

Permit Reports for NPS and USNA, 2009

Abstract

Invertebrates are very important ecologically, but are under-represented in the District's Wildlife Action Plan. Knowledge of their populations, diversity and abundance will be useful when making long-term management decisions in the District of Columbia. In FY 2009 the District Department of the Environment – Fisheries and Wildlife Division surveyed springs and seeps for groundwater invertebrates. The FWD discovered and surveyed four springs and seeps on District-owned land. Groundwater invertebrates were collected from organic material in the spring or seep. Three springs yielded groundwater invertebrates, and one amphipod has been identified as genus Crangonyx. A taxonomist is under contract to identify the samples and create a voucher collection. We also surveyed odonata, dragonflies and damselflies, for the third year of a multi-year inventory. The WAP identifies eight odonata as species of greatest conservation need. The FWD conducted walking surveys of adult odonata at thirteen sites in four main locations over the course of the summer. Forty-four species were recorded. Two species of greatest conservation need, Arigomphus villosipes (Unicorn Clubtail) and Ischnura kellicotti (Lilypad Forktail) were recorded. The most dominant species were Pachydiplax longipennis (Blue Dasher) and Libellula lydia (Common Whitetail). The fewest species (10) were seen at the Rock Creek Park location (at four sites), while 27 of the 44 species were seen at the C&O Canal location (at three sites). The C&O Canal location also had the highest abundance of the summer, with 980 records. The number of species seen peaked in mid-summer. The FWD will be continuing these studies in FY10 to include more habitats and more springs and seeps.

Rock Creek Park - Groundwater Invertebrate Survey

Introduction

Washington D.C. has a wide range of ecosystems and habitats that can support many types of invertebrates, but these species may be limited to parks and other natural areas due to the urban, human-altered landscape. Little is known about the many groups of invertebrates that reside in the forests, meadows, streams, ponds and rivers in the city. A local entomologist has found over 2,000 species of insect in his yard in suburban Maryland (Peter Mundel, pers. comm.), but there are only 21 species of insects on the list of species of greatest conservation need (SGCN) in the DC Wildlife Action Plan (WAP). In order to add to information about several types of invertebrates in various habitats in the city, the District Department of the Environment (DDOE) Fisheries and Wildlife Division (FWD) implemented a survey of soil and groundwater invertebrates in the spring and summer of 2009.

There are fifty-one invertebrate SGCN in the District's WAP. The list includes insects, mollusks such as freshwater mussels, and crustaceans such as isopods and amphipods. Invertebrates are often cryptic, non-charismatic and are little-studied, but they are important to many ecosystem processes (Hughes et al 2000). The insect SGCN include the orders Odonata (dragon and damselflies) and Lepidoptera (butterflies and moths). There are no bees or ants, and none of the aquatic and terrestrial flies, beetles or other less visible groups. There are eleven isopod and amphipod species on the list of SGCN but over twenty known species in various sites in the city. Some of these are species that were fairly recently discovered in the District, such as the copepod *Acanthocyclops columbiensis*, which was identified in 1988. The federally endangered Hay's Spring amphipod *Stygobromus hayi* and Kenk's Amphipod *Stygobromus kenki* are also recent discoveries and are endemic to the Rock Creek and Anacostia River watersheds (USFWS 2002).

More information is needed about a broad range of invertebrates in the city. The goal of this job was to examine the invertebrate groups that are underrepresented in the WAP, to get an idea of their populations and distribution in the city. These multi-year surveys will add information to the WAP and to the SGCN list. Searches were made for groundwater invertebrates (amphipods and isopods) that may not be listed, or even named in the literature. These studies are part of a plan to create an annual long-term monitoring regime to improve knowledge and prevent extinction or local extirpations in the District. The goal of these studies is to collect data about the abundance and diversity of the invertebrate species, and to examine species composition in various habitats in the city in relation to physical environmental variables and biological habitat variables.

Rock Creek Park

Study Sites

In the summer of 2009 the FWD discovered several springs and seeps on District-owned land. These springs were sampled, along with several springs located on National Park Service land. The springs on NPS land are in various units of Rock Creek National Park. One site was on the grounds of the Rock Creek Golf Course and one is located in Glover Archibold Park at 44th and Dexter Sts. NW.

Methods

Springs and seeps can only be sampled when water is flowing from underground. Groundwater invertebrates are flushed to the surface when water flow is moderate and can be collected at the spring or downstream in wet organic material. To sample groundwater invertebrates, searches were made in organic material (leaves and sticks) in the spring or seep and invertebrates were gleaned using forceps. Researchers also collected water and organic litter samples in a dissection tray at the springs using a 60µm plankton net and a turkey baster and gleaned any isopods or amphipods from the sample. Researchers preserved the specimens in isopropyl alcohol for later dissection and mounting.

Results

Amphipods and copepods were collected from springs at Rock Creek Golf Course and Glover Archibold Park. Due to the cryptic nature of the invertebrates collected, the FWD has contracted with an expert to dissect, mount and identify the organisms collected from the springs and seeps. The work on the contract began in August 2009. As a part of the contract, the contractor will be teaching one FWD biologist the dissection and identification methods.

One species of amphipod has been tentatively identified as being in the genus *Crangonyx*. This genus is easily identified as the only amphipod genus in this region that has eyes. Several other specimens collected did not have eyes; there are several eyeless species that are listed as SGCN.

Rock Creek Park - Dragonfly and Damselfly Survey

Introduction

Although there are extensive species lists for invertebrates in the DC area, and extensive studies of water quality that have included qualitative assessments of dragonfly and damselfly populations, there have been few quantitative analyses of the populations, diversity and abundance of Odonata in the city. The District of Columbia WAP calls for inventories and surveys of invertebrate populations to establish baseline data on populations and species

abundance trends. FWD began this process with scoping surveys of dragon and damselfly species at several natural areas in the city.

There are several species lists available for various areas of the city. Orr (2007) has a comprehensive list of all odonata in the Washington-Baltimore region, and a list of Odonata found in Rock Creek Park. Both of those lists include recent and historical records. There are also species lists from the 1996 BioBlitz in Kenilworth Aquatic Gardens and the 2006 BioBlitz in the Potomac Gorge. These lists were used to create the District of Columbia master list of insects that was used in the preparation of the WAP.

While some estimates of insect diversity in the area are very high (3000 species from one site in Silver Spring, MD; Mundel, pers. comm.), little is known overall about insect populations in the region. There are 314 invertebrate species listed in the DC WAP, yet only 224 of these are insects. The rest are freshwater mollusks and crustaceans. The population status of many resident invertebrate species is unknown, and the number of species of greatest conservation need (SGCN) is probably lower than it should be (WAP Ch. 8, p. 262).

Seventy-four species of dragonfly and damselfly are known to exist currently or historically in the city. Of the 21 insect SGCN, eight are Odonata, with four being suborder Anisoptera (Dragonflies) and four being suborder Zygoptera (Damselflies). The others are lepidopterans (butterflies and moths). These species were listed as SGCN if they appeared on endangered lists in the surrounding jurisdictions (Maryland and Virginia) or if they appeared on a local list such as the National Park Service's list.

As a part of initial invertebrate inventories in the District, we expanded upon previous surveys of adult dragonflies and damselflies at four locations during the spring and summer of 2009. FWD is studying this group because they are charismatic, easily identified and counted, and can be an indicator of overall ecosystem health. These studies are improving the knowledge base about local populations of odonata and will justify a monitoring strategy for other invertebrates in the city. These studies are implemented actions of the FWD's Wildlife Action Plan and will lead to an annual long-term monitoring regime to prevent extinctions in the District. The goal of these studies is to collect data about the abundance and diversity of the invertebrate species in the District, and to examine species composition in various habitats in the city in relation to physical and biological habitat variables.

There were three main research objectives for this scoping study: 1) To target various habitats to find SGCN; 2) to find species that might function as environmental indicators. When learning the species composition is a research goal, targeted searches are necessary to find rare species and to create a picture of species assemblages in critical habitats (Noss 1990); and 3) to sample across habitats to determine the spatial distribution of species within the city (Kremen et al 1993) and the correct scale for future sampling, and to survey throughout the summer to determine peak flight periods for various species of adult odonata.

Methods

Surveys began on 28 April and continued through 30 September. Site visits were rotated weekly to survey each site at least once a month. To survey for adult odonata, biologists walked along the water's edge at each site, and counted individuals as they were encountered. Unknown individuals were photographed from several angles if possible to have a record for identification. Individuals were identified using Eaton and Kaufman (2007), Bangma (njodes.com, 2003) and Czaplak (odolep.com, 2004). Each walk lasted one hour, and the time was extended for time

spent photographing individual odonates. This procedure is similar to the Pollard walk (Pollard 1977) used to survey lepidopterans. This method translates to walked transects of 0.5-1.0 km in riparian zones, forested wetlands and other wetlands. Methods followed Bried and Ervin (2005, 2006), where odonates within 10m of the transect were surveyed. Surveys were conducted during the afternoon hours, mainly on sunny days, when odonata are more active. Voucher specimens were not collected, but a photographic voucher collection was made and used to assist with species identification.

At the beginning of each survey local weather data including ambient temperature, percent cloud cover and wind speed was recorded.

Sites

Rock Creek Park is a large forested park in the center of Washington DC. It surrounds the stream valley of Rock Creek, which crosses the fall line as it passes through the park towards the Potomac River. Two sites were above the fall line at picnic areas (Areas 10 and 7) along the creek. These sites are open canopy forest with mature oak and poplar. The creek bank is vegetated, often with non-native invasive plants. One site was at the rocky rapids at the fall line. The creek is wider at that point, and is not shaded. The floodplain at this site is narrow and the canopy is closed. The final site was at Pierce Mill below the fall line. At this site the creek widens due to the presence of an historical dam. The floodplain is broad and the forest canopy is open.

Data Analysis

The analysis is qualitative and limited to descriptive statistics and measurements. The FWD targeted areas that should yield SGCN rather than performing randomized site selection.

Species richness, species evenness, relative abundance and diversity indices are calculated for each survey site and for the overall region. The Shannon diversity index (Shannon 1948) was used as a measure of site diversity, and to compare between site diversity. The index takes into account relative abundance and species evenness: $H' = -1 * (\text{SUM}\{ p_i \ln(p_i) \})$. Where p = per-site species abundance. The Shannon index is a measure of local (alpha) site diversity. Finally, species/time curves will be calculated to examine flight times and proper sampling periods for the next surveys.

Results

Summary

Forty-four species were recorded at the four locations during the 2009 survey. The highest species richness (27 species) and highest abundance (980 individuals) was at the C&O Canal sites. Twenty-five species were seen at the National Arboretum sites and 429 individuals were recorded. Fifteen species were seen at the Anacostia location and a total abundance of 295 individuals was recorded. The fewest number of species, 10, and lowest abundance, 215 individuals, was recorded at the Rock Creek sites.

Several of the species documented are very common. Two species were found at every location, but no single species was found at all thirteen sites. *Argia fumipennis* Violet Dancer and *Ischnura posita* Fragile Forktail were seen at every location. Four species, *Pachydiplax longipennis* Blue Dasher, *Plathemis lydia* Common Whitetail, *Anax junius* Common Green

Darner and *Perithemis tenera* Eastern Amberwing, were found at three locations throughout the study period. *Plathemis lydia* was seen at the most sites, nine, and was seen most often. *Pachydiplax longipennis* was most abundant, with 287 records.

Some species were seen at only one site throughout the survey and have rarely been seen in other locations during past surveys. At Rock Creek Park a *Hagenius brevistylus* Dragonhunter was recorded at Picnic Area 10.

Diversity

The measurement of species richness, diversity and evenness for the locations surveyed in 2009 are listed in the table below:

Location:	C&O Canal	Rock Creek	USNA	Anacostia Park
Species Richness				
# Species	27	10	25	15
Total Abundance				
# Records	980	215	429	295
Shannon-Wiener Index				
	2.71	1.88	2.81	2.29
Evenness				
	0.78	0.79	0.82	0.76

The Shannon index takes into account the relative abundance of each species at each site surveyed. H increases as the relative abundance of all species increases, but H can be reduced by a single dominant species. The index is the sum of the relative abundances, but the total number of species is not used in the calculation. C&O and USNA locations had a high number of species and no dominant species; therefore, their evenness and diversity indices are high.

The greatest number of individuals and species were recorded at C&O, but this location did not have the highest Shannon-Wiener diversity index (H). USNA had a similar number of species and a slightly higher H, but only half as many records. Rock Creek, with the fewest records and species had the lowest H. Evenness was similar among the four sites. This indicates that no species was overly dominant at any one location.

These indices are listed below by the several sites in the Rock Creek Park location

Rock Creek	Picnic Area 10	Picnic Area 7	Rapids/ Fall Line	Pierce Mill
Species Richness				
# Species	10	6	5	5
Total Abundance				
# Records	96	67	31	23
Shannon-Wiener Index				
	1.89	1.44	1.23	1.45

Evenness

0.82	0.80	0.76	0.90
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Shannon-Wiener diversity index is low at the three Rock Creek sites that had very few species and individual records. H at Picnic Area 10 is relatively high. Species evenness was highest at Pierce Mill and lowest at the Rapids site. Five species were seen at both of these sites, but the Rapids site had one dominant species, *Argia apicalis* Blue-fronted Dancer.

Seasonal Abundance

Species and individual abundance in Rock Creek was highest at Picnic Area 10 in late spring and then dropped in mid-summer. Species abundance at the three other sites at the Rock Creek never went above three species. Picnic Area 10 had the highest individual abundance for all sites at this location. Abundance peaked in late June at this site when many recently-emerged (teneral) damselfly adults of genus *Argia* were observed. Individual abundance at Picnic Area 7 was steady at just above twenty records per visit through August. The other two sites had few individuals recorded at each site visit.

We surveyed odonata, dragonflies and damselflies, for the third year of a multi-year inventory. The WAP identifies eight odonata as species of greatest conservation need. The FWD conducted walking surveys of adult odonata at thirteen sites in four main locations over the course of the summer. Forty-four species were recorded. Two species of greatest conservation need, Arigomphus villosipes (Unicorn Clubtail) and Ischnura kellicotti (Lilypad Forktail) were recorded. The most dominant species were Pachydiplax longipennis (Blue Dasher) and Libellula lydia (Common Whitetail). The fewest species (10) were seen at the Rock Creek Park location (at four sites), while 27 of the 44 species were seen at the C&O Canal location (at three sites). The C&O Canal location also had the highest abundance of the summer, with 980 records. The number of species seen peaked in mid-summer. The FWD will be continuing these studies in FY10 to include more habitats and more springs and seeps.

USNA - Dragonfly and Damselfly Survey

Introduction

Although there are extensive species lists for invertebrates in the DC area, and extensive studies of water quality that have included qualitative assessments of dragonfly and damselfly populations, there have been few quantitative analyses of the populations, diversity and abundance of Odonata in the city. The District of Columbia WAP calls for inventories and surveys of invertebrate populations to establish baseline data on populations and species abundance trends. FWD began this process with scoping surveys of dragon and damselfly species at several natural areas in the city.

There are several species lists available for various areas of the city. Orr (2007) has a comprehensive list of all odonata in the Washington-Baltimore region, and a list of Odonata found in Rock Creek Park. Both of those lists include recent and historical records. There are also species lists from the 1996 BioBlitz in Kenilworth Aquatic Gardens and the 2006 BioBlitz in the Potomac Gorge. These lists were used to create the District of Columbia master list of insects that was used in the preparation of the WAP.

While some estimates of insect diversity in the area are very high (3000 species from one site in Silver Spring, MD; Mundel, pers. comm.), little is known overall about insect populations in the region. There are 314 invertebrate species listed in the DC WAP, yet only 224 of these are insects. The rest are freshwater mollusks and crustaceans. The population status of many resident invertebrate species is unknown, and the number of species of greatest conservation need (SGCN) is probably lower than it should be (WAP Ch. 8, p. 262).

Seventy-four species of dragonfly and damselfly are known to exist currently or historically in the city. Of the 21 insect SGCN, eight are Odonata, with four being suborder Anisoptera (Dragonflies) and four being suborder Zygoptera (Damselflies). The others are lepidopterans (butterflies and moths). These species were listed as SGCN if they appeared on endangered lists in the surrounding jurisdictions (Maryland and Virginia) or if they appeared on a local list such as the National Park Service's list.

As a part of initial invertebrate inventories in the District, we expanded upon previous surveys of adult dragonflies and damselflies at four locations during the spring and summer of 2009. FWD is studying this group because they are charismatic, easily identified and counted, and can be an indicator of overall ecosystem health. These studies are improving the knowledge base about local populations of odonata and will justify a monitoring strategy for other invertebrates in the city. These studies are implemented actions of the FWD's Wildlife Action Plan and will lead to

an annual long-term monitoring regime to prevent extinctions in the District. The goal of these studies is to collect data about the abundance and diversity of the invertebrate species in the District, and to examine species composition in various habitats in the city in relation to physical and biological habitat variables.

There were three main research objectives for this scoping study: 1) To target various habitats to find SGCN; 2) to find species that might function as environmental indicators. When learning the species composition is a research goal, targeted searches are necessary to find rare species and to create a picture of species assemblages in critical habitats (Noss 1990); and 3) to sample across habitats to determine the spatial distribution of species within the city (Kremen et al 1993) and the correct scale for future sampling, and to survey throughout the summer to determine peak flight periods for various species of adult odonata.

Methods

Surveys began on 28 April and continued through 30 September. Site visits were rotated weekly to survey each site at least once a month. To survey for adult odonata, biologists walked along the water's edge at each site, and counted individuals as they were encountered. Unknown individuals were photographed from several angles if possible to have a record for identification. Individuals were identified using Eaton and Kaufman (2007), Bangma (njodes.com, 2003) and Czaplak (odolep.com, 2004). Each walk lasted one hour, and the time was extended for time spent photographing individual odonates. This procedure is similar to the Pollard walk (Pollard 1977) used to survey lepidopterans. This method translates to walked transects of 0.5-1.0 km in riparian zones, forested wetlands and other wetlands. Methods followed Bried and Ervin (2005, 2006), where odonates within 10m of the transect were surveyed. Surveys were conducted during the afternoon hours, mainly on sunny days, when odonata are more active. Voucher specimens were not collected, but a photographic voucher collection was made and used to assist with species identification.

At the beginning of each survey local weather data including ambient temperature, percent cloud cover and wind speed was recorded.

Sites

The US Department of Agriculture National Arboretum (USNA) is a 170 ha botanical park containing managed meadows, managed flower and shrub beds, managed hardwood and pine forests, and unmanaged forests. The habitat is patchy and varied. There are several areas that support odonata, the largest of which is Beech Pond. It is an artificial pond of 0.5 ha with a concrete seawall and berm around half of its shoreline. It is surrounded by managed forests, meadows, a road and a small creek. Much of the shoreline is vegetated with *Salix*, *Quercus* and *Taxodium* species, while the rest is mowed grass and invasive *Alliolaria brevipedunculata* (Porcelainberry vine). Much of the water surface is open to the sun, though there was little aquatic vegetation or aglal growth in the pond throughout the summer.

The second site at USNA is Fern Valley. This is a forested stream valley that USNA cultivates as a native plant display. The area contains poplar-oak forest, meadows, a small stream and two small ponds. One pond is located at the forest edge, in the meadow, and the other is within the canopy of the forest. The final site at USNA is a large vernal pool, called Azalea Pond. It is a 50 meter diameter pond that dries out completely in the late summer. It is fed by runoff from roads and higher elevation sites, but it does support breeding populations of *Ambystoma maculatum*

(Spotted Salamander) and *Rana sylvatica* (Wood Frog). Azalea Pond is forested, but is adjacent to managed meadows and a District residential street.

Data Analysis

The analysis is qualitative and limited to descriptive statistics and measurements. The FWD targeted areas that should yield SGCN rather than performing randomized site selection.

Species richness, species evenness, relative abundance and diversity indices are calculated for each survey site and for the overall region. The Shannon diversity index (Shannon 1948) was used as a measure of site diversity, and to compare between site diversity. The index takes into account relative abundance and species evenness: $H' = -1 * (\text{SUM}\{ p_i \ln(p_i) \})$. Where p = per-site species abundance. The Shannon index is a measure of local (alpha) site diversity. Finally, species/time curves will be calculated to examine flight times and proper sampling periods for the next surveys.

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Summary

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SGCN and Indicator Species

Two species of greatest conservation need were recorded during this survey. *Arigomphus villosipes* Unicorn Clubtail was found in two locations in the city. There were two records from the Beech Pond at USNA and two unconfirmed records from the Chain Bridge Vernal Pool at C&O. At Kenilworth Aquatic Garden there was an incidental record of *Ischnura kellicotti* Lilypad Forktail.

Several of the species documented are very common. Two species were found at every location, but no single species was found at all thirteen sites. *Argia fumipennis* Violet Dancer and *Ischnura posita* Fragile Forktail were seen at every location. Four species, *Pachydiplax longipennis* Blue Dasher, *Plathemis lydia* Common Whitetail, *Anax junius* Common Green Darner and *Perithemis tenera* Eastern Amberwing, were found at three locations throughout the study period. *Plathemis lydia* was seen at the most sites, nine, and was seen most often. *Pachydiplax longipennis* was most abundant, with 287 records.

Some species were seen at only one site throughout the survey and have rarely been seen in other locations during past surveys. At the National Arboretum *Enallagma traviatum* Slender Bluet was seen at Beech Pond and *Enallagma aspersum* Azure Bluet and *Enallagma civile* Familiar Bluet were recorded at the meadow at the Fern Valley/Meadow site.

Diversity

The measurement of species richness, diversity and evenness for the locations surveyed in 2009 are listed below:

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The greatest number of individuals and species were recorded at C&O, but this location did not have the highest Shannon-Wiener diversity index (H). USNA had a similar number of species and a slightly higher H, but only half as many records. Evenness was similar among the four sites, which indicates that no species was overly dominant at any one location.

These indices are listed by the several sites in the National Arboretum location:

	Azalea Road Vernal Pond	Fern Valley/Meadow	Beech Pond
Species Richness			
# Species	9	15	19
Total Abundance			
# Records	77	80	174
Shannon-Wiener Index			
	1.58	2.28	2.50
Evenness			
	0.72	0.84	0.85

The USNA sites Fern Valley/ Meadow and Beech Pond had Shannon-Wiener Index over 2.0. Species evenness is similar at all sites. These values indicate that the native plant forest/meadow habitat contains some of the highest species diversity in the District.

Seasonal Abundance

Species numbers peaked in early July at all sites at USNA, and then fell steadily through late summer. Fourteen species were recorded at Beech Pond, in July, twelve species were recorded at

Fern Valley/Meadow and eight were recorded at the vernal pool adjacent to M Street. Individual abundance peaked at a similar time to species abundance. Peak abundance at USNA was highest at Beech Pond at nearly 100 individuals recorded. Abundance at the other sites in early July was forty individuals per site.

C&O Canal Park - Dragonfly and Damselfly Survey

Introduction

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At the beginning of each survey local weather data including ambient temperature, percent cloud cover and wind speed was recorded.

Sites

The Chesapeake and Ohio Canal Park (C&O) is a 295 km long national park that follows the canal from Georgetown in the District to Cumberland, Maryland. The FWD surveyed three sites in C&O. South of Fletcher's Cove, there are several vernal pools; biologists surveyed one long, thin vernal pool in this area. The habitat is forested but with an open canopy. The dominant plants are *Acer negundo* (box elder) and various grasses such as *Chasmanthium latifolium* (Indian wood oat). The vernal pool is 200m by 5m, with varying amounts of emergent vegetation. It also supports breeding populations of *Ambystoma maculatum* (spotted salamander) and *Rana sylvatica* (wood frog).

Biologists also walked transects in the Potomac Gorge on the Chain Bridge flats and at riparian pools south of Chain Bridge. The Chain Bridge flats are a riparian plain that is seasonally flooded and has large river-fed ponds and flat rocky terrain. FWD biologists walked transects along the ponds north of Chain Bridge. The pools south of Chain Bridge are similar habitats to the vernal pools near Fletcher's Cove, but the pools are stream- and river-fed.

Data Analysis

The analysis is qualitative and limited to descriptive statistics and measurements. The FWD targeted areas that should yield SGCN rather than performing randomized site selection.

Species richness, species evenness, relative abundance and diversity indices are calculated for each survey site and for the overall region. The Shannon diversity index (Shannon 1948) was used as a measure of site diversity, and to compare between site diversity. The index takes into account relative abundance and species evenness: $H' = -1 * (\text{SUM}\{ p_i \ln(p_i) \})$. Where p = per-site species abundance. The Shannon index is a measure of local (alpha) site diversity. Finally, species/time curves will be calculated to examine flight times and proper sampling periods for the next surveys.

Results

Summary

Forty-four species were recorded at the four locations during the 2009 survey. The highest species richness (27 species) and highest abundance (980 individuals) was at the C&O Canal sites. Twenty-five species were seen at the National Arboretum sites and 429 individuals were recorded. Fifteen species were seen at the Anacostia location and a total abundance of 295 individuals was recorded. The fewest number of species, 10, and lowest abundance, 215 individuals, was recorded at the Rock Creek sites.

SGCN and Indicator Species

Two species of greatest conservation need were recorded during this survey. *Arigomphus villosipes* (Unicorn Clubtail) was found in two locations in the city. There were two records from the Beech Pond at USNA and two unconfirmed records from the Chain Bridge Vernal Pool at C&O. At Kenilworth Aquatic Garden there was an incidental record of *Ischnura kellicotti* (Lilypad Forktail).

Several of the species documented are very common. Two species were found at every location, but no single species was found at all thirteen sites. *Argia fumipennis* Violet Dancer and *Ischnura posita* Fragile Forktail were seen at every location. Four species, *Pachydiplax longipennis* Blue Dasher, *Plathemis lydia* Common Whitetail, *Anax junius* Common Green Darner and *Perithemis tenera* Eastern Amberwing, were found at three locations throughout the study period. *Plathemis lydia* was seen at the most sites, nine, and was seen most often. *Pachydiplax longipennis* was most abundant, with 287 records.

Some species were seen at only one site throughout the survey and have rarely been seen in other locations during past surveys. In C&O Canal Park *Celithemis elisa* Calico Pennant and *Argia moesta* Powdered Dancer were recorded at the Chain Bridge Vernal Pools site and *Ischnura ramburii* Rambur's forktail and *Lestes rectangularis* Slender Spreadwing were recorded at Fletcher's Vernal Pools. *Ischnura ramburii* has been seen in other locations in other years.

Diversity

The measurement of species richness, diversity and evenness for the locations surveyed in 2009 are listed in the table below:

Location:	C&O Canal	Rock Creek	USNA	Anacostia Park
Species Richness				
# Species	27	10	25	15
Total Abundance				
# Records	980	215	429	295
Shannon-Wiener Index	2.71	1.88	2.81	2.29
Evenness	0.78	0.79	0.82	0.76

The Shannon index takes into account the relative abundance of each species at each site surveyed. H increases as the relative abundance of all species increases, but H can be reduced by a single dominant species. The index is the sum of the relative abundances, but the total number of species is not used in the calculation. C&O and USNA locations had a high number of species and no dominant species; therefore, their evenness and diversity indices are high.

The greatest number of individuals and species were recorded at C&O, but this location did not have the highest Shannon-Wiener diversity index (H). USNA had a similar number of species and a slightly higher H, but only half as many records. Evenness was similar among the four sites, which indicates that no species was overly dominant at any one location.

These indices are listed below by the several sites in the C&O Canal location:

	Chain Bridge Flats	Chain Bridge Vernal Pools	Fletcher's Cove Vernal Ponds
Species Richness			
# Species	22	28	13
Total Abundance			
# Records	467	408	101
Shannon-Wiener Index			
	2.46	2.65	1.74
Evenness			
	0.80	0.80	0.68

Two of the sites at C&O had more than 400 records and high H and evenness. The third site, Fletcher's Cove Vernal Ponds, had the lowest evenness of all sites in the survey, most likely due to the dominance of one species, *Lestes rectangularis* Slender Spreadwing. This dominant species also lowered H for that site. These values indicate that the riparian floodplain in the Potomac Gorge may contain the highest odonate species diversity in the District.

Seasonal Abundance

The number of species seen at the Chain Bridge Flats and Chain Bridge Vernal Pools had the highest species abundance of all the sites at all locations. Chain Bridge Vernal Pools had steady and high species abundance at 14 – 16 species per site from May to July, while the Chain Bridge Flats site's species abundance peaked at 15 species in mid-June but fell steadily through the summer. The forested Fletcher's Vernal Pool site had lower species abundance with four to six species seen, but these levels were steady through mid-September. Individual abundance at the Chain Bridge Flats and Chain Bridge Vernal Pools sites peaked in mid-June at about 140 individual records per visit and dropped steadily through the summer to the end of the survey period. Individual abundance at Fletcher's Vernal Pool rose from three records in late April to forty records in August.

Anacostia Park - Dragonfly and Damselfly Survey

Introduction

Although there are extensive species lists for invertebrates in the DC area, and extensive studies of water quality that have included qualitative assessments of dragonfly and damselfly populations, there have been few quantitative analyses of the populations, diversity and abundance of Odonata in the city. The District of Columbia WAP calls for inventories and surveys of invertebrate populations to establish baseline data on populations and species abundance trends. FWD began this process with scoping surveys of dragon and damselfly species at several natural areas in the city.

There are several species lists available for various areas of the city. Orr (2007) has a comprehensive list of all odonata in the Washington-Baltimore region, and a list of Odonata found in Rock Creek Park. Both of those lists include recent and historical records. There are also species lists from the 1996 BioBlitz in Kenilworth Aquatic Gardens and the 2006 BioBlitz in the Potomac Gorge. These lists were used to create the District of Columbia master list of insects that was used in the preparation of the WAP.

While some estimates of insect diversity in the area are very high (3000 species from one site in Silver Spring, MD; Mundel, pers. comm.), little is known overall about insect populations in the region. There are 314 invertebrate species listed in the DC WAP, yet only 224 of these are insects. The rest are freshwater mollusks and crustaceans. The population status of many resident invertebrate species is unknown, and the number of species of greatest conservation need (SGCN) is probably lower than it should be (WAP Ch. 8, p. 262).

Seventy-four species of dragonfly and damselfly are known to exist currently or historically in the city. Of the 21 insect SGCN, eight are Odonata, with four being suborder Anisoptera (Dragonflies) and four being suborder Zygoptera (Damselflies). The others are lepidopterans (butterflies and moths). These species were listed as SGCN if they appeared on endangered lists in the surrounding jurisdictions (Maryland and Virginia) or if they appeared on a local list such as the National Park Service's list.

As a part of initial invertebrate inventories in the District, we expanded upon previous surveys of adult dragonflies and damselflies at four locations during the spring and summer of 2009. FWD is studying this group because they are charismatic, easily identified and counted, and can be an indicator of overall ecosystem health. These studies are improving the knowledge base about local populations of odonata and will justify a monitoring strategy for other invertebrates in the city. These studies are implemented actions of the FWD's Wildlife Action Plan and will lead to an annual long-term monitoring regime to prevent extinctions in the District. The goal of these studies is to collect data about the abundance and diversity of the invertebrate species in the District, and to examine species composition in various habitats in the city in relation to physical and biological habitat variables.

There were three main research objectives for this scoping study: 1) To target various habitats to find SGCN; 2) to find species that might function as environmental indicators. When learning the species composition is a research goal, targeted searches are necessary to find rare species and to create a picture of species assemblages in critical habitats (Noss 1990); and 3) to sample across habitats to determine the spatial distribution of species within the city (Kremen et al 1993) and the correct scale for future sampling, and to survey throughout the summer to determine peak flight periods for various species of adult odonata.

Methods

Surveys began on 28 April and continued through 30 September. Site visits were rotated weekly to survey each site at least once a month. To survey for adult odonata, biologists walked along the water's edge at each site, and counted individuals as they were encountered. Unknown individuals were photographed from several angles if possible to have a record for identification. Individuals were identified using Eaton and Kaufman (2007), Bangma (njodes.com, 2003) and Czaplak (odolep.com, 2004). Each walk lasted one hour, and the time was extended for time spent photographing individual odonates. This procedure is similar to the Pollard walk (Pollard 1977) used to survey lepidopterans. This method translates to walked transects of 0.5-1.0 km in riparian zones, forested wetlands and other wetlands. Methods followed Bried and Ervin (2005, 2006), where odonates within 10m of the transect were surveyed. Surveys were conducted during the afternoon hours, mainly on sunny days, when odonata are more active. Voucher specimens were not collected, but a photographic voucher collection was made and used to assist with species identification.

At the beginning of each survey local weather data including ambient temperature, percent cloud cover and wind speed was recorded.

Sites

The FWD surveyed three sites along the upper Anacostia River in Anacostia Park. The first site was a meadow adjacent to Kingman Lake and the RFK Stadium Parking lot. There is a thin strip of riparian forest between the meadow and the lake and there are reconstructed emergent freshwater wetlands in Kingman Lake. The meadow is not mowed regularly and is dominated by non-native grasses and small trees. The second site (River Terrace) is a reconstructed freshwater tidal wetland in the main stem of the Anacostia River. This is a 3 ha site dominated by cattail, phragmites and arum species. The final site (Kenilworth Fields) is a former landfill that has four soccer fields. The edges of the fields are unmanaged, such that a 6 ha meadow with native plants has become established. The site is adjacent to the Anacostia River and Kenilworth Aquatic Gardens, separated from both by riparian forests.

Data Analysis

The analysis is qualitative and limited to descriptive statistics and measurements. The FWD targeted areas that should yield SGCN rather than performing randomized site selection.

Species richness, species evenness, relative abundance and diversity indices are calculated for each survey site and for the overall region. The Shannon diversity index (Shannon 1948) was used as a measure of site diversity, and to compare between site diversity. The index takes into account relative abundance and species evenness: $H' = -1 * (\text{SUM}\{ p_i \ln(p_i) \})$. Where p = per-site species abundance. The Shannon index is a measure of local (alpha) site diversity. Finally, species/time curves will be calculated to examine flight times and proper sampling periods for the next surveys.

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Some species were seen at only one site throughout the survey and have rarely been seen in other locations during past surveys. In Anacostia Park the Halloween Pennant *Celithemis eponina* was seen at RFK Meadow and the Spot-winged glider *Pantala hymenaea* was recorded at the River Terrace Fringe Wetland. *Celithemis eponina* Halloween Pennant has been seen in other locations in other years.

Diversity

The measurement of species richness, diversity and evenness for the locations surveyed in 2009 are listed in the table below:

Location:	C&O Canal	Rock Creek	USNA	Anacostia Park
Species Richness				
# Species	27	10	25	15
Total Abundance				
# Records	980	215	429	295
Shannon-Wiener Index				
	2.71	1.88	2.81	2.29
Evenness				
	0.78	0.79	0.82	0.76

The Shannon index takes into account the relative abundance of each species at each site surveyed. H increases as the relative abundance of all species increases, but H can be reduced by a single dominant species. The index is the sum of the relative abundances, but the total number

of species is not used in the calculation. C&O and USNA locations had a high number of species and no dominant species; therefore, their evenness and diversity indices are high.

The greatest number of individuals and species were recorded at C&O, but this location did not have the highest Shannon-Wiener diversity index (H). USNA had a similar number of species and a slightly higher H, but only half as many records. Evenness was similar among the four sites, which indicates that no species was overly dominant at any one location.

These indices are listed below by the several sites in the Anacostia Park location:

	RFK Meadow	River Terrace Wetland	Kenilworth Athletic Fields
Species Richness			
# Species	11	14	7
Total Abundance			
# Records	96	153	50
Shannon-Wiener Index			
	1.76	2.16	1.62
Evenness			
	0.74	0.82	0.83

The River Terrace Wetlands had H much higher than the other sites, although species evenness was similar between the three sites. These sites had fewer individual records and fewer species, and may have had one or two dominant species. These values indicate that the restored wetland on the Anacostia River contains some of the highest odonate species diversity in the District.

Seasonal Abundance

The number of species at Anacostia Park in the River Terrace Wetland was steady through late July and August at nine species seen, but the number of individuals seen went from twenty to eighty in that time. By late September both the species abundance and the individual abundance had fallen to two at the fringe wetland. Species abundance at both meadow sites (RFK and Kenilworth) in Anacostia Park peaked in mid-June, then fell and leveled off at about four species through the rest of the survey period. Individual records peaked in mid-June at both meadow sites as well. Sixty individuals were seen at the RFK Stadium meadow and about thirty were seen at the Kenilworth Athletic Fields. Abundance at these sites fell to 33% of the peak by August, and remained at those lower numbers through the end of the survey.

Figure 1. Species abundance through summer 2009 at thirteen sites in four locations in Washington DC.

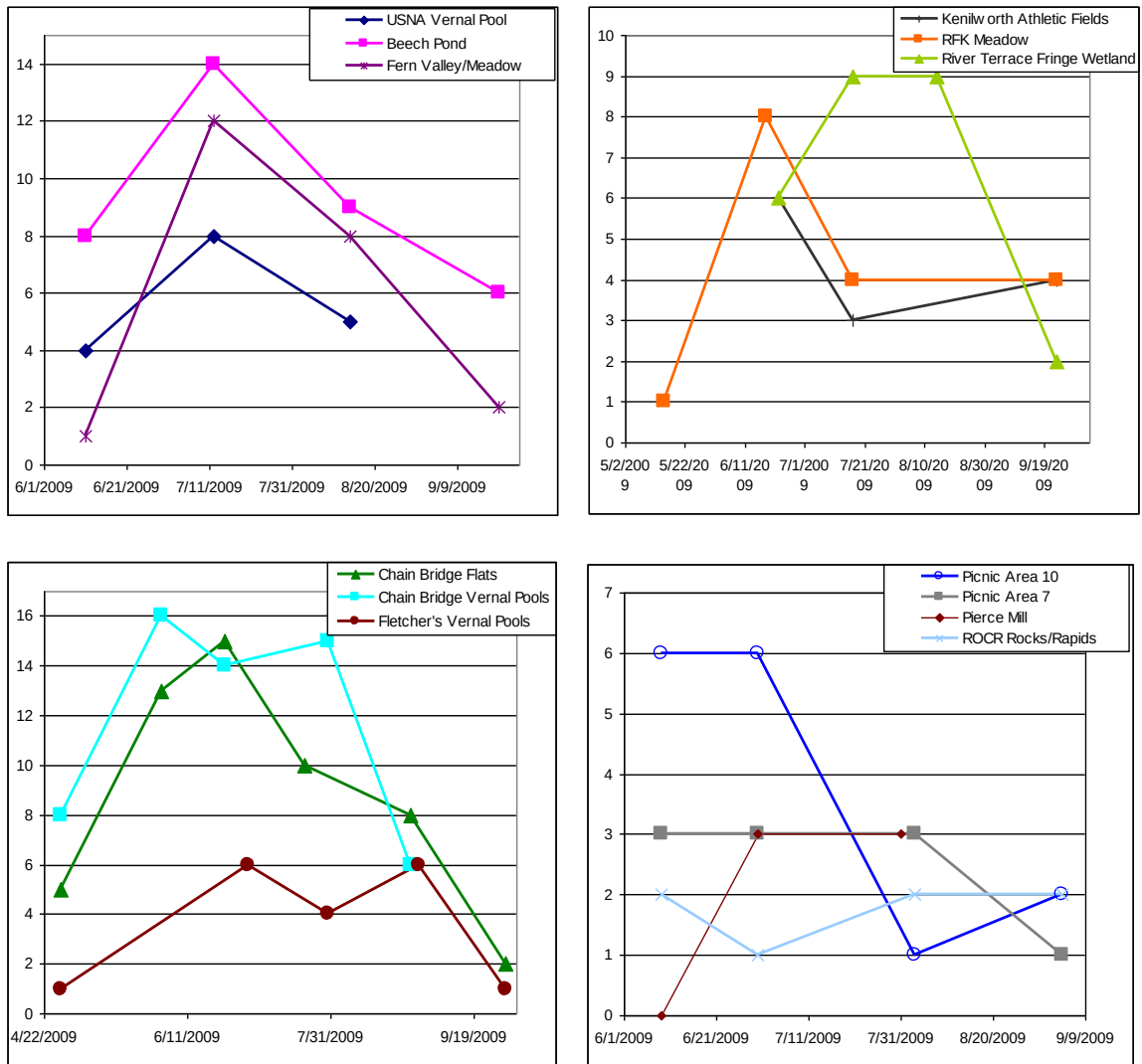
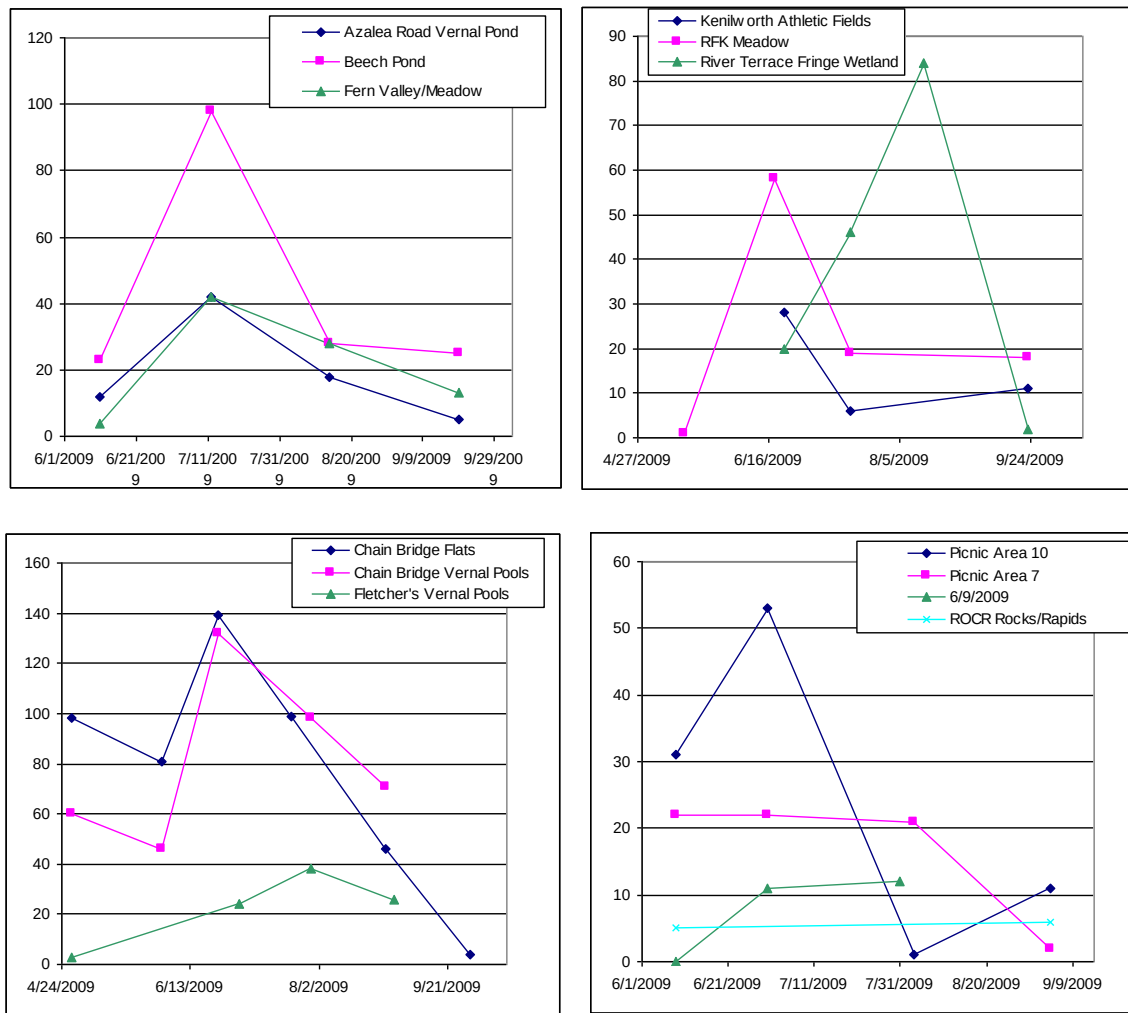


Figure 2. Individual odonata records through summer 2009 at thirteen sites in four locations in Washington DC.



Future Monitoring

In the future, FWD will sample environmental and habitat variables to determine habitat heterogeneity (Noss 1990) and be able to compare diversity across sites in relation to habitat variables. The FWD will expand the survey to find other SGCN and to target non-SGCN species for potential listing. Biologists will examine literature for examples of the habitats of the seven SGCN not found, and may add sites to survey. Potential sites to add may include springs and seeps in Rock Creek Park and sites along the creek, the wetlands on Theodore Roosevelt Island, vernal pools in USNA and C&O Canal, wetlands around Kingman Island, and more habitats along the Potomac River gorge. The FWD also hopes to add surveys for larval odonata beginning in early spring using artificial substrates and searches for castoff larval exuvia on vegetation along waterways.