

Community-based Dragonfly & Damselfly Monitoring in Johnson Creek Watershed: Final Report for 2019



California Spreadwing male, Westmoreland Park; C.A. Searles Mazzacano

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Executive Summary

In 2019, Johnson Creek Watershed Council worked with CASM Environmental to continue community-based monitoring of odonate populations (dragonflies and damselflies) in the Johnson Creek watershed. This was the fourth year of surveys at Westmoreland Park (Crystal Springs Creek) and Brookside Wetland (Johnson Creek), and the third at Centennial Pond (Mitchell Creek). Volunteers received a day of classroom and field training prior to surveys, and returning volunteers (peer mentors) teamed with new participants. Teams surveyed at two-week intervals from June to October, walking transects and recording species, abundance, genders, and behaviors. Volunteers netted specimens and took photo vouchers when possible. Data were reported on iNaturalist (www.inaturalist.org/projects/dragonfly-surveys-in-johnson-creek-watershed). CASM Environmental surveyed monthly at each site to ensure quality control. A mid-season field session provided a refresher course and an opportunity for volunteers to socialize.

Surveys were done on 16 dates at Westmoreland Park (9 volunteer; 7 CASM), and 13 dates at both Brookside Wetland (8 volunteer, 5 CASM) and Centennial Pond (9 volunteer, 4 CASM). A total of 243 observations of 23 species (17 dragonfly, 6 damselfly) was reported among all sites; these are more observations than in previous years, but a similar overall number of species (22 species in 2016, 23 species in 2017, and 21 species in 2018). Richness among sites was also more similar than in previous years, with 19 species at Brookside (15 dragonfly, 4 damselfly), and 18 each at Centennial (12 dragonfly, 6 damselfly) and Westmoreland (13 dragonfly, 5 damselfly). Odonate community composition was most similar at Westmoreland and Brookside (Jaccard Index = 0.71). The community at Centennial was more similar to that at Brookside (Jaccard Index = 0.68) than to Westmoreland (Jaccard Index = 0.59).

A total of 31 species has been recorded among all sites since the project began in 2016, representing three-quarters of the species currently known from Multnomah County. Three new species were added to the project list in 2019: *Aeshna constricta* (Lance-tipped Darner; Brookside), one of only three records in Multnomah County; *Rhionaeschna californica* (California Darner; Westmoreland, Brookside); and River Jewelwing (*Calopteryx aequabilis*; Westmoreland), one of only two records in Multnomah County. Three of the five main migratory species in North America were also observed using habitat at these sites: Common Green Darner (*Anax junius*; all sites); Variegated Meadowhawk (*Sympetrum corruptum*; all sites); and Black Saddlebags (*Tramea lacerata*; Brookside, Westmoreland).

The number of species among all sites generally followed the seasonality in prior years, except for a decrease in richness from June to July, due in part to construction work at Centennial. However, species richness at Brookside was also stagnant in this span, which did not occur in prior years. Species numbers in 2019 were lower early in the season than in many previous years, but by August diversity increased and was higher through the remainder of the season than in 2018. Habitat conditions at all sites changed in 2019, and the odonate community reflected this. Unusually low water levels at Brookside, likely due to blown-out beaver dams, contributed to lower odonate diversity and abundance at the site. In contrast, vegetation management at Westmoreland Park improved wetland condition and creek flow and was accompanied by increased diversity compared to 2018. At Centennial, disruption due to restoration activities in early summer crashed odonate populations. However, the restored habitat (drying ponds, increased flow and vegetation in Mitchell Creek) supported greater diversity and abundance of odonates almost immediately post-restoration, including species that prefer colder flowing waters, such as Vivid Dancer (*Argia vivida*).

Background

This report presents data from a fourth year of volunteer-based monitoring of odonate (dragonfly and damselfly) populations at three sites in the Johnson Creek watershed: Westmoreland Park (Crystal Springs Creek; year 4 of monitoring), Brookside wetlands (Johnson Creek; year 4 of monitoring), and Centennial Ponds (Mitchell Creek; year 3 of monitoring). The protocols, training techniques, and methodologies developed for this project support self-organizing volunteer teams that survey local odonates on a regular basis during the majority of the flight season. Regular monitoring at multiple sites is greatly facilitated by the use of well-trained volunteers; their participation increases the frequency and scope of data collection, and they can collect useful, high-quality data (McKinley et al., 2017; Dennis et al., 2017). The JCWC volunteers are enthusiastic about what they learn during this project, and several volunteers from previous seasons return and act as peer mentors to project newcomers.

Dedicated long-term monitoring of a key group such as odonates provides useful ecological information. Characterizing odonate diversity and abundance at the regional scale aids in discovering stressors impacting local populations, incorporating odonate habitat needs into restoration plans, and learning the effects of restoration projects on different species. This study is adding to our knowledge of local odonate populations; new species have been added to the list of odonates known from Multnomah County, and rare visitors to our region have been recorded. Impacts of climatic stressors and habitat changes on seasonal patterns of abundance and diversity have been noted, and data from the project have been used to inform habitat management decisions. Project data are freely available via the iNaturalist portal, and have been used by odonatologists in North America to investigate aspects of intraspecies variation, flight dates, and distributions for articles in journals such as *Argia* (the news journal of the Dragonfly Society of the Americas; <www.dragonflysocietyamericas.org>).

Methods

Volunteer training

Volunteers were provided with a detailed Protocols Manual and Quick Guide to Dragonfly and Damselfly Families, developed by CASM Environmental. JCWC staff maintained a Volunteer Toolkit on their web site with an interactive scheduling document, surveyor checklist, equipment checkout, contact information for volunteers and staff of JCWC and CASM Environmental, hyperlinks to the JCWC dragonfly science page and iNaturalist project site, and links to additional resources.

JCWC solicited project participants from their network of volunteers, and several project volunteers from prior years returned as peer mentors. A full day of training was done on 1 June 2019, beginning with a morning social hour that peer mentors were encouraged to attend to meet new participants. The first half of the training was a classroom session where volunteers learned about odonate ecology, life history, and behaviors; how to recognize common species in Multnomah County; key components for species identification; and how to use the monitoring protocol

and reporting methods. The remainder of the day was spent in the field at one of the project sites (Westmoreland Park), where volunteers learned how to walk transects and practiced netting and identification.

Volunteers signed up for survey dates spanning roughly every 14 days in June-September at three sites: Brookside Park, on Johnson Creek (11201-11243 SE Brookside Dr, Portland, OR); Westmoreland Park, on Crystal Springs Creek (7530 SE 22nd Ave, Portland, OR); and Centennial Pond, on Mitchell Creek (SE Foster & SE Dahlquist Rd., Pleasant Valley, OR). They used a GoogleSheets document in the Volunteer Toolkit to sign up for surveys; each site and date was covered by at least two surveyors, with a substitute as back-up. Volunteers used additional columns to note the date each survey was actually done, the number of hours and surveyors at the site, and the date their observations were entered into the iNaturalist project. Teams signed out survey kits with nets, maps, data sheets, sunglasses, hand lenses, and the field guide *Dragonflies and Damselflies of Oregon* (Kerst & Gordon, 2011) from the JCWC office. A mid-season “mini-orientation” session was made available to volunteers who wanted to refresh their training on 13 July at Centennial Pond, and a potluck/survey session was held at Westmoreland Park on 18 July.

Survey techniques

The flight season for odonates in the Portland area generally runs from early May through early to mid-November. Volunteer surveys do not begin until June, but CASM Environmental visits project sites in spring when weather conditions become conducive to odonate activity, to ensure that first dates for return of migratory species and for resident species being on the wing are captured. Volunteer surveys ideally occur every 14 days, but dates often shift slightly due to weather conditions and volunteer availability, so that in practice they occur once every 8-16 days.

Surveys were done on days with optimal conditions for odonate activity (Table 1). Volunteers tended to use this table effectively; on one date (6 July 2019) a survey was done during cool cloudy weather, but the team notified CASM Environmental to explain the absence of odonates on that visit. Volunteers survey transects along the water's edge, scanning the water and adjacent vegetation. They are encouraged to take photos and net odonates for in-hand examination whenever possible. Surveyors filled out their data sheet upon arriving at the site with start time, observer names, and weather conditions (sun, cloud cover, wind, precipitation), then slowly walked their transects and noted:

- Species: Volunteers were encouraged to capture specimens for in-hand examination and to take photographic vouchers of perched or in-hand specimens when possible. Methods of identification were noted on the data sheet (**V**isual, **C**aptured, **P**hotographed).
- Gender: **M**ales and **F**emales, differentiated based on coloration, markings, and genitalia.
- Abundance category: **U**ncommon (1-4 individuals seen), **F**requent (5-20), **C**ommon (21-100), or **A**bundant (>100)
- Reproductive stage: **W**heel (mating pair), **T**andem **P**air (male holding female but not engaged in copulation), **O**vipositing (laying eggs), and **T**eneral **A**dult (newly-emerged)

Volunteers kept tallies of the individual abundances for each species while conducting the survey, then recorded the final abundance categories, stop time, and weather conditions.

Table 1. Survey decision matrix for weather conditions conducive to odonate activity

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)
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
Rain	No	No	No	No	No

Data reporting

All data were entered into the iNaturalist project *Dragonfly Surveys in Johnson Creek Watershed* (www.inaturalist.org/projects/dragonfly-surveys-in-johnson-creek-watershed). Data fields on the iNaturalist project site are identical to each entry on the data sheet. Data can also be entered in the field using the iNaturalist mobile app. iNaturalist was chosen for reporting for its ease of use and data exportation, and there is a free app for iOS and Android. Its crowdsourcing method of identification provides a useful image gallery for volunteers (from large numbers of identified, vetted photos in the database) and a way for CASM Environmental to confirm volunteers' identification of their uploaded photos and easily download each season's data. Volunteers could also e-mail CASM Environmental or JCWC staff with questions about survey and reporting protocols and species identification.

QA/QC

CASM Environmental conducted 17 surveys among all project sites from mid-April through October to compare expert- vs. volunteer-collected data. Data from QA surveys were entered into the iNaturalist project. CASM Environmental reviewed project submissions; some observations accompanied by photos that were either too poor or lacked a view of the necessary body structures for identification were subsequently omitted from the analysis.

The additional field session on 13 July and potluck on 18 July helped volunteers who had not yet done a survey and/or those who wished to refresh their skills. In the past, volunteer feedback has been solicited at an annual end-of-season potluck (held in January 2019 for the 2018 field season), where a data summary is presented and volunteers are encouraged to share their impressions of the project and discuss challenge and strengths of the training, resources, and reporting. Feedback is also solicited via an annual JCWC online survey to all volunteers.

Data analysis

Jaccard similarity indices were calculated on species presence/absence matrices using PAST 3 software (Hammer et al., 2001). The Jaccard Index is used to measure similarity and diversity between samples; values range from 0 (no species in common between two samples) to 1 (identical species composition between two samples).

Results

Species diversity

Volunteers conducted surveys between 1 June and 14 October 2019. Additional surveys by CASM Environmental between 20 March and 24 October established ranges for first and last flight dates at the sites (around the 2nd week of April and end of October, respectively). Surveys were done on 16 dates at Westmoreland Park (9 volunteer, including the 1st training session; 7 CASM), 13 at Brookside Wetland (8 volunteer, 5 CASM), and 13 at Centennial Pond (9 volunteer, 4 CASM). This is about the same number of surveys at Westmoreland as in prior years, but an increased number at both Centennial and Brookside. Although restoration work to remove a culvert on Mitchell Creek that blocked fish passage and ponded and heated water was ongoing at Centennial from late June through early July, volunteers were still able to access the site on weekends. This enabled collection of pre-project data right up until project implementation, as well as immediate monitoring of odonate responses to the restored habitat.

A total of 23 species (17 dragonfly, 6 damselfly) was reported among all sites in 2019. Species richness recovered from a project low in 2018 and is similar to previous years (22 species reported in 2016; 23 species in 2017; 21 species in 2018), but more observations were made in 2019 (243 observations) compared to 2018 (196 observations). Richness among individual sites was also more similar than in previous years, with 19 species at Brookside, and 18 at both Centennial and Westmoreland. Overall, the odonate communities at Westmoreland and Brookside showed the greatest similarity (Jaccard Index = 0.71). The community at Centennial in 2019 was more similar to that at Brookside than to Westmoreland (Jaccard Index = 0.68 and 0.59, respectively).

Nine 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 Dasher (*Pachydiplax longipennis*), Blue-eyed Darner (*Rhionaeschna multicolor*), Pacific Forktail (*Ischnura cervula*), Western Forktail (*I. perparva*), and Tule Bluet (*Enallagma carunculatum*). This list remained unchanged in 2019, as none of the species found among all sites through 2018 were absent from any site in 2019. These species are all common in the region and are frequently found in urban areas (Paulson, 2009; Kerst & Gordon, 2011).

Since the inception of this project in 2016, a total of 31 species has been recorded among all project sites, representing about three-quarters (74%) of the species currently known from Multnomah County (Abbott, 2006-2019). Three species new to the project list were added in 2019. *Aeshna constricta* (Lance-tipped Darner) was photographed and identified by volunteers at Brookside on 20 July 2019 (Figure 1). This is one of 34 records for this

species in Oregon (Abbott, 2006-2019), only three of which are in Multnomah County. This species is known to inhabit small ponds and nutrient-rich marshes (Kerst & Gordon, 2011), and will breed in seasonal wetlands, which is unusual behavior for darners. It has been declining in the West as climate conditions dry out many of its usual habitats (Paulson, 2009), and it is interesting that it was seen at Brookside in a year when water levels there were much lower throughout the season than in previous years.

Another new darner for the project, *Rhionaeschna californica* (California Darner; Figure 1), was reported for the first time at Westmoreland (11 and 22 June; CASM Environmental) and Brookside (3 August, 2019; volunteer Phil Nosler). This is one of the smallest and earliest-flying darners in our region, and though its presence was suspected at Brookside in previous years by CASM Environmental, no view clear enough to warrant confirmation was obtained until this year.

Figure 1. New darner species for the project. (left) Male Lance-tipped Darner (*Aeshna constricta*), photographed by volunteer Zach Kemp on 20 July 2019 at Brookside. (right) Male California Darner (*Rhionaeschna californica*), one of multiple images taken by volunteer Phil Nosler on 3 August 2019 at Westmoreland Park



Although not strictly part of the project (but nonetheless included in the project total of 31 species), a River Jewelwing (*Calopteryx aequabilis*) was seen for the first time at Westmoreland Park on 3 June (Figure 2). It was found in a shady area of the creek downstream from the usual transects by a colleague of a project volunteer (Julia Bond), both of whom work for Bureau of Environmental Services. The volunteer forwarded her colleague's photo to CASM Environmental for confirmation of identification; though blurry, this species is so distinctive that an unequivocal identification was possible. Although River Jewelwing has been reported from most counties in Oregon, this record is one of only two for the species in Multnomah County, and was submitted to OdonataCentral by CASM Environmental on behalf of the observer (record #496348). This species is often seen perching in large numbers in sunny spots on low vegetation overhanging small wooded streams and can be quite abundant where it occurs, but it has not been observed in multiple prior years of park surveys by CASM Environmental.

Figure 2. Male River Jewelwing (*Calopteryx aequabilis*), photographed on 3 June 2019 at Westmoreland Park by Melissa Brown and sent to CASM Environmental by volunteer Julia Bond.



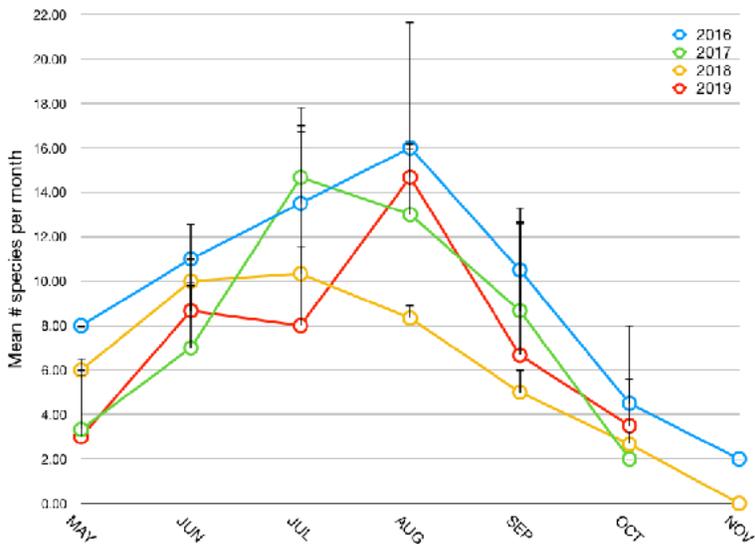
Seasonality and abundance

The most frequent observations overall were of Tule Bluet (*Enallagma carunculatum*; observed on 29 dates among all sites), Pacific Forktail (*Ischnura cervula*; observed on 25 dates among all sites), and Common Green Darner (*Anax junius*; observed on 25 dates among all sites). The two damselfly species have been reliably the most abundant, although in 2019 Pacific Forktail numbers were lower at some of the sites, and both have an extended flight season in our area. Common Green Darner is one of our long-distance migrants and also has an extended flight period in our area, due to the combination of returning migratory adults in spring, resident overwintered nymphs emerging as adults in summer, and the next generation of migrant adults emerging at the end of the summer. Species sighted earliest in the season included Pacific Forktail (18 April, Westmoreland) and Twelve-spotted Skimmer (10 May, Brookside). Interestingly, a survey done at Centennial on the same date as the early Brookside survey (10 May) found five species: Common Green Darner, Four-spotted Skimmer (*Libellula quadrimaculata*), Pacific Forktail, Tule Bluet, and Western Forktail (*Ischnura perparva*).

Skimmers such as Common Whitetail (*Plathemis lydia*) and Eight-spotted Skimmer (*Libellula forensis*) dominated the summer months among the dragonflies; for the damselflies, Tule Bluet was often too numerous to count, but the usually super-abundant Pacific Forktail had lower numbers this year at both Centennial and Brookside. Species not seen until late summer/early fall included California Spreadwing (*Archilestes californica*), Flame Skimmer (*Libellula saturata*), and Shadow Darner (*Aeshna umbrosa*). Species still on the wing in early to mid-October included Western Forktail, Vivid Dancer (*Argia vivida*), and Shadow Darner (*Aeshna umbrosa*).

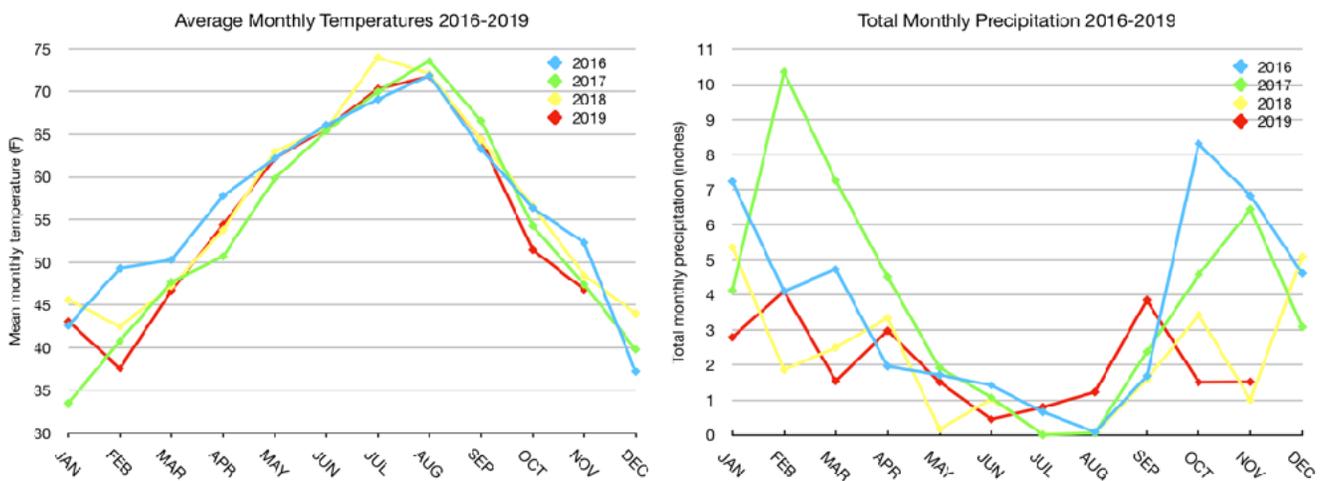
The number of species among all sites generally followed the seasonality seen in prior years (Figure 3), with the exception of a decrease in richness from June to July. This was due in part to construction work at Centennial during this period, but species richness at Brookside was also stagnant from June to July, in contrast to the large increases in diversity between these two months at this site in both 2017 and 2018. Although species numbers in 2019 were lower early in the season than in many previous years, by August diversity had increased and was higher through the remainder of the season than it had been in 2018.

Figure 3. Mean number of species per month among all sites, 2016-2019. Bars indicate standard deviation.



The annual average monthly temperatures have been similar across all years of surveys, with the greatest between-year variations seen in winter/spring, but precipitation patterns varied more (Figure 4). The wettest spring and fall occurred in 2017; in 2019, total precipitation in each month was generally lower compared to other years, except for a small spike in September. Precipitation patterns can impact odonates in a variety of ways; a dry fall or winter can reduce survival of overwintering nymphs, leading to potentially lower adult abundances the following spring and summer; and a dry spring may increase mortality among nymphs breaking hibernation, and reduce available oviposition habitat for returning migrants and newly-emerging resident adults.

Figure 4. Average monthly temperature (left) and total precipitation (right) in Portland, 2016-2019. Data taken from NOAA monthly weather summaries for Portland (<http://w2.weather.gov/climate/index.php?wfo=PQR>).



Odonate community at individual sites

Centennial Pond

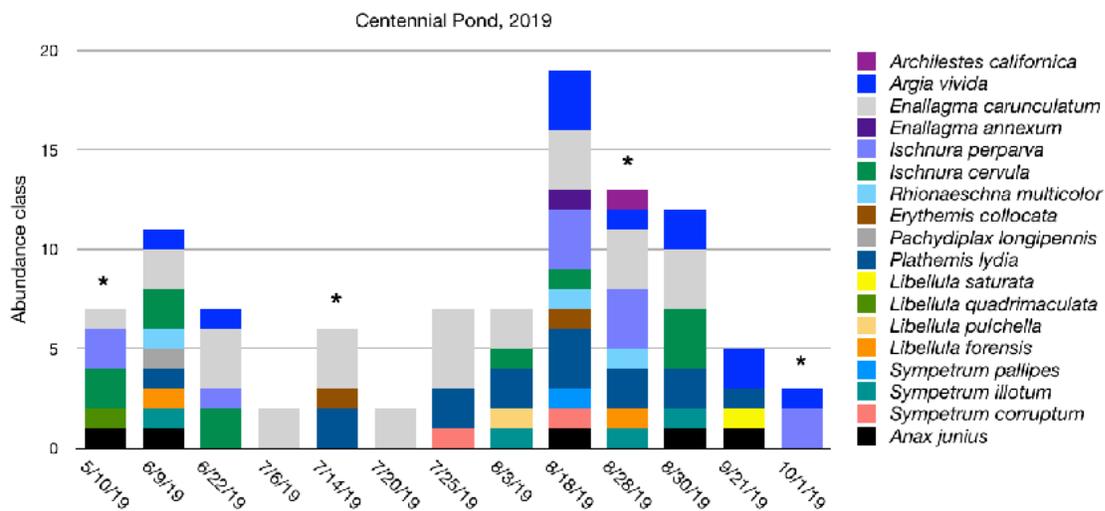
This was the third year of monitoring at Centennial. In 2017 and 2018, volunteers collected baseline data on the community. In 2019, surveys bracketed the restoration work done from late June through early July on a 275 m (900 ft.) length of Mitchell Creek to remove fish passage barriers and an in-line pond (i.e., Centennial Pond). This continuous monitoring enabled visualization of rapid changes in the odonate community as a result of both restoration activities and subsequent changes in habitat. The ponded area still held water in July, but dried down substantially by the end of the season, while the restored creek bed had increasing though slow flow and more emergent vegetation (Figure 5). The surrounding Himalayan blackberry thicket was removed, and a large upland field was mowed prior in preparation for later planting.

Figure 5. Centennial Pond/Michell Creek prior to restoration work, 6 Sept. 2018 (upper left); Mitchell Creek immediately post-restoration through the season, 14 Jul 2019 (upper right); 28 Aug 2019 (lower left); and 10 Oct 2019 (lower right).



Odonate populations were clearly affected, as only 1-3 species were seen throughout July (Figure 6). However, odonate reproduction was already occurring at the site as early as 20 July (a pair of ovipositing Tule Bluets reported). Remarkably, by mid-August the number of species not only recovered but surpassed that in prior years, with a record 11 species in one day on 18 August. In contrast, the most species seen in a single day in 2017 and 2018 were 10 and six, respectively. In addition, some species that were present in prior years were much more common and abundant in 2019. For example, Vivid Dancer (*Argia vivida*), a damselfly that prefers small spring-fed streams, was only recorded at Centennial on a single early June date in 2018 at low abundance (Uncommon; 1-4 individuals); in 2019 it was seen on seven dates from June through October, at abundances ranging from Uncommon to Common (21-100 individuals), and males were reliably found sunning themselves on rocks in Mitchell Creek downstream of the former pond. In contrast, no Vivid Dancers were reported from Westmoreland this year, and while they were seen frequently at Brookside, they were present at low abundances.

Figure 6. Odonate seasonality and abundance at Centennial in 2019. Abundances are in categories: 1 (uncommon, 1-4 individuals); 2 (frequent, 5-20); 3 (common, 21-100); 4 (abundant, >100). *surveys done by CASM Environmental.



Site richness was higher in 2019, with 18 species (12 dragonfly, 6 damselfly) throughout the season; in 2017 and 2018, season totals of 15 and 14 species were recorded. The most commonly observed damselflies (on >53% of survey dates) were Tule Bluet (*Enallagma carunculatum*) and Vivid Dancer; the most commonly observed dragonfly species (on >38% of survey dates) were Common Whitetail (*Plathemis lydia*) and Common Green Darner (*Anax junius*). This was also the first monitoring year in which Striped Meadowhawk (*Sympetrum pallipes*), Four-spotted Skimmer (*Libellula quadrimaculata*), Flame Skimmer (*L. saturata*), Northern/Boreal Bluet (*Enallagma annexum/boreale*), and California Spreadwing (*Archilestes californicus*) were reported at Centennial. *S. pallipes* and *E. annexum/boreale* were not seen at Westmoreland or Brookside in 2019, though they were observed there in previous years; the remaining species reported from Centennial this year were also seen at one or both of the other sites.

The number of species reported in each month showed a similar pattern to 2018, with the exception of a spike in diversity in August 2019 (Figure 7). However, species composition differed; the communities in 2017 and 2018 were quite similar (Jaccard Index = 0.81), while the 2019 community differed much more and to a similar degree from both (Jaccard Index = 0.65 and 0.60 compared to 2017 and 2018, respectively). The proportion of survey dates on which migratory species were seen (46% of total survey dates; Figure 8) was similar to 2018 (43% of survey dates) and was again lower than in 2017 (67% of survey dates). In addition, this was the first year in which Black Saddlebags (*Tramea lacerata*) was not reported at Centennial. Common Green Darner (*Anax junius*) was observed both pre- and post-restoration, while Variegated Meadowhawk (*Sympetrum corruptum*) was seen only post-restoration.

Figure 7. Total number of species observed in each month at Centennial Pond, 2017-2019.

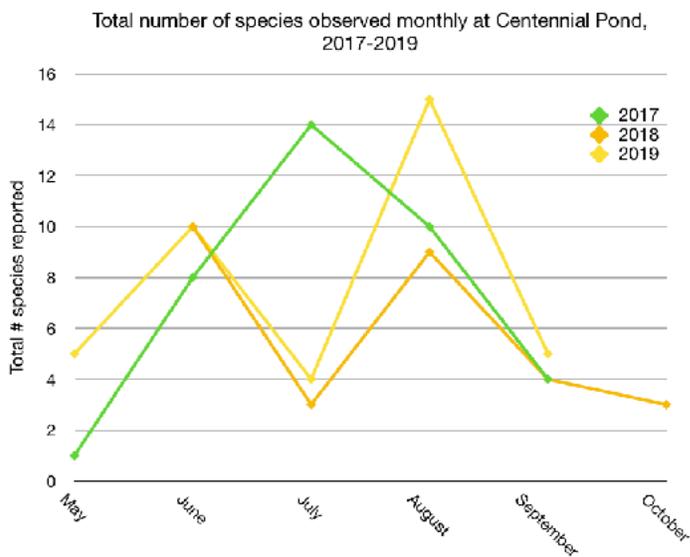
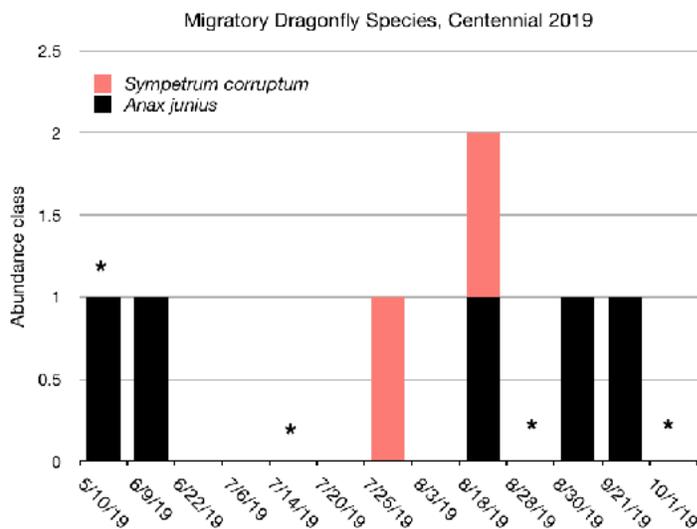


Figure 8. Migratory species at Centennial in 2019. Species abundances are in categories: 1 (uncommon, 1-4 individuals); 2 (frequent, 5-20); 3 (common, 21-100); 4 (abundant, >100). *surveys by CASM Environmental

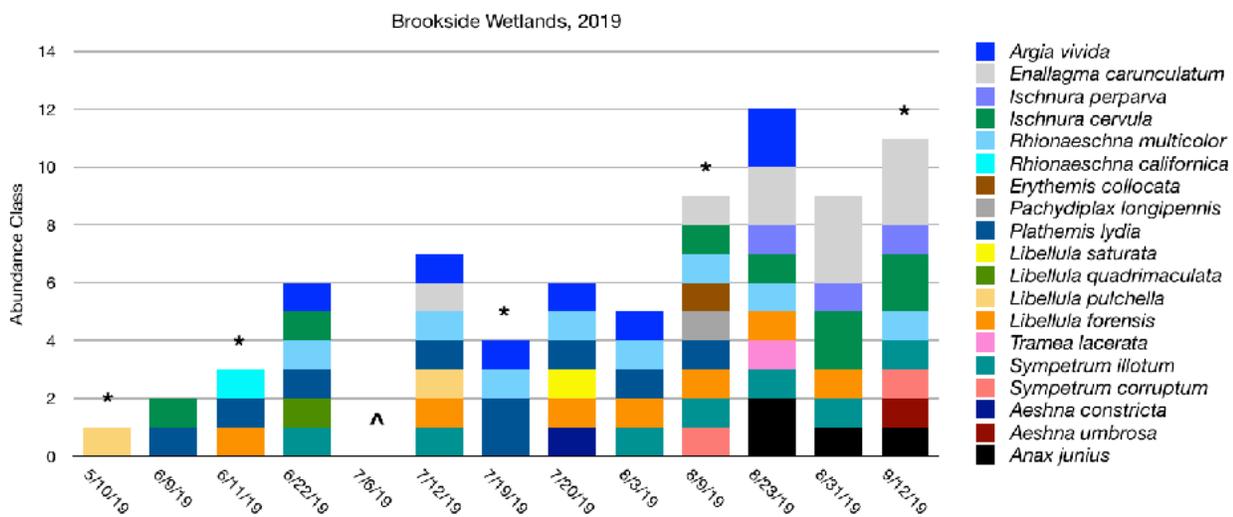


Brookside Wetland

Water levels at Brookside were notably lower than in previous years, even in early spring (i.e., 20 March), likely due to blow-out of existing beaver dams on Johnson Creek over the winter. For the first time since monitoring began, water levels were so low that the large wetted area dried down to two isolated ponds, which by late July were very shallow, with large expanses of bare cracked mud. Water levels were a bit higher in mid-August, as the two ponds were again connected by a narrow, shallow, flowing channel with more areas of shallowly submerged soil and increased vegetative growth (CASM, pers. obs.)

A total of 19 species (15 dragonfly, 4 damselfly) was seen across the season (Figure 9); the maximum number of species reported on a single date was nine (in early and late August). Species richness at this site has been remarkably consistent (19 and 18 species total reported in 2018 and 2017, respectively). The most commonly observed damselfly species (on >46% of survey dates) were Pacific Forktail (*Ischnura cervula*) and Vivid Dancer (*Argia vivida*), and the most commonly observed dragonflies (on >61% of survey dates) were Common Whitetail (*Plathemis lydia*) and Blue-eyed Darner (*Rhionaeschna multicolor*).

Figure 9. Odonate seasonality and abundance at Centennial in 2019. Abundances categories: 1 (uncommon, 1-4 individuals); 2 (frequent, 5-20); 3 (common, 21-100); 4 (abundant, >100). *surveys by CASM Environmental; ^ volunteer survey on day with poor weather conditions (heavy clouds, cool)



Composition of the Brookside community has also been fairly consistent across time, although the communities in 2016 and 2017 were the most similar (Jaccard index = 0.80), while those in 2016 and 2018 were the least similar (Jaccard Index = 0.61); similarity indices between all other year pairs range from 0.68-0.72. The odonate community at Brookside in 2019 was somewhat more similar to that at Westmoreland (Jaccard Index = 0.71) than at Centennial (Jaccard Index = 0.68). However, the photo-vouchered record of Lance-tipped Darner at Brookside is the first report

of this species from any project site in any year. With the exception of Lance-tipped Darner and California Darner, all other species reported from Brookside in 2019 were observed there in one or more previous years, and were also observed in 2019 at Centennial and/or Westmoreland.

The total number of species observed in each month at Brookside was lower in several months compared to previous years (Figure 10). In addition, although three migratory species were reported, they were present on only 31% of survey dates, all in late summer/early fall (Figure 11).

Figure 10. Total number of species observed in each month at Brookside, 2016-2019.

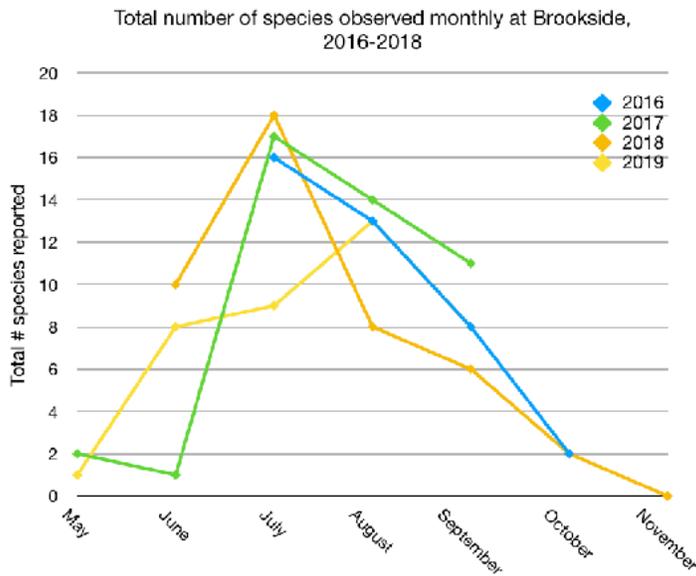
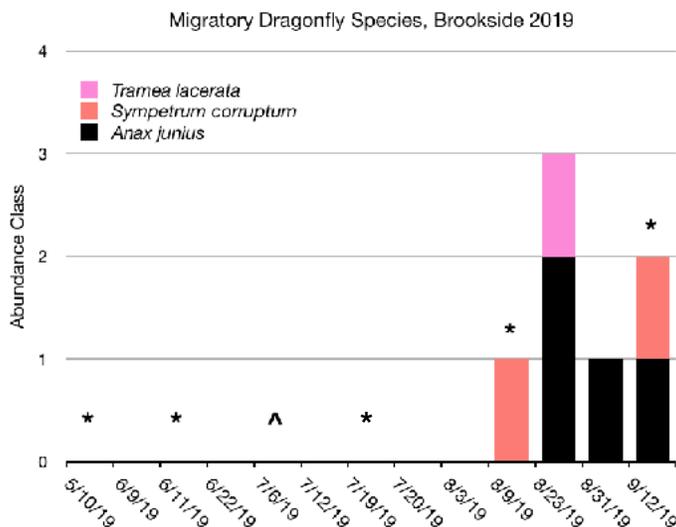


Figure 11. Migratory species at Brookside in 2019. Species abundances are in categories: 1 (uncommon, 1-4 individuals); 2 (frequent, 5-20); 3 (common, 21-100); 4 (abundant, >100). *surveys by CASM Environmental; ^ volunteer survey on day with poor weather conditions (heavy clouds, cool)

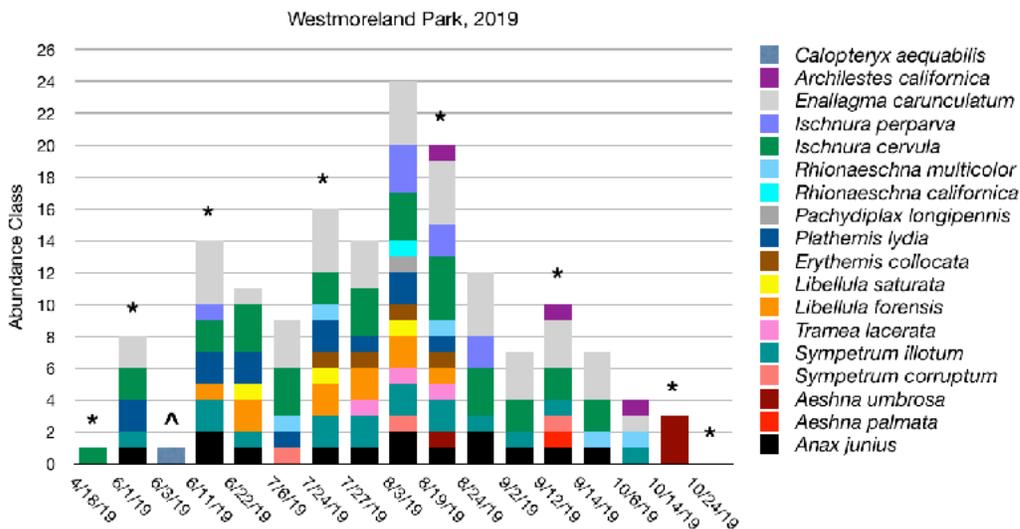


Westmoreland Park

By the end of 2018, it was noted that habitat conditions at Westmoreland had deteriorated significantly. Upland wetlands were almost obscured by dense thickets of jewelweed, thick mats of emergent vegetation in Crystal Springs Creek covered much of the open water and backed up the flow, and high water levels plus nutria activity eroded the banks (Searles Mazzacano, 2018). The decrease in habitat quality was accompanied by decreased odonate diversity; the total number of species seen at Westmoreland in 2018 was the lowest for any site and year. However, by 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.

A total of 18 species (13 dragonfly, 5 damselfly) was reported throughout the flight season (Figure 12). This diversity is higher than in 2018 (13 species total), though still lower than in the first two years of monitoring at this site (22 and 21 species in 2016 and 2017, respectively). Species diversity peaked in early to mid-August, and the maximum number of species reported on a single date (13) occurred within this span. The most commonly observed damselfly species (on >80% of survey dates) were Tule Bluet and Pacific Forktail, and the most commonly observed dragonflies (on >68% of survey dates) were Common Green Darner and Cardinal Meadowhawk (*Sympetrum illotum*). A few species that were seen in both 2016 and 2017 but not reported in 2018 were observed again this year, i.e., Paddle-tailed Darner (*Aeshna palmata*) and Flame Skimmer (*Libellula saturata*). In addition, two species new to the project list were reported in 2019: California Darner (*Rhionaeschna californica*, also reported at Brookside in 2019) and River Jewelwing (*Calopteryx aequabilis*). However, the overall community in 2019 was more similar to that seen in 2018 at this site (Jaccard index = 0.76) than to those in previous years (Jaccard Index = 0.65-0.70).

Figure 12. Odonate seasonality and abundance at Westmoreland Park in 2019. Abundances are in categories: 1 (uncommon, 1-4 individuals); 2 (frequent, 5-20); 3 (common, 21-100); 4 (abundant, >100). *surveys by CASM Environmental; ^ incidental observation by colleague of surveyor



The number of species reported in each month followed a pattern more similar to earlier monitoring years (Figure 13), and was two to three times greater in late summer compared to 2018. Three of our migratory species were observed on 75% of survey days, with Common Green Darner in particular present throughout the summer (Figure 14). In contrast, in 2018 Black Saddlebags was not seen at the park, and Common Green Darner and Variegated Meadowhawk were present in a more restricted date range and only seen on 33% of survey days.

Figure 13. Total number of species observed in each month at Westmoreland Park, 2016-2019.

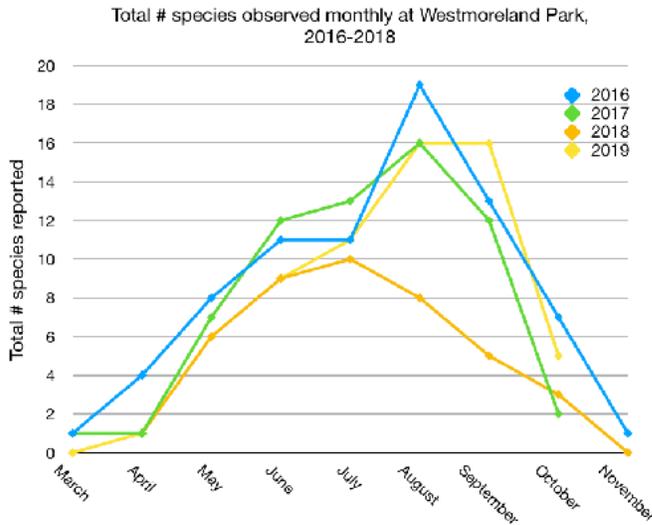
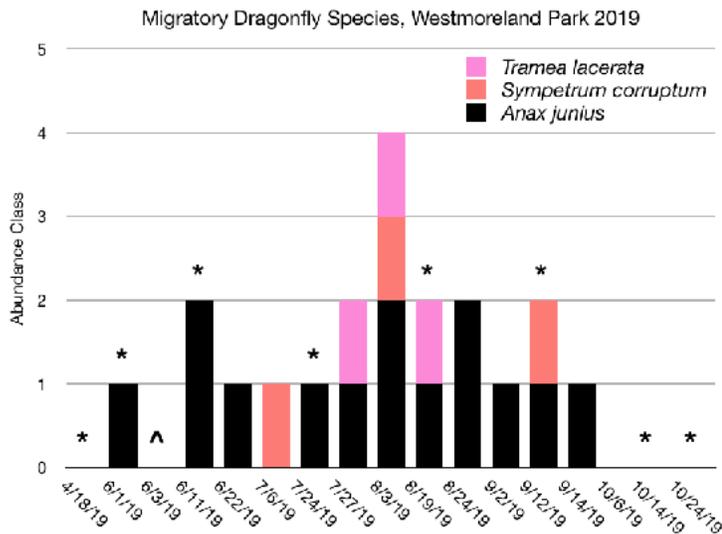


Figure 14. Migratory species at Westmoreland in 2019. Species abundances are in categories: 1 (uncommon, 1-4 individuals); 2 (frequent, 5-20); 3 (common, 21-100); 4 (abundant, >100). *surveys by CASM Environmental; ^ date of incidental single-species observation by colleague of surveyor



Working with volunteers

Modifications of training based on feedback from prior years appeared to be successful. These included increasing social interaction among volunteers, connecting new volunteer teams with returning “peer mentor” volunteers, expanding training on how to use iNaturalist, encouraging a greater number of photo vouchers, and spending additional time on how to photograph in-hand specimens for greater ease of identification. More records included photo vouchers, and although some were inevitably blurry, many still provided the necessary details for identification. In addition, any unexpected and/or new species for the project were accompanied by photos that enabled unequivocal species identification. There were some cases in which an ID could not be confirmed based on the photo (for example, a blurred image of an ovipositing dragonfly could have been either a Cardinal Meadowhawk or a Flame Skimmer), and some teneral damselflies could not be identified further than family, but these represented a small proportion of the total observations and are an expected part of monitoring projects such as this.

The GoogleDocs system, used to designate teams and survey dates and indicate when data were submitted to iNaturalist, also appeared easy to navigate and was very useful for CASM Environmental as data were being collated. Almost all sites were visited multiple times by volunteers from June through September, so through coverage was obtained. Having new teams go out for at least their first site survey with an experienced volunteer was appreciated, and the presence of multiple peer mentors suggests a high level of satisfaction with the experience.

Although volunteers often express substantial anxiety about correct identification, vetting of iNaturalist records indicates that most are making good use of the training and resources provided. Once again, new species were added to the project list by volunteers who were familiar enough with the appearance of more commonly observed groups that they recognized when they saw something different, and pursued the correct ID. Furthermore, the capture of a photographic voucher of one such new species (River Jewelwing) by the colleague of a volunteer speaks to the effectiveness of additional outreach by project participants to their own personal and professional circles.

Discussion

This project provides an effective way to engage watershed council volunteers in new activities while providing outreach and education about wildlife within the watershed and generating new data about odonate populations. It also illustrates the importance and effectiveness of long-term monitoring at dedicated sites. In four years of surveys, volunteers have added new species records at both the county and site level, and it is remarkable that even after several years of surveys in a highly urbanized watershed, new project species are still being recorded.

Insect populations can typically fluctuate greatly from year to year, and one of the challenges associated with monitoring is determining whether observed changes are due to normal annual variation, or changes in habitat or climate conditions. Long-term monitoring is important, because it can reveal trends and provide a better idea of what is “normal” for a given group. For example, in 2019, the numbers of adults observed in early to mid-summer were

lower than in previous years. Drier conditions in fall 2018 and early spring 2019 may have contributed to this, as prior year's moisture affects successful overwintering of hibernating nymphs. Precipitation totals in the final months of 2019 are over an inch below normal, so if another dry winter and/or spring impacts our region, odonate populations may be further impacted.

One new factor in 2019 is that for the first time, there were changes in habitat at all three monitoring sites. At Brookside, water levels were much lower than normal throughout the season, and decreased open water combined with reduced edge vegetation as retreating water left only mud made the habitat less attractive and useful to many of the slow-water species that normally use the site. Only two of the species found at the site, Common Whitetail (*Plathemis lydia*) and Tule Bluet (*Enallagma carunculatum*), were seen at abundances greater than 1-4 (Uncommon) on any site visit, and then only on one (*P. lydia*) or three (*E. carunculatum*) survey dates. While a teneral adult dragonfly was seen there early in the season, most observations during the season were of mature adults, and those were mostly patrolling males (though some tandem pairs and wheels were seen for Tule Bluet, Vivid Dancer, and Common Green Darner), suggesting that little oviposition or successful emergence occurred there this summer.

Habitat improvements at Centennial and Westmoreland in 2019 were also accompanied by rapid changes in odonate populations. Ongoing decrease in habitat quality at Westmoreland after a successful restoration were linked to an all-time low of only 13 species at the park in 2018. However, vegetation management done in late 2018 at Westmoreland improved creek flow and wetland conditions, resulting in both habitat conditions and an odonate community more similar to previous years. By the same token, at Centennial, where two years of monitoring had characterized the baseline odonate community pre-restoration, monitoring after restoration found a changed odonate community that reflected the new flow and habitat conditions. Vivid Dancer, a species that prefers small cold streams, became quite common in the restored portions of Mitchell Creek, while Black Saddlebags, a migrant that prefers large open expanses of water, was not seen at Centennial in 2019 due at least in part to the dry-down of the large impoundment at the site.

Project-wide, interesting shifts in overall populations have been seen in recent years. Once the most super-abundant species at all sites, the numbers of Pacific Forktails have been lower in recent years, while Tule Bluets and Western Forktails now dominate the numerical abundance of damselflies. Although Variegated Meadowhawks (*Sympetrum corruptum*) continue to be seen at all sites, the large late-season emergence of the new generation of migrants that was especially noticeable at Westmoreland hasn't occurred for the last two years, and the only other meadowhawk seen in abundance throughout the season is *S. illotum* (Cardinal Meadowhawk). Similarly, some of the skimmers seen in earlier years such as Widow Skimmer (*Libellula luctuosa*) and Twelve-spotted Skimmer (*L. pulchella*) are less commonly seen, while the once-rare Four-spotted Skimmer (*L. quadrimaculata*) and the common Eight-spotted Skimmer (*L. forensis*) have become more ubiquitous.

The work of JCWC staff to increase communication between volunteers, assign peer mentors to new teams, and solicit feedback to determine volunteer satisfaction and needs has also been effective. Site surveys are done for over four months each year, which is a substantial commitment, but enough people have been involved that regular

monitoring at three sites can be maintained. The return of peer mentors each year also speaks to a high degree of volunteer interest and satisfaction. Successful, sustainable, high-quality community-based science that provides for volunteer satisfaction and retention involves training by subject-matter experts, good reference materials, and discovering the motivating factors and barriers for project participants (Bonney et al., 2009; Domroese & Johnson, 2017; Orchard, 2018), and work done in this project further supports these findings.

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