**
Coenagrionidae	**Scarlet Bluet**	**Enallagma pictum**	**M - PHOT (lateral), F - SPEC**	**coastal plain ponds, lakes**
Coenagrionidae	**Pine Barrens Bluet**	**Enallagma recurvatum**	**M - PHOT (term app), F - SPEC**	**coastal plain ponds, lakes**
Coenagrionidae	Orange Bluet	Enallagma signatum	M - OBS, F - SPEC	

Family	Common Name	Scientific Name	Identification Level	Habitat
Coenagrionidae	Slender Bluet	Enallagma traviatum	M - PHOT (term app), F - SPEC	
Coenagrionidae	Northern Bluet	Enallagma vernale	SPEC	
Coenagrionidae	Vesper Bluet	Enallagma vesperum	M - OBS, F - SPEC	
Coenagrionidae	Blackwater Bluet	Enallagma weewa	M - PHOT (term app), F - SPEC	streams, rivers
Coenagrionidae	Citrine Forktail	Ischnura hastata	M – PHOT, F - SPEC	
Coenagrionidae	Lilypad Forktail	Ischnura kellicotti	M – PHOT, F - SPEC	
Coenagrionidae	Fragile Forktail	Ischnura posita	OBS	
Coenagrionidae	**Furtive Forktail**	**Ischnura prognata**	**M – PHOT, F - SPEC**	
Coenagrionidae	**Rambur's Forktail**	**Ischnura ramburii**	**M – PHOT, F - SPEC**	**brackish ponds, marshes**
Coenagrionidae	Eastern Forktail	Ischnura verticalis	OBS	
Coenagrionidae	Sphagnum Sprite	Nehalennia gracilis	M – OBS, F - PHOT	
Coenagrionidae	**Southern Sprite**	**Nehalennia integricollis**	**SPEC**	**ponds, bogs**
Coenagrionidae	Sedge Sprite	Nehalennia irene	M – OBS, F - PHOT	
Petaluridae	**Gray Petaltail**	**Tachopteryx thoreyi**	**PHOT**	**seeps, rivulets, ravines**
Aeshnidae	Canada Darner	Aeshna canadensis	PHOT (lateral thoracic, term app)	
Aeshnidae	**Mottled Darner**	**Aeshna clepsydra**	**PHOT (lateral thoracic, term app)**	**ponds, bogs**
Aeshnidae	Lance-tipped Darner	Aeshna constricta	PHOT (lateral thoracic, term app)	
Aeshnidae	Lake Darner	Aeshna eremita	PHOT (lateral thoracic, term app)	

Family	Common Name	Scientific Name	Identification Level	Habitat
Aeshnidae	Variable Darner	Aeshna interrupta	PHOT (lateral thoracic, term app)	
Aeshnidae	Sedge Darner *	Aeshna juncea	SPEC	
Aeshnidae	**Spatterdock Darner**	**Rhionaeschna mutata**	**PHOT in hand only (lateral thoracic,face)**	**ponds, lakes**
Aeshnidae	Zigzag Darner *	Aeshna sitchensis	SPEC	
Aeshnidae	**Subarctic Darner**	**Aeshna subarctica**	**PHOT (in hand only - lateral thoracic, term app)**	**bogs**
Aeshnidae	Black-tipped Darner	Aeshna tuberculifera	PHOT (lateral thoracic, term app)	
Aeshnidae	Shadow Darner	Aeshna umbrosa	PHOT (lateral thoracic, term app)	
Aeshnidae	Green-striped Darner	Aeshna verticalis	PHOT (lateral thoracic, term app)	
Aeshnidae	Common Green Darner	Anax junius	OBS	
Aeshnidae	**Comet Darner**	**Anax longipes**	**M – OBS, F – PHOT (top of head)**	**ponds, lakes**
Aeshnidae	Springtime Darner	Basiaeschna janata	PHOT (lateral thoracic, wings)	
Aeshnidae	Ocellated Darner	Boyeria grafiana	PHOT in hand only	
Aeshnidae	Fawn Darner	Boyeria vinosa	PHOT	
Aeshnidae	Swamp Darner	Epiaeschna heros	PHOT	
Aeshnidae	**Taper-tailed Darner**	**Gomphaeschna antilope**	**SPEC**	**bogs**
Aeshnidae	Harlequin Darner	Gomphaeschna furcillata	PHOT	
Aeshnidae	Cyrano Darner	Nasiaeschna pentacantha	PHOT	
Gomphidae	Horned Clubtail *	Arigomphus cornutus	SPEC	

Family	Common Name	Scientific Name	Identification Level	Habitat
Gomphidae	Lilypad Clubtail	Arigomphus furcifer	M – PHOT (term app), F - SPEC	
Gomphidae	Unicorn Clubtail	Arigomphus villosipes	M – PHOT (term app), F - SPEC	
Gomphidae	Black-shouldered Spinyleg	Dromogomphus spinosus	PHOT	
Gomphidae	**Spine-crowned Clubtail**	**Gomphus abbreviatus**	**SPEC**	**rivers, lakes**
Gomphidae	Mustached Clubtail	Gomphus adelphus	SPEC	
Gomphidae	Beaverpond Clubtail	Gomphus borealis	SPEC	
Gomphidae	Harpoon Clubtail	Gomphus descriptus	SPEC	
Gomphidae	Lancet Clubtail	Gomphus exilis	SPEC	
Gomphidae	**Midland Clubtail**	**Gomphus fraternus**	**M – PHOT (in hand – dorsal view of end of abdomen), F - SPEC**	**rivers, lakes**
Gomphidae	Pronghorn Clubtail *	Gomphus graslinellus	SPEC	
Gomphidae	Splendid Clubtail *	Gomphus lineatifrons	SPEC	
Gomphidae	Ashy Clubtail	Gomphus lividus	M – PHOT (term app), F - SPEC	
Gomphidae	**Rapids Clubtail**	**Gomphus quadricolor**	**SPEC**	**rivers**
Gomphidae	**Sable Clubtail**	**Gomphus rogersi**	**SPEC**	**forest streams**
Gomphidae	**Septima's Clubtail**	**Gomphus septima**	**SPEC**	**rivers**
Gomphidae	Dusky Clubtail	Gomphus spicatus	SPEC	
Gomphidae	**Cobra Clubtail**	**Gomphus vastus**	**M – PHOT (in hand – dorsal view of end of abdomen), F - SPEC**	**rivers**

Family	Common Name	Scientific Name	Identification Level	Habitat
Gomphidae	**Skillet Clubtail**	**Gomphus ventricosus**	**M – PHOT (in hand – dorsal view of end of abdomen), F - SPEC**	**rivers**
Gomphidae	**Green-faced Clubtail**	**Gomphus viridifrons**	**M – PHOT (term app), F - SPEC**	**rivers**
Gomphidae	Dragonhunter	Hagenius brevistylus	OBS	
Gomphidae	Northern Pygmy Clubtail	Lanthus parvulus	SPEC	
Gomphidae	Southern Pygmy Clubtail	Lanthus vernalis	SPEC	
Gomphidae	**Extra-striped Snaketail**	**Ophiogomphus anomalus**	**SPEC**	**rivers**
Gomphidae	**Brook Snaketail**	**Ophiogomphus aspersus**	**SPEC**	**brooks, rivers**
Gomphidae	Riffle Snaketail	Ophiogomphus carolus	SPEC	
Gomphidae	**Boreal Snaketail**	**Ophiogomphus colubrinus**	**SPEC**	**brooks, rivers**
Gomphidae	**Pygmy Snaketail**	**Ophiogomphus howei**	**SPEC**	**rivers**
Gomphidae	Maine Snaketail	Ophiogomphus mainensis	SPEC	
Gomphidae	Rusty Snaketail	Ophiogomphus rupinsulensis	SPEC	
Gomphidae	**Common Sanddragon**	**Progomphus obscurus**	**PHOT (TERM APP)**	**brooks, rivers (sandy)**
Gomphidae	Least Clubtail	Stylogomphus albistylus	PHOT (term app)	
Gomphidae	**Riverine Clubtail**	**Stylurus amnicola**	**SPEC**	**rivers**
Gomphidae	Laura's Clubtail *	Stylurus laurae	SPEC	
Gomphidae	**Elusive Clubtail**	**Stylurus notatus**	**SPEC**	**rivers, lakes**
Gomphidae	**Russet-tipped Clubtail**	**Stylurus plagiatus**	**SPEC**	**rivers**
Gomphidae	Zebra Clubtail	Stylurus scudderi	SPEC	
Gomphidae	**Arrow Clubtail**	**Stylurus spiniceps**	**SPEC**	**rivers, lakes**

Family	Common Name	Scientific Name	Identification Level	Habitat
Cordulegastridae	Brown Spiketail *	Cordulegaster bilineata	SPEC	
Cordulegastridae	Delta-spotted Spiketail	Cordulegaster diastatops	PHOT	
Cordulegastridae	**Tiger Spiketail**	**Cordulegaster erronea**	**PHOT (abdomen – dorsal)**	**seeps, rivulets, brooks**
Cordulegastridae	Twin-spotted Spiketail	Cordulegaster maculata	PHOT	
Cordulegastridae	**Arrowhead Spiketail**	**Cordulegaster obliqua**	**PHOT (abdomen – dorsal)**	**seeps, rivulets, brooks**
Macromiidae	Stream Cruiser	Didymops transversa	OBS	
Macromiidae	Allegheny River Cruiser	Macromia alleghaniensis *	SPEC	
Macromiidae	Illinois River Cruiser	Macromia illinoensis	SPEC	
Macromiidae	Royal River Cruiser	Macromia taeniolata *	SPEC	
Corduliidae	American Emerald	Cordulia shurtleffi	M – PHOT (term app), F - SPEC	
Corduliidae	Petite Emerald	Dorocordulia lepida	M – PHOT (term app), F - SPEC	
Corduliidae	Racket-tailed Emerald	Dorocordulia libera	M – PHOT (term app), F - SPEC	
Corduliidae	Prince Baskettail	Epicordulia princeps	OBS	
Corduliidae	Beaverpond Baskettail	Epitheca canis	M – PHOT (term app), F - SPEC	
Corduliidae	Stripe-winged Baskettail *	Epitheca costalis	SPEC	
Corduliidae	Common Baskettail	Epitheca cynosura	SPEC	
Corduliidae	**Mantled Baskettail**	**Epitheca semiaquea**	**SPEC**	**lakes, ponds, bogs**
Corduliidae	Spiny Baskettail	Epitheca spinigera	M – PHOT (abdomen – dorsal or ventral view), F - SPEC	

Family	Common Name	Scientific Name	Identification Level	Habitat
Corduliidae	Uhler's Sundragon	Helocordulia uhleri	PHOT	
Corduliidae	Broadtailed Shadowdragon *	Neurocordulia michaeli	SPEC	
Corduliidae	Umber Shadowdragon	Neurocordulia obsoleta	SPEC	
Corduliidae	Stygian Shaddowdragon	Neurocordulia yamaskanensis	SPEC	
Corduliidae	**Ringed Emerald**	**Somatochlora albicincta**	**SPEC**	**bogs**
Corduliidae	**Lake Emerald**	**Somatochlora cingulata**	**SPEC**	**lakes, rivers**
Corduliidae	Ski-tailed Emerald	Somatochlora elongata	SPEC	
Corduliidae	**Forcipate Emerald**	**Somatochlora forcipata**	**SPEC**	**bogs**
Corduliidae	**Delicate Emerald**	**Somatochlora franklini**	**SPEC**	**bogs**
Corduliidae	Hine's Emerald *	Somatochlora hineana	PHOT (term app)	
Corduliidae	**Incurvate Emerald**	**Somatochlora incurvata**	**SPEC**	**bogs**
Corduliidae	**Kennedy's Emerald**	**Somatochlora kennedyi**	**SPEC**	**bogs**
Corduliidae	**Mocha Emerald**	**Somatochlora linearis**	**SPEC**	**forest streams**
Corduliidae	**Ocellated Emerald**	**Somatochlora minor**	**SPEC**	**forest streams**
Corduliidae	Clamp-tipped Emerald	Somatochlora tenebrosa	M – PHOT (term app), F - spec	
Corduliidae	Brush-tipped Emerald	Somatochlora walshii	M – PHOT (term app), F - spec	
Corduliidae	Williamson's Emerald	Somatochlora williamsoni	M – PHOT (term app), F - spec	
Corduliidae	Coppery Emerald *	Somatoclora georgiana	SPEC	
Corduliidae	**Ebony Boghaunter**	**Williamsonia fletcheri**	**SPEC**	**bogs**
Corduliidae	**Ringed Boghaunter**	**Williamsonia lintneri**	**PHOT**	**bogs**
Libellulidae	Calico Pennant	Celithemis elisa	OBS	

Family	Common Name	Scientific Name	Identification Level	Habitat
Libellulidae	Halloween Pennant	Celithemis eponina	OBS	
Libellulidae	Banded Pennant	Celithemis fasciata	OBS	
Libellulidae	Martha's Pennant	Celithemis martha	OBS	
Libellulidae	Double-ringed Pennant	Celithemis verna	SPEC	
Libellulidae	Eastern Pondhawk	Erythemis simplicicollis	OBS	
Libellulidae	Seaside Dragonlet	Erythrodiplax berenice	PHOT	
Libellulidae	Little Blue Dragonlet	Erythrodiplax minuscula	SPEC	
Libellulidae	Blue Corporal	Ladona deplanata	M – OBS, F - SPEC	
Libellulidae	White Corporal	Ladona exusta	M – OBS, F - SPEC	
Libellulidae	Chalk-fronted Corporal	Ladona julia	M – OBS, F - SPEC	
Libellulidae	Frosted Whiteface	Leucorrhinia frigida	M – PHOT (hamules), F - SPEC	
Libellulidae	Crimson-ringed Whiteface	Leucorrhinia glacialis	M – PHOT (hamules), F - SPEC	
Libellulidae	Hudsonian Whiteface	Leucorrhinia hudsonica	M – PHOT (hamules), F - SPEC	
Libellulidae	Dot-tailed Whiteface	Leucorrhinia intacta	M – OBS, F - SPEC	
Libellulidae	Red-waisted Whiteface	Leucorrhinia proxima	M – PHOT (hamules), F - SPEC	
Libellulidae	**Golden-winged Skimmer**	**Libellula auripennis**	**SPEC**	**ponds**
Libellulidae	Bar-winged Skimmer	Libellula axilena	M – PHOT, F - SPEC	
Libellulidae	Spangled Skimmer	Libellula cyanea	OBS	
Libellulidae	**Yellow-sided Skimmer**	**Libellula flavida**	**SPEC**	**bogs, ponds**
Libellulidae	Slaty Skimmer	Libellula incesta	M – OBS, F - SPEC	
Libellulidae	Widow Skimmer	Libellula luctuosa	OBS	

Family	Common Name	Scientific Name	Identification Level	Habitat
Libellulidae	**Needham's Skimmer**	**Libellula needhami**	**SPEC**	**brackish ponds, marshes**
Libellulidae	Twelve-spotted Skimmer	Libellula pulchella	OBS	
Libellulidae	Four-spotted Skimmer	Libellula quadrimaculata	OBS	
Libellulidae	Painted Skimmer	Libellula semifasciata	OBS	
Libellulidae	Great Blue Skimmer	Libellula vibrans	M – OBS, F - SPEC	
Libellulidae	Elfin Skimmer	Nannothemis bella	OBS	
Libellulidae	Blue Dasher	Pachydiplax longipennis	M – OBS, F - PHOT	
Libellulidae	Wandering Glider	Pantala flavescens	PHOT	
Libellulidae	Spot-winged Glider	Pantala hymenaea	PHOT	
Libellulidae	Eastern Amberwing	Perithemis tenera	OBS	
Libellulidae	Common Whitetail	Plathemis lydia	OBS	
Libellulidae	Variegated Meadowhawk	Sympetrum corruptum	PHOT	
Libellulidae	Saffron-winged Meadowhawk	Sympetrum costiferum	M – OBS, F - SPEC	
Libellulidae	**Black Meadowhawk**	**Sympetrum danae**	**M – PHOTO, F - SPEC**	**ponds, bogs**
Libellulidae	Cherry-faced Meadowhawk	Sympetrum internum	SPEC	
Libellulidae	Jane's Meadowhawk	Sympetrum janeae	SPEC	
Libellulidae	White-faced Meadowhawk	Sympetrum obtrusum	SPEC	
Libellulidae	Ruby Meadowhawk	Sympetrum rubicundulum	SPEC	
Libellulidae	Band-winged Meadowhawk	Sympetrum semicinctum	OBS	
Libellulidae	Yellow-legged Meadowhawk	Sympetrum vicinum	M – OBS, F - SPEC	
Libellulidae	Vermilion Saddlebags	Tramea abdominalis	PHOT (lateral, wings)	
Libellulidae	Striped Saddlebags	Tramea calverti	PHOT (lateral, wings)	
Libellulidae	Carolina Saddlebags	Tramea carolina	PHOT	
Libellulidae	Black Saddlebags	Tramea lacerata	OBS	