

National Park Service Research Project (CHOH-00147)

SURVEY OF THE DRAGONFLIES AND DAMSELFLIES OF THE 116 MILE WESTERN SECTION OF THE C&O CANAL NATIONAL HISTORICAL PARK (2012 through 2014)

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ABSTRACT

A survey for dragonflies and damselflies covering the upper 116 miles (from the mouth of Antietam Creek to the western end of the Park) was conducted from 2012 through 2014. The information was augmented with all known historical records covering this section of the Park. Adults, cast skins, and larvae data were included in the survey. In total, eighty-one (81) species of dragonflies and damselflies were found to utilize the upper 116 miles of the Park. Ten (10) of the species found are of conservation importance (S2+ ranks) due to rarity by the Department of Natural Resources in Maryland. All data collected were entered into an EXCEL spreadsheet for current and future data manipulation. The spreadsheet contains forty-one thousand, nine-hundred and thirty-nine (41,939) individual dragonflies/damselflies by species, date, location, along with other relevant information. Data from the current survey was combined with dragonfly/damselfly surveys that covered the eastern section of the Park during the 1990s and 2000s. The current known dragonflies/damselflies species found within the Park numbered one-hundred and six (106) plus three additional species considered expired. The combined surveys demonstrate that the C&O Canal National Historical Park has the highest diversity of dragonflies and damselflies species of any single National Park Service property in the Nation.

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COVER PHOTOGRAPH: Splendid Clubtail (*Gomphus lineatifrons*), Mouth of Town Creek,
June 1, 2014

INTRODUCTION

This report meets the contract goals by providing a general overview and discussion of the study. In addition to this report, the following were provided to meet contract requirements: a CD containing data collected from the survey in EXCEL, a photographic record of the rare dragonfly and damselfly species found during the survey and a checklist covering the dragonflies and damselflies (odonates) of the full length of the C&O Canal National Historical Park (Park) and adjacent wetlands for use by the public. The few voucher specimens collected during the survey were also provided to the National Park Service.

The Park's freshwater resources are vast. The western section of the Park includes over 116 miles (187 km) of the northern shore of the Potomac River in Maryland. Portions of over 90 perennial streams including significant tributaries pass through the Park as do an unknown number of intermittent streams. The Park has cave and karst resources, numerous vernal pools, springs and seeps. The Park manages one of the largest unfragmented floodplain forests in the East, which spans across four physiographic regions. A significant portion of the park is in the 100 year floodplain much of which is non-tidal wetlands of the forested palustrine type. Ground water, generally moving towards the Potomac River, resurfaces into numerous seeps and springs in the Park. Approximately 30 miles of historic canal are re-watered and maintained as a watered cultural resource with natural resource importance.

Over 3 million visitors annually enjoy the C&O Canal National Historical Park. The Park actively provides opportunities for visitors to increase their knowledge and enjoyment of the natural resources. Better informed visitors become better stewards and perhaps advocates for the resources within the Park. Dragonflies and damselflies are rapidly gaining popularity among amateur naturalists as a subject of leisure time enjoyment and study. Many bird enthusiasts are turning to these large conspicuous insects, because many of the same identification skills that were acquired through birding are appropriate for the identification of the larger odonates.

A recent publication of dragonfly field guides has intensified this trend. This type of information is important in providing the public with an appreciation of their natural heritage. Such actions are important in sparking and sustaining a conservation ethic to those who visit the Park. Dragonflies are the most common and conspicuous animals around the aquatic wetlands of the Park and the presence of a checklist will add to the public's appreciation and enjoyment of the Park.

Odonates are excellent indicator species. The odonate species population composition of a given aquatic environment reflects the overall health of that system (Corbet, 1999). Changes in the aquatic system whether due to natural or man-made disturbance, pollution, or climate change are quickly reflected in changes in the odonate species composition at a much faster rate than can be monitored for most other plant or animal groups. This is not surprising since it is well documented that other arthropod taxa respond in the same way for terrestrial and aquatic systems (Kremn et al, 1993; Throp and Covich, 2001). Having a baseline survey can and does provide a clear indicator of the current health of the aquatic systems within the Park and provides an excellent tool for monitoring or determining future changes within the Park's aquatic environments.

Eastern North America is one of six recognized dragonfly refugial regions in the world (Carle, 1982). Refugial regions are global hot spots where relic species survive untouched and little changed. These areas retain an extremely high degree of endemic species and even endemic genera. For example, the Eastern North America endemic genera of *Tachopteryx*, *Arigomphus*, *Dromogomphus*, *Gomphaeschna*, *Basiaeschna*, *Epiaeschna*, *Nasiaeschna*, *Didymops*, *Helocordulia*, *Neurocordulia* and *Celithemis* have populations within the Park. From a global biodiversity standpoint, these dragonflies take on added scientific significance, because they have no close counterparts elsewhere in the world.

The potential exists for adverse effects to dragonflies and damselflies in general and to Maryland State identified rare, threatened, and endangered species in particular. Odonates are currently at risk from a number of environmental threats, including habitat destruction, climate change and pesticide applications. Inappropriately timed pesticide releases might pose a risk to these state-listed species.

METHODS

Field excursions were organized to provide maximum coverage of the diverse aquatic habitats within and adjacent to the Park at different times of the year and under various weather conditions. A general survey took place primarily during the first year to identify which locations would provide best access and species diversity for additional sampling. Survey emphases during the second and third year were spent primarily at the pre-selected sites that were determined during the first year. Focusing on specific sites provided better quantitative and qualitative data for the study and provided the best scientific information available for future monitoring of these species or for making management decisions that could potentially affect these populations.

Field data collected were mainly from the identification of imagoes (adults) and exuvia (the cast skin remains left by emerging adults). Some larval sampling was also conducted on a limited basis. With some exceptions, mature adults were identified using binoculars or by capturing and releasing individuals using an insect net. Collecting was done only when necessary and, if of scientific importance, processed as NPS voucher specimens.

Cast skins (exuvia) were collected and identified to species in the laboratory. As these empty insect shells are very ephemeral their removal from the parks had little or no impact on the ecosystem in question. The presence of cast skins provided the emergent times and distributions of some of the rare species whose adults otherwise are difficult to locate in the field. A few representative cast skins were kept for future training workshops. The rest were discarded after the identifications had been made.

Juvenile, freshly-emerged teneral damselflies are soft and non-descript. On a warm spring or summer day, some common damselfly species emerged in the hundreds to thousands from the Potomac River covering the vegetation along the C&O canal. Unfortunately, these teneral damselflies can only be identified in the laboratory. In addition, these soft-bodied specimens make poor museum or voucher specimens. Representative samples of these teneral damselflies

were collected for laboratory identification to establish emergence times of the common resident species. These were discarded after identification.

Total numbers of each species identified during a field excursion were recorded along with the date, time, weather conditions, location, and when appropriate, additional biological information. Only those individuals actually identified were counted. Relevant information while in the field was saved to a digital recorder. The saved information was transferred to standardized log sheets after returning to the laboratory to ensure consistency in recording field data. Each individual dragonfly/damselfly that was identified was recorded as a single data point.

The data points were eventually entered into an EXCEL spreadsheet designed by the Principle Investigator. The spreadsheet was designed so that queries can be made for any or a combination of the following: date, location, genus or species name, common name, number of adults reported, number of larvae reported, number of cast skins reported, whether mature or teneral adults were observed and whether a voucher specimen was taken. In addition, the spreadsheet provides the preferred larval habitats of each species, the larvae ecological mode-of-existence, the Maryland rare or highly-rare species status, and the location of the selected sampling sites using NPS C&O Canal tow-path mile markers.

RESULTS

The EXCEL spreadsheet accompanying this report contains the totality of the information collected from the study. The data contained within the spreadsheet provides information for additional scientific papers and provides biological information that should prove helpful for future management decisions. The information summarized in this report was obtained from data in the spreadsheet.

In total, eighty-one (81) species of dragonflies and damselflies were found to utilize habitats within the surveyed area. Ten (10) species found are identified as of conservation importance due to rarity in Maryland (S2 rank or higher).

Table 1 provides a summary of the survey results. Table 1 lists the 81 species found in the surveyed area by family, scientific name (genus & species columns), common name, preferred larval habitat, larval lifestyle, adult flight period, number of data points recorded and the rarity ranking of the species by the Maryland Department of Natural Resources. Those species with Rare or Highly-Rare rankings (S2+ or higher) are marked in yellow. A data point represents a single individual reported in the project's spreadsheet by date and location. Larval habitat and lifestyle information, when not derived directly from the study, was obtained from Merritt et al (2008). Common names for dragonflies are from Needham et al (2014) and those for damselflies are from Westfall and May (2006). The adult flight period data is a combination of the cast skin and adult data contained within the survey's spreadsheet.

TABLE 1: DRAGONFLIES AND DAMSELFLIES BY FAMILY, SCIENTIFIC NAME, COMMON NAME, LARVAL HABITAT, LARVAL LIFESTYLE, ADULT FLIGHT PERIOD, NUMBER OF DATA POINTS AND MARYLAND CONSERVATION LISTING

FAMILY	GENUS	SPECIES	COMMON NAME	LARVAL HABITAT	LARVAL LIFESTYLE	ADULT FLIGHT SEASON	DATA POINTS	MD LISTING
Calopterygidae	<i>Calopteryx</i>	<i>angustipennis</i>	Appalachian Jewelwing	Rivers	C	April 29 to June 30	373	S1
Calopterygidae	<i>Calopteryx</i>	<i>maculata</i>	Ebony Jewelwing	Rivers, Streams	C	May 20 to July 23	57	S5
Calopterygidae	<i>Hetaerina</i>	<i>americana</i>	American Rubyspot	Rivers	C	May 27 to October 21	4,628	S4
Lestidae	<i>Lestes</i>	<i>australis</i>	Southern Spreadwing	Ponds, Marshes, Swamps	C	June 7 to June 7	2	S5
Lestidae	<i>Lestes</i>	<i>inaequalis</i>	Elegant Spreadwing	Ponds, Marshes, Swamps	C	June 7 to June 7	1	S4
Lestidae	<i>Lestes</i>	<i>rectangularis</i>	Slender Spreadwing	Ponds, Marshes, Swamps	C	June 7 to September 17	5	S4S5
Lestidae	<i>Lestes</i>	<i>vigilax</i>	Swamp Spreadwing	Ponds, Marshes, Swamps	C	June 30 to June 30	1	S4
Coenagrionidae	<i>Amphiagrión</i>	<i>saucium</i>	Eastern Red Damsel	Seeps	C	May 31 to June 7	7	S3S4
Coenagrionidae	<i>Argia</i>	<i>apicalis</i>	Blue-fronted Dancer	Rivers, Streams	C,S	June 17 to October 4	218	S4
Coenagrionidae	<i>Argia</i>	<i>fumipennis</i>	Violet Dancer	Rivers, Streams, Ponds, Swamps	C,S	May 30 to August 26	50	S5
Coenagrionidae	<i>Argia</i>	<i>moesta</i>	Powdered Dancer	Rivers	C,S	May 7 to October 4	18,742	S5
Coenagrionidae	<i>Argia</i>	<i>sedula</i>	Blue-ringed Dancer	Rivers	C,S	July 12 to September 9	57	S3
Coenagrionidae	<i>Argia</i>	<i>tibialis</i>	Blue-tipped Dancer	Rivers, Streams	C,S	June 7 to July 26	52	S4
Coenagrionidae	<i>Argia</i>	<i>translata</i>	Dusky Dancer	Rivers, Streams	C,S	July 3 to October 4	366	S4
Coenagrionidae	<i>Chromagrion</i>	<i>conditum</i>	Aurora Bluet	Marshes, Swamps, Seeps	C	May 21 to May 31	3	S3S4
Coenagrionidae	<i>Enallagma</i>	<i>aspersum</i>	Azure Bluet	Ponds, Marshes	C	June 7 to June 22	9	S4
Coenagrionidae	<i>Enallagma</i>	<i>basidens</i>	Double-striped Bluet	Ponds, Marshes	C	May 20 to August 12	10	S4
Coenagrionidae	<i>Enallagma</i>	<i>civile</i>	Familiar Bluet	Ponds, Marshes, River Pools	C	May 27 to October 4	36	S5
Coenagrionidae	<i>Enallagma</i>	<i>exulans</i>	Stream Bluet	River, Streams	C	May 6 to October 5	6,003	S5
Coenagrionidae	<i>Enallagma</i>	<i>geminatum</i>	Skimming Bluet	Ponds, Marshes	C	May 18 to June 14	10	S5
Coenagrionidae	<i>Enallagma</i>	<i>signatum</i>	Orange Bluet	Ponds, Marshes	C	May 18 to May 31	5	S4
Coenagrionidae	<i>Enallagma</i>	<i>traviatum</i>	Slender Bluet	Ponds	C	July 15 to July 15	1	S3
Coenagrionidae	<i>Ischnura</i>	<i>hastata</i>	Citrine Bluet	Ponds, Pools grassy areas	C	May 18 to July 26	8	S4S5
Coenagrionidae	<i>Ischnura</i>	<i>kellicotti</i>	Lilypad Forktail	Ponds	C	June 7 to July 28	8	S3S4
Coenagrionidae	<i>Ischnura</i>	<i>posita</i>	Fragile Forktail	Ponds, Marshes, River Pools	C	April 29 to October 4	319	S5
Coenagrionidae	<i>Ischnura</i>	<i>verticalis</i>	Eastern Forktail	Marshes, Ponds, River Pools	C	April 29 to August 19	197	S5
Gomphidae	<i>Arigomphus</i>	<i>villosipes</i>	Unicorn Clubtail	Ponds	B	May 20 to July 3	32	S4
Gomphidae	<i>Dromogomphus</i>	<i>spinosus</i>	Black-shouldered Spinyleg	Rivers, Streams	B	May 27 to October 4	313	S5

Gomphidae	<i>Erpetogomphus</i>	<i>designatus</i>	Eastern Ringtail	Rivers	B	July 29 to June 7	4	S2
Gomphidae	<i>Gomphus</i>	<i>abbreviatus</i>	Spine-crowned Clubtail	Rivers	B	April 20 to May 30	75	S1
Gomphidae	<i>Gomphus</i>	<i>exilis</i>	Lancet Clubtail	Rivers, Streams, Ponds	B	April 29 to June 30	29	S5
Gomphidae	<i>Gomphus</i>	<i>fraternus</i>	Midland Clubtail	Rivers	B	April 30 to June 7	4	S2
Gomphidae	<i>Gomphus</i>	<i>lividus</i>	Ashy Clubtail	Rivers, Streams	B	April 20 to June 7	41	S5
Gomphidae	<i>Gomphus</i>	<i>lineatifrons</i>	Splendid Clubtail	Rivers	B	April 30 to July 23	35	S1
Gomphidae	<i>Gomphus</i>	<i>quadricolor</i>	Rapids Clubtail	Rivers	B	April 30 to May 27	18	S2
Gomphidae	<i>Gomphus</i>	<i>vastus</i>	Cobra Clubtail	Rivers	B	April 29 to July 29	1,549	S4
Gomphidae	<i>Gomphus</i>	<i>viridifrons</i>	Green-faced Clubtail	Rivers	B	April 20 to June 30	209	S1
Gomphidae	<i>Hagenius</i>	<i>brevistylus</i>	Dragonhunter	Rivers, Streams	S	May 27 to September 17	322	S4
Gomphidae	<i>Ophiogomphus</i>	<i>howei</i>	Pygmy Snaketail	Rivers	B	April 30 to June 4	7	S1
Gomphidae	<i>Ophiogomphus</i>	<i>rupinsulensis</i>	Rusty Snaketail	Rivers	B	April 29 to August 26	1,564	S1
Gomphidae	<i>Stylogomphus</i>	<i>albistylus</i>	Eastern Least Clubtail	Rivers, Streams	B	May 6 to June 17	283	S4
Gomphidae	<i>Stylurus</i>	<i>plagiatus</i>	Russet-tipped Clubtail	Rivers	B	August 12 to August 12	1	S3
Gomphidae	<i>Stylurus</i>	<i>spiniceps</i>	Arrow Clubtail	Rivers	B	June 30 to July 22	8	S3
Aeshnidae	<i>Anax</i>	<i>junius</i>	Common Green Darner	Ponds, Marshes, River Pools	C	April 29 to June 7	51	S5
Aeshnidae	<i>Anax</i>	<i>longipes</i>	Comet Darner	Ponds, Marshes	C	June 7 to June 7	1	S3
Aeshnidae	<i>Basiaeschna</i>	<i>janata</i>	Springtime Darner	Rivers, Streams	C,S	April 20 to June 7	159	S5
Aeshnidae	<i>Boyeria</i>	<i>grafiana</i>	Ocellated Darner	Rivers, Streams	C,S	July 22 to October 4	2	S1
Aeshnidae	<i>Boyeria</i>	<i>vinosa</i>	Fawn Darner	Rivers, Streams	C,S	June 17 to October 4	76	S5
Aeshnidae	<i>Epiaeschna</i>	<i>heros</i>	Swamp Darner	Swamps	C,S	May 12 to August 5	17	S5
Aeshnidae	<i>Nasiaeschna</i>	<i>pentacantha</i>	Cyrano Darner	Ponds, Swamps	C,S	July 3 to July 3	1	S3S4
Cordulegastriidae	<i>Cordulegaster</i>	<i>maculata</i>	Twin-spotted Spiketail	Seeps, Streams	B	May 7 to May 30	2	S4
Macromiidae	<i>Didymops</i>	<i>transversa</i>	Stream Cruiser	Rivers, Streams	S	April 20 to June 2	50	S5
Macromiidae	<i>Macromia</i>	<i>illinoensis</i>	Illinois River Cruiser	Rivers	S	May 20 to August 26	130	S4
Macromiidae	<i>Macromia</i>	<i>taeniolata</i>	Royal River Cruiser	Rivers	S	May 27 to July 12	7	S3
Cordulidae	<i>Cordulia</i>	<i>shurtleffii</i>	American Emerald	Ponds, Marshes	S	May 19 to May 20	5	S3
Cordulidae	<i>Epitheca</i>	<i>cynosura</i>	Common Baskettail	Ponds, Swamps	C,S	April 29 to June 22	855	S5
Cordulidae	<i>Epitheca</i>	<i>princeps</i>	Prince Baskettail	Ponds, River Pools	C,S	May 27 to September 9	194	S4
Cordulidae	<i>Helocordulia</i>	<i>uhleri</i>	Uhleri's Sundragon	Rivers, Streams	S	April 30 to May 31	29	S3
Cordulidae	<i>Neurocordulia</i>	<i>obsoleta</i>	Umber Shadowdragon	Rivers	C	May 7 to August 12	102	S3
Cordulidae	<i>Neurocordulia</i>	<i>yamaskanensis</i>	Stygian Shadowdragon	Rivers	C	May 7 to July 29	35	S3
Libellulidae	<i>Celithemis</i>	<i>elisa</i>	Calico Pennant	Ponds, Marshes	C	June 7 to July 15	5	S5
Libellulidae	<i>Celithemis</i>	<i>eponina</i>	Halloween Pennant	Ponds, Marshes	C	June 7 to Aug 26	100	S4S5
Libellulidae	<i>Erythemis</i>	<i>simpliciflora</i>	Eastern Pondhawk	Ponds, Marshes, River Pools	S	May 17 to October 4	398	S5
Libellulidae	<i>Ladona</i>	<i>deplanata</i>	Blue Corporal	Ponds	S	April 29 to June 7	136	S4S5
Libellulidae	<i>Leucorrhinia</i>	<i>intacta</i>	Spot-tailed Whiteface	Ponds	C	May 18 to June 22	11	S3

Libellulidae	<i>Libellula</i>	<i>cyanea</i>	Spangled Skimmer	Ponds, Marshes, River Pools	S	May 25 to July 29	372	S5
Libellulidae	<i>Libellula</i>	<i>incesta</i>	Slaty Skimmer	Ponds, Marshes, River Pools	S	June 7 to September 9	97	S5
Libellulidae	<i>Libellula</i>	<i>luctuosa</i>	Widow Skimmer	Ponds, Marshes, River Pools	S	May 31 to Aug 26	149	S5
Libellulidae	<i>Libellula</i>	<i>pulchella</i>	Twelve-Spotted Skimmer	Ponds, Marshes, River Pools	S	May 6 to August 26	23	S5
Libellulidae	<i>Libellula</i>	<i>semifasciata</i>	Painted Skimmer	Ponds, Marshes	S	May 14 to May 14	1	S5
Libellulidae	<i>Libellula</i>	<i>vibrans</i>	Great Blue Skimmer	Ponds	S	June 30 to August 5	5	S5
Libellulidae	<i>Pachydiplax</i>	<i>longipennis</i>	Blue Dasher	Ponds, Marshes, River Pools	S	May 31 to September 9	1,855	S5
Libellulidae	<i>Pantala</i>	<i>flavescens</i>	Wandering Glider	Ponds, River Pools	S	June 12 to July 12	3	S5
Libellulidae	<i>Pantala</i>	<i>hymenaea</i>	Spot-winged Glider	Ponds, River Pools	S	May 18 to July 29	10	S5
Libellulidae	<i>Perithemis</i>	<i>tenera</i>	Eastern Amberwing	Ponds, Marshes, River Pools	S	June 22 to September 13	1,150	S5
Libellulidae	<i>Plathemis</i>	<i>lydia</i>	Common Whitetail	Ponds, Marshes, River Pools	S	April 20 to October 4	313	S5
Libellulidae	<i>Sympetrum</i>	<i>ambiguum</i>	Blue-faced Meadowhawk	Temperary Ponds and Pools	C	June 2 to October 4	122	S3S4
Libellulidae	<i>Sympetrum</i>	<i>interim</i>	Cherry-faced Meadowhawk	Ponds, Marshes	C	July 15 to July 15	2	SU
Libellulidae	<i>Sympetrum</i>	<i>rubicundulum</i>	Ruby Meadowhawk	Ponds, Marshes	C	June 23 to September 17	2	S4
Libellulidae	<i>Tramea</i>	<i>carolina</i>	Carolina Saddlebags	Ponds	S	May 31 to August 5	3	S4S5
Libellulidae	<i>Tramea</i>	<i>lacerata</i>	Black Saddlebags	Ponds	S	May 12 to July 26	71	S5

KEYS

MARYLAND RANK OF HIGHLY RARE OR STATE RARE LISTING

State Rare

Rare

List

Secure

Secure

Rare But status Currently Uncertain

Only

B = Burrower

S = Sprawler

C = Climber

* Taken from 4th Edition of "An

Introduction of Aquatic Insects of

North America" Edited by Merritt, Cummins and Berg

MD

S1 = State Rank -- Highly

S2 = State Rank -- State

S3 = State Rank -- Watch

S4 = State Rank -- Apparently

S5 = State Rank -- Demonstrably

SU = State Rank -- Possibly

SH = State Rank -- Historical

DISCUSSION

The number of data points recorded in the EXCEL spreadsheet for each species does not represent an absolute (statistically valid) measurement of the abundance of that species. However, it does provide a reasonable approximation of relative abundance of the species, provided the limitations of the data gathering method are taken into consideration. These limitations are:

- Some species were so abundant that actual numbers seen could not be reasonably counted. In these cases the estimated minimum number that was seen was recorded. Therefore, for very abundant species the data points underestimate the number of

individuals. For species like the American Rubyspot and Powdered Dancer which are often present in large numbers along the Potomac River, daily number estimates of adults seen may have been under counted by as much as a third or more in the spreadsheet.

- Chance findings of synchronous emergence of some species increased the number of data points compared to similar species in which their mass emergence times were missed. Examples are the Cobra Clubtail and Rusty Snaketail.
- Those species that are inconspicuous or small (e.g. Fragile Forktail or Citrine Forktail) are underestimated by the number of data points compared to those species that are very large and conspicuous on the wing (e.g. Swamp Darner or Common Green Darner).
- Because the cast skin data points contained in the spreadsheet came mostly from the edge of the Potomac River this favored those species that left cast skins that were easy to find and favored stretches of the river whose banks could be searched in safety. Examples include the two species of Shadowdragons and various Clubtail species.

The spreadsheet contains useful information for making comparisons between locations, species and dates. However, in general it should be kept in mind that when comparing numbers of data points between species, that those species with a high number of data points are likely underestimated while those with very low data points are likely overestimated when compared as a ratio against each other.

Because of these limitations, the database should be used with the understanding that it is a compromise of quantitative and subjective measurements and should be interpreted as general information. The information would not be expected to capture minor fluctuations in the adult population but does provide enough rigor to yield insight into the general abundance of the species. The survey methods that were developed and used for this study were designed to maximize the survey needs of the study. The survey methods were not designed as a monitoring tool despite the fact that many of the same data fields used in the spreadsheet would be the same as those used in a rigorous monitoring program.

Odonate species are currently at risk from a number of environmental threats, both from habitat destruction and contamination. During emergence, dragonflies are especially vulnerable to aerosol biocides, because their exoskeletons have yet to harden which would otherwise provide a level of protection (Corbet, 1999). The risk from biocides within the Park might increase if outbreaks of Gypsy Moth, West Nile virus or other invasive species becomes necessary. There is the potential that inappropriate timed pesticide releases (especially arousals) might pose a risk to adult dragonflies and damselflies. Particular caution should be given to aerosol pesticide spray times that occur during the flight period of the State-Rare and Highly-State-Rare species. In Table 1, the flight periods of the State-Rare and Highly-State-Rare dragonflies and damselflies are marked in yellow. Equal caution is warranted from the direct or indirect introduction of pesticides or other environmental contaminants into the aquatic habitats of the larvae of the State-Rare and Highly-State-Rare species. These habitats are also identified in Table 1.

In the upper 161 miles of the C&O canal the highest concentration of State-Rare and Highly-State-Rare species, and indeed the highest diversity of dragonflies and damselflies occur from the convergence of the North and South Branches of the Potomac River to the Fort Frederick State Park area. Most likely this reflects the health of the Potomac River within this section of Maryland. Although, the larval habitats of these state-listed species is the Potomac River which is owned by Maryland, a significant portion of the adult habitat resides within the Park. Protection of the riverine habitat and its tributaries will be necessary if these populations are to remain healthy.

When the data from the current survey is combined with the surveys conducted on the lower section of the Park (Appendix I: Table 2) the results show a wealth of species biodiversity for the C&O Canal National Historical Park. Not only do dragonflies and damselflies represent the highest number of Maryland State-Rare and Highly-State-Rare species (21) of any animal group found within the Park, but the C&O Canal National Historical Park has the greatest number of dragonfly and damselfly species (109) of any single National Park Service property in the Nation. This attests to the uniqueness of the Park and the Potomac River corridor and its tributaries as a national biodiversity resource.

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APPENDIX I: SUMMARY OF THE DRAGONFLIES AND DAMSELFLIES OF THE C&O CANAL NATIONAL HISTORICAL PARK

Table 2 provides a summary of the current information on dragonflies and damselflies for the full length of the Park. This table includes information from the 2012-2014 survey, earlier surveys conducted by the Author (Orr, 1995, 1996a, 1996b, 2005), published information (Donnelly, 1961) and records from the Smithsonian’s National Insect Collection. Also included are numerous unpublished records from local naturalists and entomologists.

The format of this table is similar to Table 1 except that the Lower Data Points column was added to represent the data collected from sources other than the current survey (Upper Data Points).

TABLE 2: SUMMARY OF THE DRAGONFLIES AND DAMSELFLIES OF THE C&O CANAL NATIONAL HISTORICAL PARK

	FAMILY	GENUS	SPECIES	ENGLISH NAME	ADULT FLIGHT SEASON	LOWER DATA POINTS	UPPER DATA POINTS	TOTAL DATA POINTS	MD LISTING
1	Calopterygidae	<i>Calopteryx</i>	<i>angustipennis</i>	Appalachian Jewelwing	April 29 to June 30		373	373	S1
2	Calopterygidae	<i>Calopteryx</i>	<i>maculata</i>	Ebony Jewelwing	May 4 to September 14	2,653	57	2,710	S5
3	Calopterygidae	<i>Hetaerina</i>	<i>americana</i>	American Rubyspot	May 23 to November 9	20,128	4,628	24,756	S4
4	Calopterygidae	<i>Hetaerina</i>	<i>titia</i>	Smoky Rubyspot	Historical (pre-1961)			0	SH
5	Lestidae	<i>Archilestes</i>	<i>grandis</i>	Great Spreadwing	September 7 to October 16	11		11	S3
6	Lestidae	<i>Lestes</i>	<i>australis</i>	Southern Spreadwing	April 17 to October 1	37	2	39	S5
7	Lestidae	<i>Lestes</i>	<i>forcipatus</i>	Sweetflag Spreadwing	July 16 to July 16	1		1	S3
8	Lestidae	<i>Lestes</i>	<i>inaequalis</i>	Elegant Spreadwing	June 7 to June 7	1	1	2	S4
9	Lestidae	<i>Lestes</i>	<i>rectangularis</i>	Slender Spreadwing	May 25 to October 8	27	5	32	S4S5
10	Lestidae	<i>Lestes</i>	<i>vigilax</i>	Swamp Spreadwing	June 30 to June 30		1	1	S4
11	Coenagrionidae	<i>Amphiagrion</i>	<i>saucium</i>	Eastern Red Damsel	May 31 to July 23	4	7	11	S3S4
12	Coenagrionidae	<i>Argia</i>	<i>apicalis</i>	Blue-fronted Dancer	June 1 to October 18	9,922	218	10,140	S4
13	Coenagrionidae	<i>Argia</i>	<i>fumipennis</i>	Violet Dancer	May 26 to September 4	224	50	274	S5
14	Coenagrionidae	<i>Argia</i>	<i>moesta</i>	Powdered Dancer	May 7 to October 18	23,478	18,742	42,220	S5
15	Coenagrionidae	<i>Argia</i>	<i>sedula</i>	Blue-ringed Dancer	June 2 to October 8	3,251	57	3,308	S3
16	Coenagrionidae	<i>Argia</i>	<i>tibialis</i>	Blue-tipped Dancer	May 25 to August 17	69	52	121	S4
17	Coenagrionidae	<i>Argia</i>	<i>translata</i>	Dusky Dancer	June 7 to October 8	815	366	1,181	S4
18	Coenagrionidae	<i>Chromagrion</i>	<i>conditum</i>	Aurora Bluet	May 21 to May 31	1	3	4	S3S4

19	Coenagrionidae	<i>Enallagma</i>	<i>aspersum</i>	Azure Bluet	June 7 to July 11		9	9	S4
20	Coenagrionidae	<i>Enallagma</i>	<i>basidens</i>	Double-striped Bluet	May 20 to September 21	7	10	17	S4
21	Coenagrionidae	<i>Enallagma</i>	<i>civile</i>	Familiar Bluet	May 5 to November 9	2,225	36	2,261	S5
22	Coenagrionidae	<i>Enallagma</i>	<i>divagans</i>	Turquoise Bluet	May 29 to June 19	4		4	S3S4
23	Coenagrionidae	<i>Enallagma</i>	<i>durum</i>	Big Bluet	July 4 to September 21	2,842		2,842	S3
24	Coenagrionidae	<i>Enallagma</i>	<i>exsulans</i>	Stream Bluet	May 6 to October 16	8,216	6,003	14,219	S5
25	Coenagrionidae	<i>Enallagma</i>	<i>geminatum</i>	Skimming Bluet	May 18 to August 13	197	10	207	S5
26	Coenagrionidae	<i>Enallagma</i>	<i>signatum</i>	Orange Bluet	May 18 to August 26	87	5	92	S4
27	Coenagrionidae	<i>Enallagma</i>	<i>triviatum</i>	Slender Bluet	June 18 to July 19	30	1	31	S3
28	Coenagrionidae	<i>Ischnura</i>	<i>hastata</i>	Citrine Forktail	May 9 to September 4	11	8	19	S4S5
29	Coenagrionidae	<i>Ischnura</i>	<i>kellicotti</i>	Lilypad Forktail	June 7 to July 28	37	8	45	S3S4
30	Coenagrionidae	<i>Ischnura</i>	<i>posita</i>	Fragile Forktail	April 8 to October 13	3,614	319	3,933	S5
31	Coenagrionidae	<i>Ischnura</i>	<i>ramburii</i>	Rambur's Forktail	August 25 to Aug 25	1		1	S4
32	Coenagrionidae	<i>Ischnura</i>	<i>verticalis</i>	Eastern Forktail	April 27 to September 21	184	197	381	S5
33	Petaluridae	<i>Tachopteryx</i>	<i>thoreyi</i>	Gray Petaltail	June 5 to June 11	11		11	S3
34	Gomphidae	<i>Arigomphus</i>	<i>villosipes</i>	Unicorn Clubtail	May 20 to July 3	1	32	33	S4
35	Gomphidae	<i>Dromogomphus</i>	<i>spinus</i>	Black-shouldered Spinyleg	May 18 to October 4	1,251	313	1,564	S5
36	Gomphidae	<i>Erpetogomphus</i>	<i>designatus</i>	Eastern Ringtail	June 1 to October 8	116	4	120	S2
37	Gomphidae	<i>Gomphus</i>	<i>abbreviatus</i>	Spine-crowned Clubtail	April 14 to May 30	59	75	134	S1
38	Gomphidae	<i>Gomphus</i>	<i>exilis</i>	Lancet Clubtail	April 27 to July 2	24	29	53	S5
39	Gomphidae	<i>Gomphus</i>	<i>fraternus</i>	Midland Clubtail	April 30 to June 16	63	4	67	S2
40	Gomphidae	<i>Gomphus</i>	<i>lineatifrons</i>	Splendid Clubtail	May 21 to July 23		35	35	S1
41	Gomphidae	<i>Gomphus</i>	<i>lividus</i>	Ashy Clubtail	April 8 to June 7	192	41	233	S5
42	Gomphidae	<i>Gomphus</i>	<i>quadricolor</i>	Rapids Clubtail	April 30 to June 6	10	18	28	S2
43	Gomphidae	<i>Gomphus</i>	<i>vastus</i>	Cobra Clubtail	April 25 to July 29	2,965	1,549	4,514	S4
44	Gomphidae	<i>Gomphus</i>	<i>ventricosus</i>	Skillet Clubtail	Historical (pre-1915)			0	SH
45	Gomphidae	<i>Gomphus</i>	<i>viridifrons</i>	Green-faced Clubtail	April 20 to June 30	3	209	212	S1
46	Gomphidae	<i>Hagenius</i>	<i>brevistylus</i>	Dragonhunter	May 21 to September 20	40	322	362	S4
47	Gomphidae	<i>Ophiogomphus</i>	<i>howei</i>	Pygmy Snaketail	April 30 to June 4		7	7	S1
48	Gomphidae	<i>Ophiogomphus</i>	<i>rupinsulensis</i>	Rusty Snaketail	April 29 to August 26	13	1,564	1,577	S1
49	Gomphidae	<i>Ophiogomphus</i>	<i>susbehcha</i>	St. Croix Snaketail	April 8 to May 12	68		68	S1
50	Gomphidae	<i>Progomphus</i>	<i>obscurus</i>	Common Sanddragon	June 11 to June 11	1		1	S3
51	Gomphidae	<i>Stylogomphus</i>	<i>albistylus</i>	Eastern Least Clubtail	May 6 to June 17	12	283	295	S4
52	Gomphidae	<i>Stylurus</i>	<i>amicola</i>	Riverine Clubtail	Historical (pre-1951)			0	SH
53	Gomphidae	<i>Stylurus</i>	<i>laurae</i>	Laura's Clubtail	June 30 to July 19	8		8	S2S3
54	Gomphidae	<i>Stylurus</i>	<i>plagiatus</i>	Russet-tipped Clubtail	July 2 to September 7	15	1	16	S3

55	Gomphidae	<i>Stylurus</i>	<i>spiniceps</i>	Arrow Clubtail	June 14 to October 16	1050	8	1,058	S3
57	Aeshnidae	<i>Aeshna</i>	<i>umbrosa</i>	Shadow Darner	July 15 to November 2	14		14	S4
58	Aeshnidae	<i>Aeshna</i>	<i>verticalis</i>	Green-striped Darner	October 23 to October 23	2		2	S1
59	Aeshnidae	<i>Anax</i>	<i>junius</i>	Common Green Darner	March 29 to October 16	429	51	480	S5
60	Aeshnidae	<i>Anax</i>	<i>longipes</i>	Comet Darner	May 22 to June 7	1	1	2	S3
61	Aeshnidae	<i>Basiaeschna</i>	<i>janata</i>	Springtime Darner	April 8 to June 7	105	159	264	S5
62	Aeshnidae	<i>Boyeria</i>	<i>grafiana</i>	Ocellated Darner	July 22 to October 4		2	2	S1
63	Aeshnidae	<i>Boyeria</i>	<i>vinosa</i>	Fawn Darner	June 3 to October 13	24	76	100	S5
64	Aeshnidae	<i>Epiaeschna</i>	<i>heros</i>	Swamp Darner	May 9 to August 26	117	17	134	S5
65	Aeshnidae	<i>Gomphaeschna</i>	<i>furcillata</i>	Harlequin Darner	April 23 to April 25	5		5	S3S4
66	Aeshnidae	<i>Nasiaeschna</i>	<i>pentacantha</i>	Cyrano Darner	May 17 to July 31	40	1	41	S3S4
56	Aeshnidae	<i>Rhionaeschna</i>	<i>mutata</i>	Spadderdock Darner	June 6 to June 6	1		1	S1
67	Cordulegastridae	<i>Cordulegaster</i>	<i>bilineata</i>	Brown Spiketail	May 10 to May 10	1		1	S3
68	Cordulegastridae	<i>Cordulegaster</i>	<i>erronea</i>	Tiger Spiketail	June 6 to June 6	1		1	S3
70	Cordulegastridae	<i>Cordulegaster</i>	<i>maculata</i>	Twin-spotted Spiketail	April 28 to May 30	1	2	3	S4
69	Cordulegastridae	<i>Cordulegaster</i>	<i>obliqua</i>	Arrowhead Spiketail	June 6 to June 19	3		3	S2
71	Macromiidae	<i>Didymops</i>	<i>transversa</i>	Stream Cruiser	April 20 to June 2	54	50	104	S5
72	Macromiidae	<i>Macromia</i>	<i>allegahaniensis</i>	Allegheny River Cruiser	May 15 to May 15	1		1	S2
73	Macromiidae	<i>Macromia</i>	<i>illinoiensis</i>	Illinois River Cruiser	May 18 to August 26	176	130	306	S4
74	Macromiidae	<i>Macromia</i>	<i>taeniolata</i>	Royal River Cruiser	May 27 to August 26	24	7	31	S3
75	Cordulidae	<i>Cordulia</i>	<i>shurtleffii</i>	American Emerald	May 19 to May 20		5	5	S3
76	Cordulidae	<i>Epithea</i>	<i>cynosura</i>	Common Baskettail	April 26 to June 22	132	855	987	S5
77	Cordulidae	<i>Epithea</i>	<i>princeps</i>	Prince Baskettail	May 25 to September 9	195	194	389	S4
78	Cordulidae	<i>Epithea</i>	<i>spinosa</i>	Robust Baskettail	April 23 to April 23	2		2	S1S2
79	Cordulidae	<i>Helocordulia</i>	<i>uhleri</i>	Uhleri's Sundragon	April 30 to May 31		29	29	S3
80	Cordulidae	<i>Neurocordulia</i>	<i>obsoleta</i>	Umber Shadowdragon	May 7 to August 12	482	102	584	S3
81	Cordulidae	<i>Neurocordulia</i>	<i>yamaskanensis</i>	Stygian Shadowdragon	May 7 to July 30	49	35	84	S3
82	Cordulidae	<i>Somatochlora</i>	<i>linearis</i>	Mocha Emerald	July 13 to July 24	2		2	S3S4
83	Cordulidae	<i>Somatochlora</i>	<i>tenebrosa</i>	Clamp-tipped Emerald	July 2 to July 13	1		1	S4
84	Libellulidae	<i>Celithemis</i>	<i>elisa</i>	Calico Pennant	May 24 to July 15	246	5	251	S5
85	Libellulidae	<i>Celithemis</i>	<i>eponina</i>	Halloween Pennant	June 7 to Aug 26	33	100	133	S4S5
86	Libellulidae	<i>Celithemis</i>	<i>fasciata</i>	Banded Pennant	June 23 to June 23	1		1	S3
87	Libellulidae	<i>Celithemis</i>	<i>verna</i>	Double-ringed Pennant	May 24 to June 23	1		1	S2
88	Libellulidae	<i>Erythemis</i>	<i>simplicicollis</i>	Eastern Pondhawk	April 27 to October 7	2627	398	3,025	S5
89	Libellulidae	<i>Ladona</i>	<i>deplanata</i>	Blue Corporal	April 23 to June 7	3	136	139	S4S5
90	Libellulidae	<i>Leucorrhinia</i>	<i>intacta</i>	Spot-tailed Whiteface	May 18 to June 22		11	11	S3

91	Libellulidae	<i>Libellula</i>	<i>axilena</i>	Bar-winged Skimmer	June 6 to June 6	1		1	S3
92	Libellulidae	<i>Libellula</i>	<i>cyanea</i>	Spangled Skimmer	May 24 to August 28	66	372	438	S5
93	Libellulidae	<i>Libellula</i>	<i>incesta</i>	Slaty Skimmer	June 7 to September 29	229	97	326	S5
94	Libellulidae	<i>Libellula</i>	<i>luctuosa</i>	Widow Skimmer	May 25 to October 3	627	149	776	S5
95	Libellulidae	<i>Libellula</i>	<i>needhami</i>	Needham's Skimmer	August 25 to Aug 25	8		8	S5
96	Libellulidae	<i>Libellula</i>	<i>pulchella</i>	Twelve-Spotted Skimmer	May 6 to September 19	88	23	111	S5
97	Libellulidae	<i>Libellula</i>	<i>semifasciata</i>	Painted Skimmer	May 14 to July 19	58	1	59	S5
98	Libellulidae	<i>Libellula</i>	<i>vibrans</i>	Great Blue Skimmer	May 16 to September 4	89	5	94	S5
99	Libellulidae	<i>Pachydiplax</i>	<i>longipennis</i>	Blue Dasher	May 21 to September 14	3,316	1,855	5,171	S5
100	Libellulidae	<i>Pantala</i>	<i>flavescens</i>	Wandering Glider	April 20 to October 13	17	3	20	S5
101	Libellulidae	<i>Pantala</i>	<i>hymenaea</i>	Spot-winged Glider	May 9 to August 31	62	10	72	S5
102	Libellulidae	<i>Perithemis</i>	<i>tenera</i>	Eastern Amberwing	June 8 to October 3	619	1,150	1,769	S5
103	Libellulidae	<i>Plathemis</i>	<i>lydia</i>	Common Whitetail	April 20 to October 4	1,015	313	1,328	S5
104	Libellulidae	<i>Sympetrum</i>	<i>ambiguum</i>	Blue-faced Meadowhawk	June 2 to October 4	3	122	125	S3S4
105	Libellulidae	<i>Sympetrum</i>	<i>interim</i>	Cherry-faced Meadowhawk	July 15 to September 24	3	2	5	SU
106	Libellulidae	<i>Sympetrum</i>	<i>rubicundulum</i>	Ruby Meadowhawk	June 23 to September 17	39	2	41	S4
107	Libellulidae	<i>Sympetrum</i>	<i>vicinum</i>	Autumn Meadowhawk	June 29 to October 18	357		357	S5
108	Libellulidae	<i>Tramea</i>	<i>carolina</i>	Carolina Saddlebags	May 31 to October 1	2	3	5	S4S5
109	Libellulidae	<i>Tramea</i>	<i>lacerata</i>	Black Saddlebags	May 12 to September 24	144	71	215	S5
					TOTAL =	95,495	42,206	137,701	

KEYS

MARYLAND RANK OF HIGHLY RARE OR STATE RARE

MD LISTING

- S1 = State Rank -- Highly State Rare
- S2 = State Rank -- State Rare
- S3 = State Rank -- Watch List
- S4 = State Rank -- Apparently Secure
- S5 = State Rank -- Demonstrably Secure
- SU = State Rank -- Possibly Rare But status Currently Uncertain
- SH = State Rank -- Historical Only