Dragonfly & damselfly monitoring in Johnson Creek Watershed: Final report for 2020

Common Whitetail (Plathemis lydia) ovipositing, Westmoreland Park; C.A. Searles Mazzacano

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Executive Summary

CASM Environmental worked with Johnson Creek Watershed Council staff in 2020 to continue monitoring odonate populations (dragonflies and damselflies) at three sites in the Johnson Creek watershed. This was the fourth year of monitoring at Centennial (Mitchell Creek; five survey dates) and the fifth year at Brookside Wetlands (Johnson Creek; 16 survey dates) and Westmoreland Park (Crystal Springs Creek; 9 survey dates). Due to restrictions during the coronavirus pandemic, it was not possible to train survey volunteers; rather, individual CASM Environmental and JCWC staff conducted surveys independently as regularly as possible. The monitoring season was further interrupted by dramatic weather conditions; strong winds followed by smoke and extremely unhealthy air quality due to widespread wildfires made surveys impossible during the first half of September.

A total of 162 observations of 18 species (13 dragonfly, 5 damselfly) was reported among all sites, which is fewer than prior years (range = 21-23 species). Species richness at each site was also lower than past years, with 16 species at Brookside (12 dragonfly, 4 damselfly), 14 at Centennial (10 dragonfly, 4 damselfly), and 12 at Westmoreland (8 dragonfly, 4 damselfly). Odonate communities were most similar between Westmoreland and Centennial (Jaccard Index = 0.80), and Brookside differed more from both (Jaccard Index = 0.56 and 0.63, respectively). No new species were added to the project list in 2020, which remains at 31, representing almost 3/4 (70%) of the species currently known from Multnomah County. However, there was a definite sighting of a clubtail (Gomphidae) at Westmoreland Park in late May; this is the first time a member of this family has been seen at any project site but because species identification was not possible, it was not included in the 2020 tally. Three of the five main migratory species in North America used these sites: Common Green Darner (*Anax junius*; all sites); Variegated Meadowhawk (*Sympetrum corruptum*; all sites); and Black Saddlebags (*Tramea lacerata*; Brookside, Centennial). Late-summer voucher photos of fresh or recently-emerged adults suggest that Common Green Darner is breeding successfully at Brookside, and Black Saddlebags may be breeding around Centennial.

The number of species in each month was generally lower at each site than in prior years, which may be due to a combination of unavoidably reduced survey dates, impacts of extreme weather, and fluctuating habitat conditions. Mitchell Creek at Centennial underwent a large restoration project in summer 2019 and the habitat continues to change; the odonate community was dominated by Vivid Dancers (*Argia vivida*), a damselfly that prefers small vegetated flowing streams. Water levels were unusually low at Brookside throughout spring and most of summer until beaver activity on adjacent Johnson Creek backed up water into the wetland, and the odonate community was dominated by slow-water species such as Common Green Darner, Common Whitetail (*Plathemis lydia*), Tule Bluet (*Enallagma carunculatum*), and Western Forktail (*Ischnura perparva*). The wetlands adjacent to Crystal Springs Creek at Westmoreland Park were also unusually low for much of the summer and the community was dominated by Common Green Darner, Pacific Forktail (*Ischnura cervula*), and Tule Bluet. The impacts of wildfire and an extended period of smoke, bad air quality, and warmer than usual temperatures on both resident and migratory species are not yet known and may be evident next spring.

Objectives

To continue monitoring dragonfly and damselfly populations at three selected sites in the Johnson Creek watershed, detect changes, analyze trends in the context of five years of dedicated monitoring at sites with changing conditions.

Background

This report presents data from a fifth year of monitoring odonate (dragonfly and damselfly) populations at three sites in the Johnson Creek watershed: Westmoreland Park (Crystal Springs Creek; year 5 of monitoring), Brookside wetlands (Johnson Creek; year 5 of monitoring), and Centennial Ponds (Mitchell Creek; year 4 of monitoring). In previous years, surveys were done during the majority of the flight season by volunteer teams trained by CASM Environmental staff. In 2020, state restrictions on gathering sizes due to the global coronavirus pandemic and safety considerations to reduce transmission meant it was not possible to train volunteers. Instead, CASM Environmental and JCWC staff who had done monitoring in previous years surveyed the sites as thoroughly as possible during the season, to avoid a gap in data collection.

Methods

Survey Techniques

The flight season for odonates in the Portland area runs from early May through early to mid-November, and varies annually depending on weather conditions. Regular surveys begin in June, but CASM Environmental visits sites in spring when the weather is conducive to odonate activity to capture first flight dates. Regular season surveys ideally occur every 14 days, but dates often shift due to weather conditions and surveyor availability. Surveys were further confounded in 2020 by string winds followed by severe wildfires that generated thick smoke and dangerously bad air quality in the Portland area during the first half of September.

Surveys are done when conditions are optimal for odonate activity (Table 1). Surveyors walk transects along the water's edge, scanning the water and vegetation, and adjacent uplands are scanned as well. Net capture for in-hand examination and voucher photos of perched or netted specimens is encouraged. The survey start and end time, weather conditions (sun, cloud cover, wind, temperature), and species seen are recorded. For each species, the following is noted:

- method(s) of identification: visual, captured, photographed
- gender: male, female
- abundance category: Uncommon (1-4 individuals); Frequent (5-20), common (21-100); Abundant (>100)

- reproductive stage: wheel (mating pair), tandem pair (male holding female but not engaged in copulation), ovipositing (laying eggs), and teneral adult (newly-emerged)

All data are subsequently entered into the iNaturalist project *Dragonfly Surveys in Johnson Creek Watershed* (www.inaturalist.org/projects/dragonfly-surveys-in-johnson-creek-watershed).

Table 1. Decision matrix for odonate surveys.

Time range	**10:00 am - 4:00 pm**			**9:30 am - 4:30 pm**	
Temperature	<59°F (15°C)	59-65°F (15-18°C)	65-75°F (18-24°C)	>75°F (24°C)	>88°F (31°C)
Cloud cover >60%	No	No	Yes	Yes	No
Cloud cover <60%	No	Yes	Yes	Yes	No
Moderate to strong wind (tree branches swaying)	No	No	No	No	No
Raining	No	No	No	No	No

Data analysis

Jaccard similarity indices were calculated on species presence/absence matrices using PAST 4 software (Hammer et al., 2001). The Jaccard Index compares members in two sets to determine which are shared and which are distinct; values range from 0 (no species in common between two samples) to 1 (identical species composition between two samples).

Results

Species diversity

Surveys were conducted between 8 April and 1 October 2020. The earliest surveys were at Westmorland Park and Brookside Wetlands, where odonates were first seen on the wing on 8 April (Westmoreland; teneral male Pacific Forktail) and 29 May (Brookside; Western & Pacific Forktail). Surveys at Centennial began on 19 June 2020. There were 162 observations recorded cumulatively across nine dates at Westmoreland, 16 dates at Brookside, and five dates at Centennial. Eighteen species (13 dragonfly, 5 damselfly) were reported among all sites in 2020. This is less than in prior years (range = 21-23 species), likely due to 1. fewer surveyors; and 2. impacts of wind,

wildfire, and smoke on insect populations. Individual site richness varied and was also lower at each site than in any previous year, with 16 species at Brookside (12 dragonfly, 4 damselfly), 14 at Centennial (10 dragonfly, 4 damselfly; note that site richness in 2018 was also 14 species), and 12 at Westmoreland (8 dragonfly, 4 damselfly).

Odonate communities at Westmoreland and Centennial had many species in common (Jaccard Index = 0.80), while Brookside differed more from both (Jaccard Index = 0.56 and 0.63, respectively). This may be influenced in part by the fact that there were more survey dates at Brookside, enabling encounters of a greater number of species. Paddle-tailed Darner (*Aeshna palmata*), Autumn Meadowhawk (*Sympetrum vicinum*), Blue Dasher (*Pachydiplax longipennis*), and California Spreadwing (*Archilestes californicus*) were recorded only at Brookside in 2020 (though all have been seen at Westmoreland and/or Centennial in other years), while Vivid Dancer (*Argia vivida*) and Western Pondhawk (*Erythemis collocata*) were absent from Brookside but present at the other two sites in 2020.

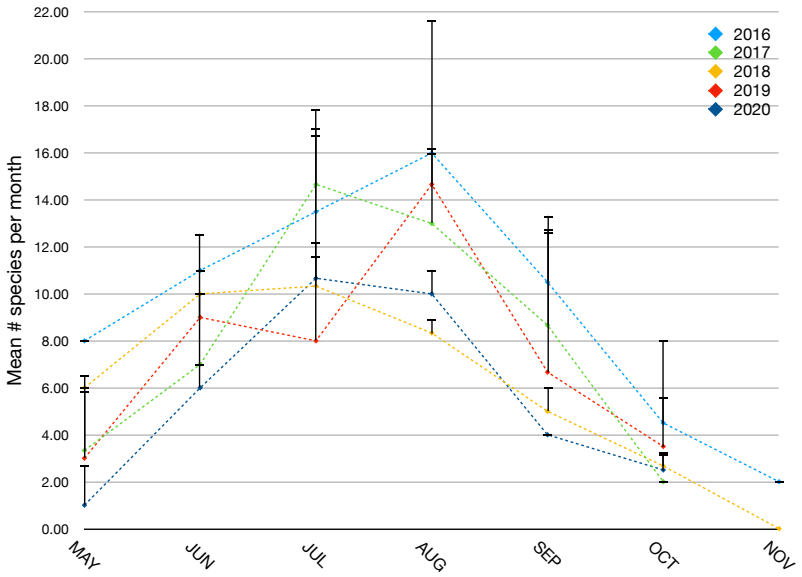
No new species were added to the project list in 2020, which remains at a total of 31, representing almost 3/4 (70%) of the species currently known from Multnomah County (Abbott, 2006-2020). Eight species have been found at all sites in all survey years: Common Green Darner (*Anax junius*), Cardinal Meadowhawk (*Sympetrum illotum*), Eight-spotted Skimmer (*Libellula forensis*), Common Whitetail (*Plathemis lydia*), Blue-eyed Darner (*Rhionaeschna multicolor*), Pacific Forktail (*Ischnura cervula*), Western Forktail (*I. perparva*), and Tule Bluet (*Enallagma carunculatum*). One species fell off this list in 2020; this was the first year in which Blue Dasher was not also seen at all sites, being found only at Brookside in low abundance (i.e, Uncommon) on two days in August. This species generally appears in mid-summer and persists through late summer, and is a common denizen of ponds and slow-moving creeks. It is easily recognized and tends to perch frequently and with great site fidelity (i.e., one individual returns to the same perch repeatedly), so it is unlikely that it was overlooked at Westmoreland or Centennial; CASM Environmental was particularly on the lookout at Westmoreland, where Blue Dasher appeared regularly throughout the season in past years and its absence was noticed early. All the above species are common in the region and well-adapted to urban habitats (Paulson, 2009; Kerst & Gordon, 2011).

Seasonality and abundance

The species observed most frequently were Tule Bluet (*Enallagma carunculatum*; observed on 20 days among all sites), Common Whitetail (*Plathemis lydia*; observed on 19 days among all sites), and Common Green Darner (*Anax junius*) and Pacific Forktail (*Ischnura cervula*; both of the latter observed on 18 days among all sites). Species seen earliest in the season were Pacific Forktail (8 April, Westmoreland) and Tule Bluet (5 May, Westmoreland), which is typical for these resident species in this region. Surveys were done at both Westmoreland and Brookside on the same days in spring, but odonates were not found at Brookside until 29 May. Species still on the wing in early October included Paddle-tailed Darner (*Aeshna palmata*), Blue-eyed Darner (*Rhionaeschna multicolor*), Pacific Forktail, and Common Green Darner; a similar suite of species has been seen in October in prior years.

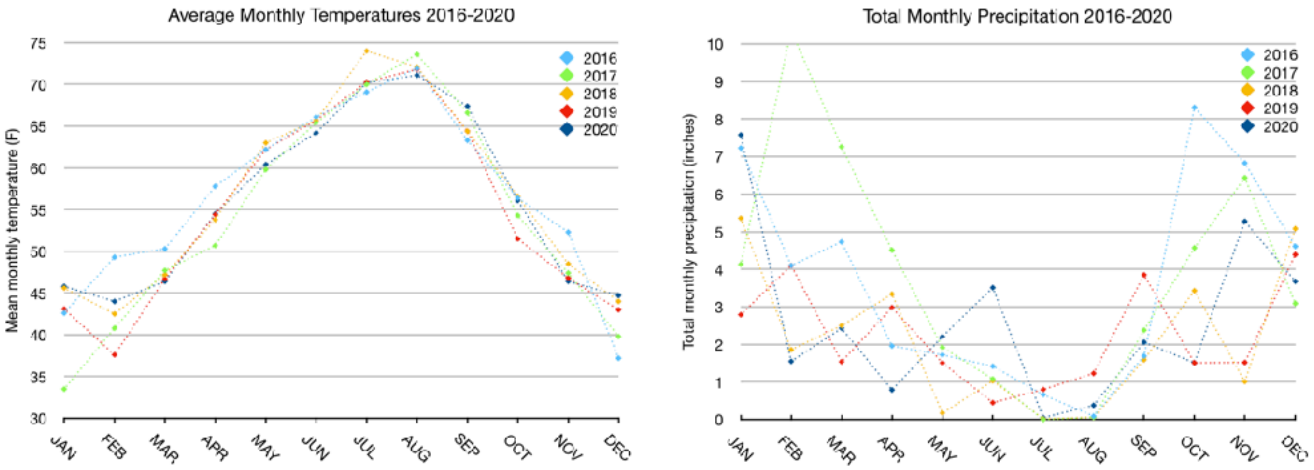
Each site differed slightly in the abundance of members of different species (see *Odonate community at individual sites*), but overall dragonfly abundance throughout the season was dominated by Common Whitetail, and damselfly abundance by Tule Bluet. The trend for Tule Bluet to outnumber the once super-abundant Pacific Forktail was first noted in 2019 at Centennial and Brookside and continued this year at all sites, although Pacific Forktail was more numerous at Westmoreland than at the other two sites. The mean number of species seen in each month and the peak species richness was lower than in many prior years (Figure 1), but the seasonal pattern of increased and decreased richness was similar.

Figure 1. Mean number of species seen monthly among all sites, 2016-2020. Bars show standard deviation.



Inter-annual variation in average monthly temperatures is greatest in January and February, where the difference between annual means spans 10-12°F (Figure 2). The recent trend of warmer December temperatures continued in 2020. Annual precipitation patterns vary more widely through the year; 2020 was notable for a drier February-April than prior years as well as unusually wet June, the rainiest November in three years, and heavy rains in late December (Figure 2). Additionally, hot dry weather combined with unusually strong sustained wind in the second week of September sparked extensive wildfires throughout the state and created dense smoke and toxic air conditions around Portland until late in the month. It is likely that these events impacted local insect populations, but this was difficult to assess as surveys were unavoidably interrupted during this period, and by the time they could resume it was late in the season for many odonates to be on the wing.

Figure 2. Average monthly temperature (left) and total precipitation (right) in Portland, 2016-2020. Data taken from NOAA monthly weather summaries for Portland (http://w2.weather.gov/climate/index.php?wfo=PQR). Data for December 2020 current through 12/21/20.

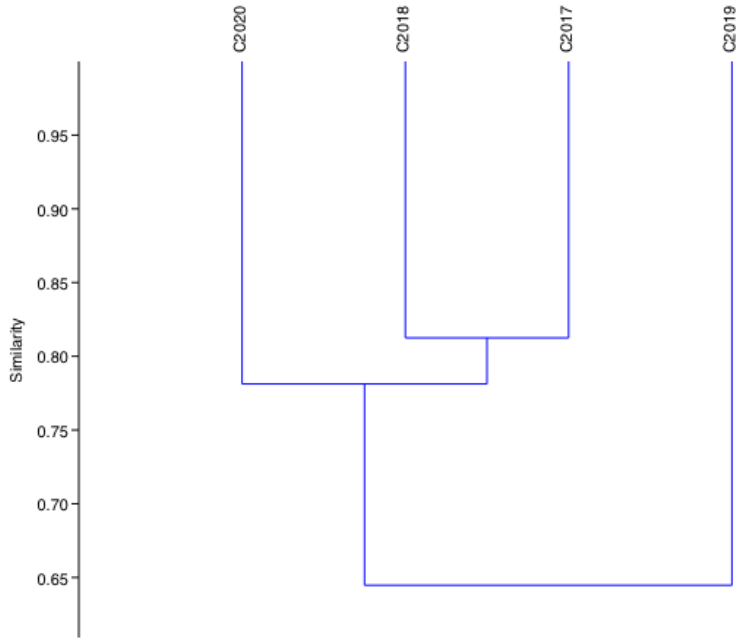


Odonate community at individual sites

Centennial

This was the fourth year of monitoring at Centennial, and the first full season after the restoration of Mitchell Creek. Overall community composition in 2020 was most similar to that seen in years prior to restoration (Figure 3), although the 2017 and 2018 communities are most similar (Jaccard Similarity index = 0.81). The community in 2019, the year when restoration was implemented, differs most from all other years.

Figure 3. CLUSTER ordination of Jaccard Similarity Index of a presence/absence matrix of species occurring annually at Centennial.



A total of 14 species (10 dragonfly, 4 damselfly) was observed throughout the season (Figure 4), which is lower than in two of the three previous years. However, this site received fewer surveys within a more restricted time period than either Brookside or Westmoreland (five surveys across three months), and some species may have been missed. Despite the fact that fewer total species were seen at Centennial in 2020, the number seen in each month was within the range of prior years (Figure 5). The site got off to a slow start, with fewer species in June than any other year, but the peak number of 12 species in July was the 2nd highest for Centennial in that month.

Figure 4. Odonate seasonality and abundance at Centennial in 2020. Height of each individual stacked bar shows abundance category: 1 (uncommon, 1-4 individuals); 2 (frequent, 5-20); 3 (common, 21-100); 4 (abundant, >100).

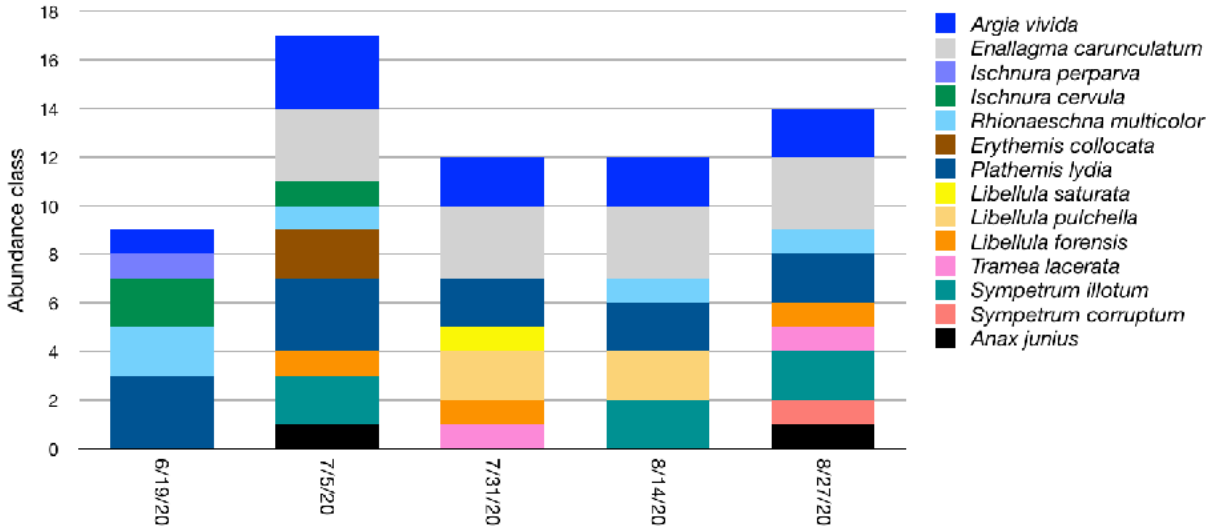
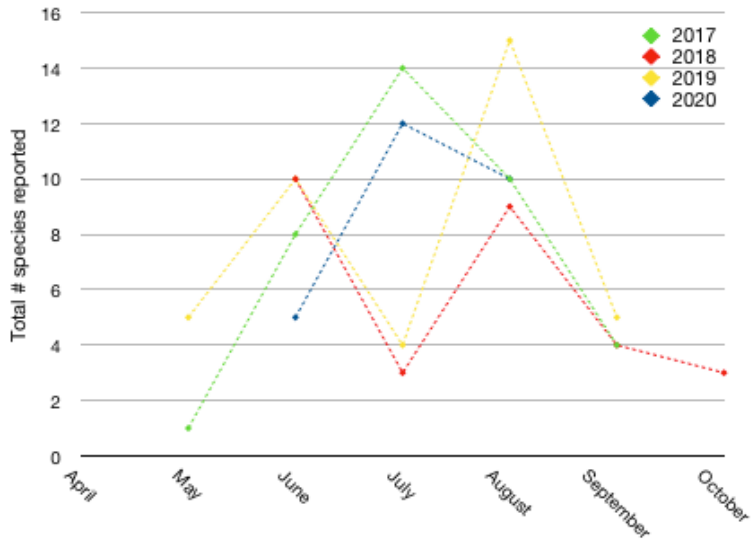


Figure 5. Total number of species observed in each month at Centennial across all survey years.



The most frequently observed species were Common Whitetail and Vivid Dancer (both found on every survey date). These two species along with Tule Bluet, which was seen on four survey dates, were also the only ones recorded at higher abundances (Common). Vivid Dancer, which prefers small, flowing, vegetated streams, has become particularly abundant at this site since stream restoration occurred. Interestingly, Twelve-spotted Skimmer (*Libellula pulchella*), which has become much less abundant and is now seen infrequently at Brookside and Westmoreland, was moderately abundant (Frequent) at Centennial in late July and early August. All species found in 2020 were seen at the site in at least one prior survey year.

Three of North America's migratory species were found at Centennial from July through August (Figure 4), with Common Green Darner and Black Saddlebags observed on two survey dates each, and Variegated Meadowhawk found only at the end of August. Voucher photos of a Black Saddlebags taken on 27 August show a mature but fresh-looking female that may be a younger individual entering the migratory phase. A Variegated Meadowhawk with bright colors and no wing wear photographed on the same date could also have been a young migrant. However, no teneral adults of either species were noted, so it is not possible to know if these individuals emerged from this site or if they flew in from a nearby stream or wetland.

Brookside

This was the fifth year of monitoring at Brookside. There have been no targeted restoration activities during that span; the main physical changes at the site are varying water levels due to beaver dams being established and blown out. Water levels were quite low from April through early July, with the wetland consisting of two shallow, un-vegetated muddy ponds connected by a narrow shallow channel. By late July water levels were much higher, converting the site to a single large wetland with emergent and submerged vegetation, and these conditions persisted through late September (Figure 6); many small fish were also noted in this period.

Figure 6. High water levels at Brookside on 25 August; this was the first survey date where the wetland contained submerged and/or emergent aquatic vegetation and the ponds were connected.

Odonate community composition in 2020 was more similar to that seen in the earliest monitoring years (Figure 7). A total of 16 species (12 dragonfly, 4 damselfly) was observed throughout the season (Figure 8). This was the most species observed at any site in 2020, which may have been influenced in part by the fact that this site also received the most surveys (16 dates), but fewer species than seen at Brookside in prior years (18-19 species in 2016-2019). The season got off to a slow start, as no odonates were observed until early June, and the number of species seen in each month was the lower overall than in prior years (Figure 9), continuing a trend first noted in 2019.

Figure 7. CLUSTER ordination of Jaccard Similarity Index of a presence/absence matrix of species occurring annually at Brookside.

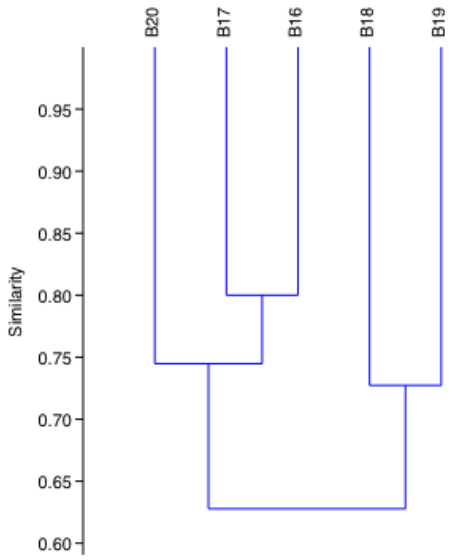


Figure 8. Odonate seasonality and abundance at Brookside in 2020. Height of each individual stacked bar shows abundance category: 1 (uncommon, 1-4 individuals); 2 (frequent, 5-20); 3 (common, 21-100); 4 (abundant, >100).

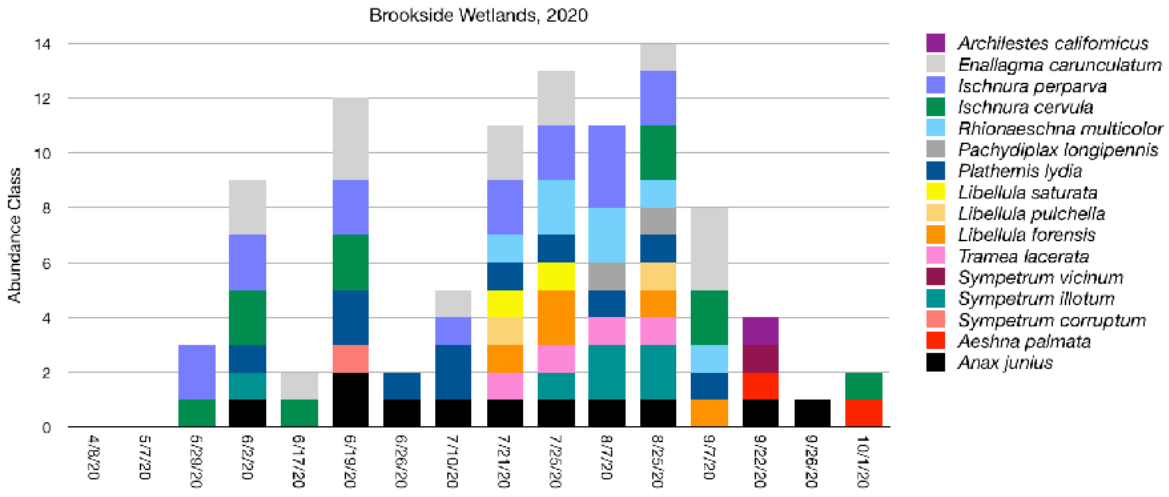
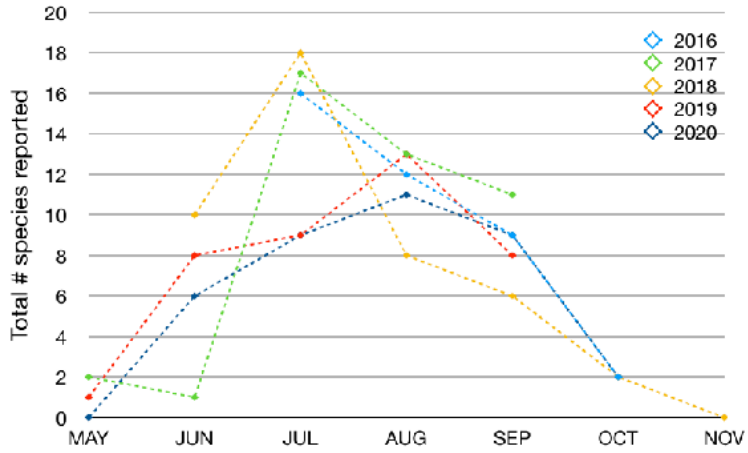


Figure 9. Total number of species observed in each month at Brookside across all survey years.



The most frequently observed dragonfly species were Common Green Darner and Common Whitetail (seen on 63% and 56% of survey days, respectively), and the most commonly occurring damselflies were Tule Bluet and Western Forktail (both found on 50% of survey dates). These were also the only species with higher recorded abundances (Common or Abundant) on any dates. Some species that were found at Brookside in every prior sampling year were not sighted in 2020, i.e., Western Pondhawk and Vivid Dancer. However, Autumn Meadowhawk (*Sympetrum vicinum*) was recorded for the first time at Brookside in 2020, with a single male found on 22 September by CASM Environmental. It was sighted at a distance and presumed to be a worn specimen of one of the many Cardinal Meadowhawks that frequented the site in late summer, but the more dull coloration prompted pursuit and in-hand identification. This species was only reported once before for the project (Westmoreland, 2016) and although it is not generally abundant in our area, it is possible that without photos or captured specimens observers may be mis-identifying occasional individuals as older/worn Variegated or Cardinal Meadowhawk.

Three of North America's migratory species in were seen at Brookside from June through September (Figure 8). Common Green Darner was especially ubiquitous, being observed on 10 survey dates; Black Saddlebags was observed on four survey dates and Variegated Meadowhawk was found once in mid-June. The last observation of Common Green Darner at this site was on 26 September by JCWC staff. The photo vouchers show two recently emerged individuals: a fresh specimen with shiny wings, and one with crumpled, nonfunctional wings from unsuccessful expansion during adult eclosion (Figure 10). Most Common Green Darner sightings each year are patrolling males, but these photos indicate that the species is breeding at or in very close proximity to this wetland, as the malformed individual would not have been able to fly. Adults emerging at this late-summer date would be migrants, destined to fly south instead of maturing at their natal wetland.

Figure 10. Common Green Darners (*Anax junius*) observed on 26 Sept. 2020 at Brookside Wetlands. (L) Individual with non-functional wings that did not expand during adult emergence; (R) Individual with the shiny wings characteristic of immature stage. Photos by Courtney Beckel.

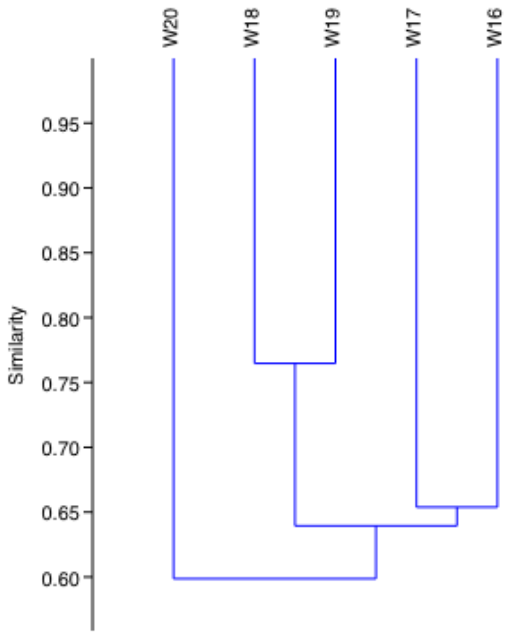
Westmoreland Park

This was the fifth year of monitoring at Westmoreland. Initially, restoration of Crystal Springs Creek at the park was followed by increased odonate diversity, but by 2018, habitat conditions had deteriorated due to nutria activity and invasive plant growth and the number of odonate species decreased. At the end of 2018, park managers engaged in vegetation control such that creek flow and upland wetland conditions in 2019 were more similar to earlier monitoring years. However, in early May 2020 water levels in the wetlands were very low, being noted as nearly dry, and dense growth of non-native teasel and reed canary grass was also noted (Figure 11). These dryer conditions persisted through mid-June, and higher water levels were not noted until early July.

Figure 11. Low water levels at Westmoreland on 28 May 2020; note exposed mud where the water generally covers a greater extent at ~1 ft. deep.

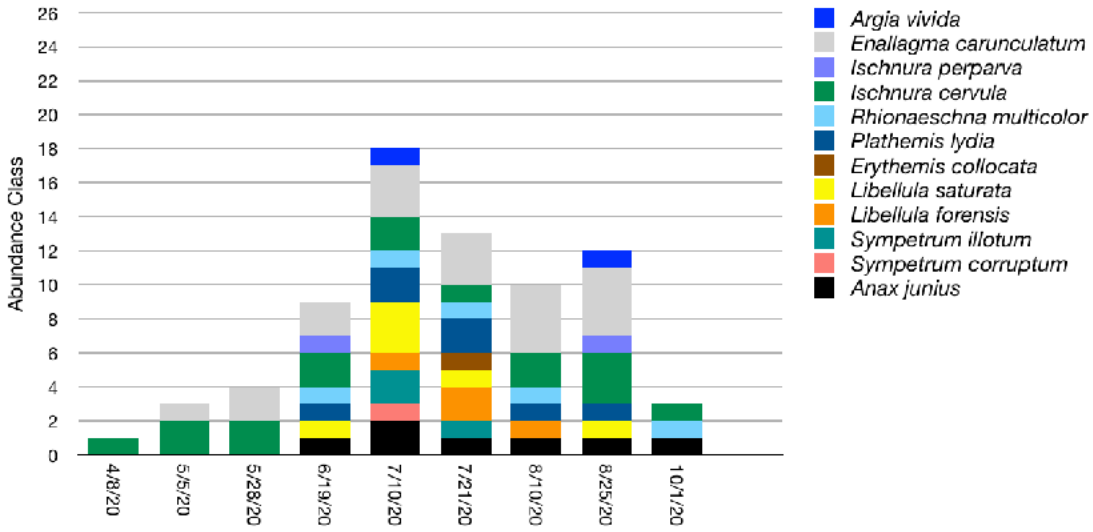
The odonate community in 2020 was least similar to any other sampling year (Figure 12) and only 12 species (8 dragonfly, 4 damselfly) were recorded, the fewest of any monitoring year at this site (Figure 13). The most frequently observed dragonfly species were Common Green Darner (seen on 67% of survey dates) along with Common Whitetail and Blue-eyed Darner (both seen on 56% of survey dates); the most frequently observed damselflies were Pacific Forktail and Tule Bluet (seen on 100% and 78% of survey dates, respectively). Tule Bluet, Western Forktail, and Flame Skimmer were the only species recorded in higher abundance categories (Common or Abundant) on any date. Odonates were on the wing earlier here than at Brookside, but the number of species reported each month was lower than most prior sampling years (Figure 14). Species absent in 2020 that were seen in every earlier sampling year included Shadow Darner, Blue Dasher, and California Spreadwing.

Figure 12. CLUSTER ordination of Jaccard Similarity Index of a presence/absence matrix of species occurring annually at Westmoreland.



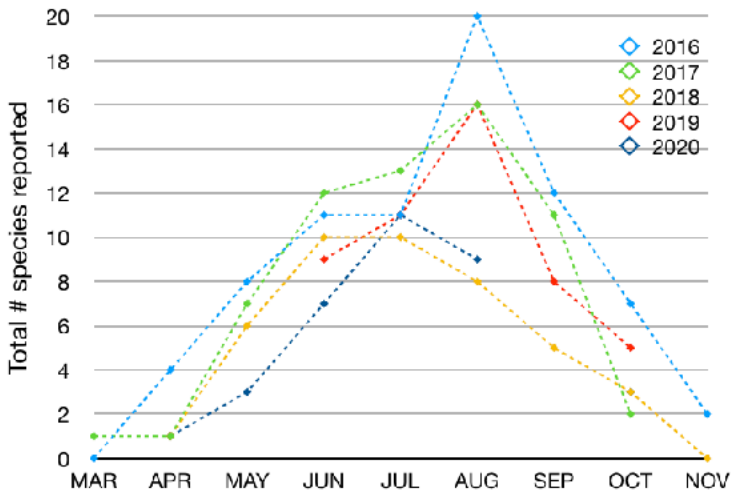
One species was found at Westmoreland that had not been seen before at any site. On 28 May, CASM Environmental spotted a clubtail (Gomphidae) perched in a patch of upland shrubs at the west side of the park (near SE Knapp St.). Only a fleeting glimpse was possible before the individual took flight, so a definitive identification could not be made and it was not included in the total species count for the park, but the body shape was unmistakably a male clubtail. This represents the first time a member of this family has been seen at any project site. Most clubtails prefer larger riverine habitat, although some species can be found around slower waters, which explains their lack or representation at these largely wetland sites. This may have been an immature individual that flew away from its emergence site to mature.

Figure 13. Odonate seasonality and abundance at Westmoreland in 2020. Height of each individual stacked bar shows abundance category: 1 (uncommon, 1-4 individuals); 2 (frequent, 5-20); 3 (common, 21-100); 4 (abundant, >100).



Two of North America's migratory species were found at Westmoreland from June through October (Figure 13). Common Green Darner was especially ubiquitous, being seen on every survey date in those months. However, it was not sighted in April or May, raising the question of whether individuals in June were late-returning migrants or newly-matured residents; no teneral adults were seen, but the warmer than usual spring temperatures may have accelerated development of mature overwintering resident nymphs. Variegated Meadowhawk continues to be an infrequent denizen of the park, with just a single, low abundance (Uncommon) report in mid-July; in earlier years a large adult emergence of late-season fall migrants occurred at Westmoreland, but this has not been noted for the last three years, and the species may no longer be breeding here.

Figure 14. Total number of species observed in each month at Westmoreland across all survey years.



Discussion

Despite disruptions due to coronavirus and wildfires, the number of surveys conducted at Brookside and Westmoreland were similar to those done in past years, although Centennial was surveyed on fewer dates in a more restricted range. Early flight dates noted in 2020 were typical both for the region and for this project, although delayed slightly at Brookside, which may have been a function of the low water conditions that persisted through late summer.

Most species seen each year are common, urban-adapted types that prefer open and/or slow-moving water, but differences between the sites continue to influence community composition. The conversion of a large stagnant wetland to a small flowing stream at Centennial shifted the dominant taxon to Vivid Dancer, which prefers small, cool, vegetated streams and was seen more infrequently and at lower abundances in 2017 and 2018. Continued community change is anticipated as newly-planted vegetation matures. In contrast, vegetation management and lower water levels in wetlands more recently at Westmoreland continue to negatively impact odonate diversity. Wetlands on both sides of the creek were extremely low this year and choked with shrubby vegetation, leaving little open water apart from the creek itself, which conversely had greater flow due to removal of some large wood that was backing up the creek through the upper end of the park. This is a likely factor in the lowered abundance and frequency of some formerly common species at this site such as Western Pondhawk, Blue Dasher, and Twelve-spotted Skimmer, as these species are associated with still, open waters (Paulson, 2009). At the same time, Common Whitetail and Eight-spotted Skimmer are widespread and abundant among all sites; males of these tolerant, widespread species aggressively patrol their territories, so inter-species competition may also come into play.

Richness at Brookside has been consistent across time (16-19 species), despite large differences in water levels in the wetland both between and within years as beaver dams on the adjacent Johnson Creek blow out and are replaced. Dynamic water levels can create greater habitat heterogeneity, which could explain why several of the more unusual species observations for this project in past years have been made at this site (i.e., Spot-winged Glider [*Pantala hymenaea*], Lance-tipped Darner [*Aeshna constricta*]). The similarity of this year's odonate community to that in 2017 and 2016 at Brookside may be influenced by the persistent higher water levels in mid to late summer, as earlier years were wetter at this site.

Although these are all highly urbanized sites utilized primarily by common tolerant species, regular annual monitoring has facilitated continued discovery of additional species among the project sites. The sighting of a clubtail at Westmoreland in 2020 represents the first time a member of this family was found at any project site. Although species identification was not possible due to the brief glimpse it afforded, based on the pale color, time of year, and the location and date of observations in our region in OdonataCentral (Abbott, 2006-2020) and iNaturalist, it was likely *Ophiogomphus occidentis* (Sinuous Snaketail). *O. occidentis* is a western species with broad distribution across primarily the eastern part of the state and lower Willamette Valley but there are records in Multnomah County as early as 23 May (Willamette River at Portland south waterfront; Gabriel Park in SW Portland close to two small creeks), as well as records from urban areas further south in the Valley. The species prefers

slow-flowing streams with sand or gravel substrate in open or wooded settings, and is known to perch in branches of low shrubs, which was where the Westmoreland clubtail was sighted. This may have been a random individual that flew away from its emergence site to mature, but it is a species to be on the lookout for in the future.

Migratory species continue using project sites, though with differing intensities. In the earliest years of the project, mating and ovipositing pairs of Common Green Darner were frequently seen at Westmoreland Park in April and May, but in recent years sightings of returning migrants are more rare and limited to patrolling males. The habitat may overall be less appealing now as a stopover for spring migrants. It may also be less suitable for oviposition by females, who lay their eggs in floating vegetation and woody branches (Paulson, 2009); in earlier years, CASM Environmental observed active oviposition primarily in small woody debris. In contrast, this was the first year in which there was evidence of successful breeding by Common Green Darner at Brookside, with September records of recently-emerged individuals, one with wing abnormalities that would have rendered it unable to fly in from another site. Variegated Meadowhawk has become much less frequently observed throughout the season, and never in large numbers or with the synchronized late-summer emergence of the year's migrants that was observed consistently in early monitoring years. In contrast, Cardinal Meadowhawk is seen much more regularly, often with multiple individuals per site, and inter-specific competition may again be a factor.

The impacts of wildfire and an extended period of smoke, bad air quality, and warmer than usual temperatures on odonate populations remain to be seen. The extreme conditions occurred as odonate season was winding down and interrupted surveys, so it is difficult to know if late-season counts were impacted. Certainly odonates would not have been able to engage in normal activities such as hunting, mating, and oviposition for at least some of this time, and individuals that emerged as adults during this period may have had reduced survival due to lower prey abundance and bad air quality. Migration of Variegated Meadowhawk, Common Green Darner, and Black Saddlebags could also have been affected, as migratory flights of these species have been observed in Oregon in September in past years. The consequences of these severe climatological events for both resident and migratory species could be more evident next spring.

Literature Cited

Abbott, J.C. 2006-2020. OdonataCentral: An online resource for the distribution and identification of Odonata. Available at http://www.odonatacentral.org. Accessed 9 December 2020.

Hammer, Ø., D.A.T. Harper, and P.D. Ryan. 2001. PAST: Paleontological statistics software package for education and data analysis. Palaeontologia Electronica 4(1): 9 pp.

Kerst, C. and S. Gordon. 2011. Dragonflies and Damselflies of Oregon. Oregon State University Press, 304 pp.

Paulson, D. 2009. Dragonflies and Damselflies of the West. Princeton Field Guides, 535 pp.