Community-based Dragonfly & Damselfly Monitoring in Johnson Creek Watershed

Cardinal Meadowhawk, Westmoreland Park; C.A. Searles Mazzacano

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December 1, 2016
Consulting Services Agreement 2016-002

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Executive Summary

In 2016, Johnson Creek Watershed Council worked with CASM Environmental, LLC to establish a new community-based research project to monitor populations of odonates (dragonflies and damselflies) in the Johnson Creek watershed. For this pilot project, two sites within the watershed were selected, both with extensive stream and wetland habitat: Westmoreland Park (Crystal Springs Creek) and Brookside Park (Johnson Creek). Volunteers received classroom and field training in odonate ecology, life history, identification, survey protocols, and data reporting. Self-assembled teams signed up for survey dates set at 14-day intervals from June through October, though weather conditions and schedule conflicts resulted in surveys actually being done every 8-16 days at each site. Survey teams walked transects at each site and recorded odonate species, abundance, sexes, and behaviors (mating, egg-laying, etc.). Volunteers were encouraged to capture specimens for in-hand identification and and take photo vouchers whenever possible. Weather conditions and total survey time were also recorded on each date. All data were reported using iNaturalist (http://www.inaturalist.org/projects/dragonfly-surveys-in-johnson-creek-watershed). CASM Environmental conducted periodic surveys at both sites to ensure quality control, and reviewed online data submissions.

Over 200 observations were made of 23 odonate species among both sites (18 dragonfly, five damselfly). Diversity was greater at Westmoreland Park, where 22 species were reported (17 dragonfly, 5 damselfly); Brookside Park had 18 species (13 dragonfly, 5 damselfly). All species present at Brookside were also seen at Westmoreland Park. Three species at Westmoreland Park were absent from Brookside: Shadow Darner (*Aeshna umbrosa*), Black Meadowhawk (*Sympetrum danae*), and Autumn Meadowhawk (*S. vicinum*). Notable findings included the addition of a new species to the known list for Multnomah County (Autumn Meadowhawk, *Sympetrum vicinum*); the first vouchered and geo-referenced record of Black Meadowhawk (*S. danae*) in what is an unexpected lowland area for this species to occur; and a new early flight date for Twelve-spotted Skimmer (*Libellula pulchella*) in the state of Oregon. Three of the five main migratory species in North America also utilized both sites, but indications of breeding (mating pairs) and successful development (newly-emerged adults) were observed only at Westmoreland.

Volunteers were highly motivated and enthusiastic about the project, and several indicated willingness to act as peer mentors to new volunteers in future years. This pilot project demonstrates that the use of proven techniques in community-based science, including clear standardized protocols, training and oversight by subject matter experts, and encouraging volunteer feedback for adaptive management, enables collection of new data about a still understudied group that is helping to expand our knowledge of local biodiversity, impacts of site restoration on local biota, and effects of climate change on local life-history of both resident and migratory dragonfly species.

Objectives

This project was undertaken to expand the Johnson Creek Watershed Council's community-based science program by initiating a pilot project in volunteer-based surveys of dragonflies and damselflies. Training materials and resources to support volunteers were developed, and self-organizing volunteer teams surveyed local odonates on a regular basis during the majority of the flight season at two sites in the Johnson Creek watershed. This pilot project will be extended and expanded in coming years, with volunteers from the 2016 field season continuing on as peer mentors to incoming volunteers in future years.

Background

Dragonflies and damselflies (Odonata) perform important ecological functions in streams and wetlands. The assemblage of odonate species in a water body can provide information about habitat type and quality. Immatures (nymphs) and adults prey on a variety of insects; dragonfly nymphs can be top predators in habitats that lack fish, and nymphs and adults provide important pest control services, eating a variety of insects including mosquitoes and midges. Odonates are also a vital food resource for aquatic and terrestrial wildlife including fish, waterfowl, songbirds, lizards, and frogs.

Although odonates are among the better-known insects, there is still much to be learned about their distribution, life history, and ecology. Moreover, little is also known about the phenomenon of dragonfly migration in North America, with questions remaining about timing, triggers, flight pathways, overwintering grounds, staging areas, and the relationship between resident and migrant individuals of the same species. Dragonflies and damselflies are also excellent subjects for studying the long-term impacts of climate change. Extensions of early and late flight dates are already being noted for many species in the U.S. (Abbott, 2006-2016), and several tropical species once considered vagrants in the southwest have recently established breeding populations (Bailowitz et al., 2016).

No systematic studies of odonates have been done in the Johnson Creek watershed, and the odonate fauna of Multnomah and Clackamas counties has not been completely described. Examining odonate diversity and abundance is a first step in discovering stressors impacting local populations, incorporating odonate habitat needs into restoration plans, and learning the effects of restoration projects on different species.

Volunteers can make a huge contribution to what we know about odonates. These insects are compelling, beautiful, and easy to observe, and learning to identify local species is fairly straightforward. This project established protocols, training techniques, and survey methodology for community-based dragonfly and damselfly monitoring in Johnson Creek Watershed Council (JCWC), and initiated the first season of monitoring at two sites in the Johnson Creek watershed, Brookside Park and Westmoreland Park.

Methods

Volunteer Training

A detailed manual for volunteers was developed by CASM Environmental in May-June 2016, and staff of JCWC reached out to their extensive network of volunteers to participate in the new project. Volunteer training was carried out across two days. On 16 June, a 2-hour classroom training was held in the evening to enable participants to learn about odonate ecology, life history, and behaviors; recognize common species found in Multnomah County; discover key components for species identification; and learn how to use the monitoring protocol and reporting methods. At the end of the training session, volunteers signed up for survey dates spanning every 14 days in July-October at two different sites: Brookside Park, off of Johnson Creek (11201-11243 SE Brookside Dr, Portland, OR) and Westmoreland Park, off of Crystal Springs Creek (7530 SE 22nd Ave, Portland, OR). On 18 June, a 3-hour field session was held at Brookside Park to demonstrate survey methodology and have volunteers practice netting and identifying odonates. Volunteers were given a list of the odonate species currently known from Multnomah County (Abbott, 2006-2016), and purchase of at least one of the following regional odonate references was recommended: Dragonflies and Damselflies of Oregon (Kerst, & Gordon, 2011); Dragonflies and Damselflies of the West (Paulson, 2009).

Survey techniques

The adult flight season for odonates in the Portland area runs from early May through late October, although early and late dates vary from year to year due to weather conditions. It was not possible to initiate this project at the start of the 2016 flight season; however, because CASM Environmental has been surveying Westmoreland Park routinely since 2015, full flight season data are available at that site. The goal was to survey each site once every 14 days, but due to changing weather conditions and volunteer availability, survey dates were often shifted slightly, such that in practice they occurred once every 8-16 days.

Volunteers surveyed odonates along a transect that runs along the water's edge, allowing them to view both the water and adjacent vegetation. Teams were given maps to guide their transect walks (Figure 1). Surveys were done on days when weather conditions were optimal for odonate activity (Table 1). Volunteers were encouraged to take photos and capture odonates for in-hand examination whenever possible. Those who lacked aerial insect nets signed out nets from the JCWC office. Observers filled out their data sheet (see Appendix A) upon arriving at the site with start time, observer names, and weather conditions (sun, cloud cover, wind, precipitation).

Surveyors walked slowly along their transects, noting the following aspects of the odonate community:

- Species: Volunteers were encouraged to capture specimens for in-hand examination and to take photographic vouchers of perched or in-hand specimens whenever possible. The method of identification was noted on the data sheet (visual, captured, photographed).
- Gender: Males and females can be differentiated based on coloration, markings, and genitalia (structures on the terminal abdominal segment).
- Abundance category: uncommon (1-4 individuals seen), frequent (5-20), common (21-100), or abundant (>100)
- Reproductive stage: wheel (mating pair), tandem pair (male still holding female but not engaged in copulation), ovipositing (laying eggs), and teneral adult (newly-emerged)

Volunteers were encouraged to keep tallies of species abundances while conducting the survey, then at the end, record the final abundance categories, and the stop time and weather conditions.

Figure 1. Survey transects for Westmoreland (left) and Brookside (right) Parks.

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)	>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
Rain	No	No	No	No	No

Data reporting

All data were entered into iNaturalist under the project "Dragonfly Surveys in Johnson Creek Watershed (http://www.inaturalist.org/projects/dragonfly-surveys-in-johnson-creek-watershed). Data entry fields on the iNaturalist project site mirrored each entry on the data sheet. Data could also be entered in the field via the mobile iNaturalist app, for those who wished, and many volunteers also earth-mailed or e-mailed their data sheets to the JCWC office. iNaturalist was chosen for data reporting due to its ease of use, availability as a mobile app on iOS and Android, and ease of data export for analysis and reporting. In addition, the crowdsourcing method of identification and verification provided both a useful image gallery for volunteers (from large numbers of identified, vetted photos in the iNaturalist database) as well as a means for volunteers to confirm species identifications of their uploaded photos. Volunteers also e-mailed CASM Environmental with questions about survey and reporting protocols and species identification.

QA/QC

CASM Environmental surveyed Brookside and Westmoreland on nine dates from June through early November to provide data sets to compare to those gathered by volunteers. These data were also entered on the iNaturalist project site. To provide information for adaptive management, volunteer feedback was solicited directly at an end-of-season potluck, where a summary of the season's results was presented and volunteers were encouraged to share their impressions of the project and discussed anything that had arisen as either a challenge or a strength of the training, resources, and reporting. Volunteers were also encouraged to remain with the project in 2017 as peer mentors to new participants. Additional project feedback was solicited via the annual JCWC online survey to volunteers.

Results

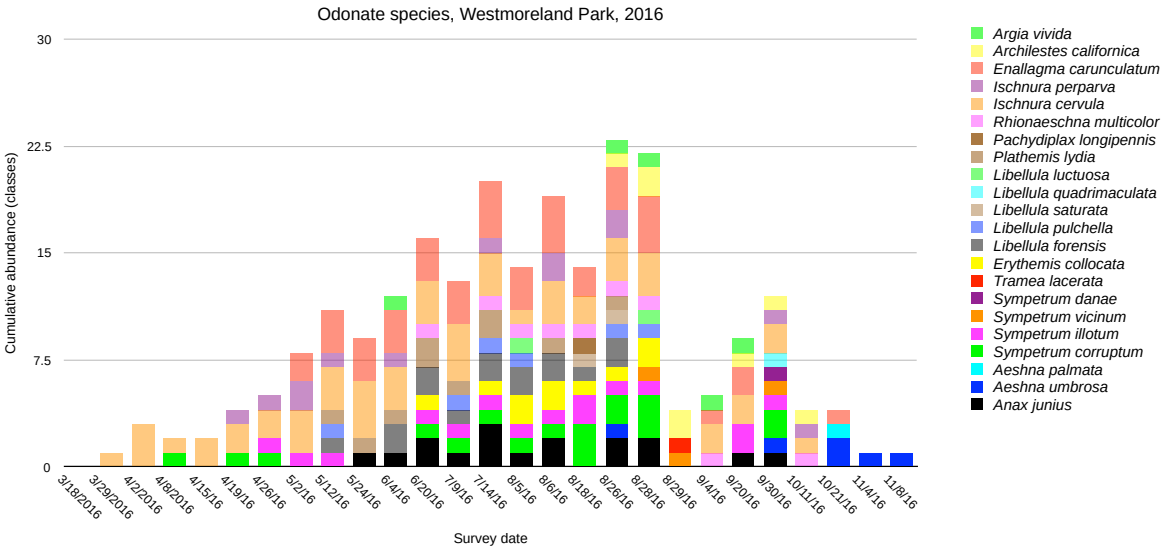
Species seasonality and abundance

Surveys were done from June through October. After formal surveys ended, a few enthusiastic volunteers continued surveying sporadically through the uncharacteristically mild weather of November and reported their findings to CASM Environmental. Those surveys, combined with the ongoing work at Westmoreland Park by CASM Environmental, enabled first and last flight dates for the 2016 season to be established (29 March through 8 November). Note that these dates refer to the flight season only at the two parks (additional darner sightings were noted at other sites in the Portland area by project volunteers and JCWC staff on 6 and 10 November).

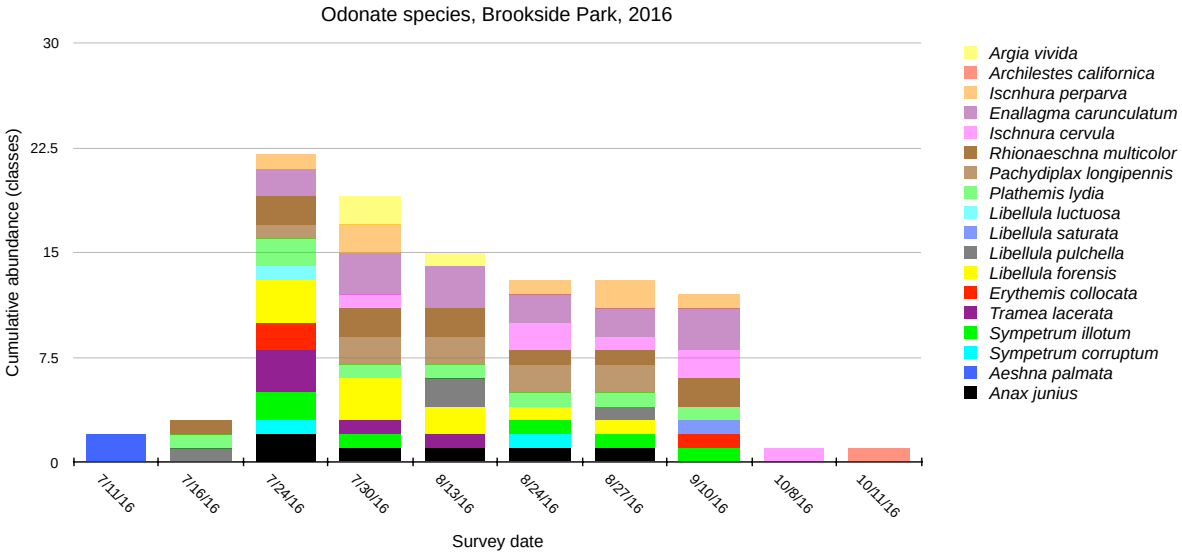
Surveys were done on 27 dates at Westmoreland Park and 10 dates at Brookside Park, with a total of 23 species of odonates reported (18 dragonfly, five damselfly). Diversity was greater at Westmoreland Park, where 22 species were reported (17 dragonfly, 5 damselfly), compared to Brookside Park, which had 18 species (13 dragonfly, 5 damselfly; see Figure 1A and B). All species at Brookside were also seen at Westmoreland Park. Three species seen at Westmoreland Park were absent from Brookside: Shadow Darner (*Aeshna umbrosa*), Black Meadowhawk (*Sympetrum danae*), and Autumn Meadowhawk (*S. vicinum*).

Figure 1. Seasonality and relative abundance of odonates at Westmoreland (A) and Brookside (B) Parks. Species abundances reported as categories: 1 (uncommon, 1-4 individuals); 2 (frequent, 5-20 individuals); 3 (common, 21-100 individuals); 4 (abundant, >100 individuals)

A. Odonates at Westmoreland Park. All surveys prior to late June conducted by CASM Environmental.



B. Odonates at Brookside Park



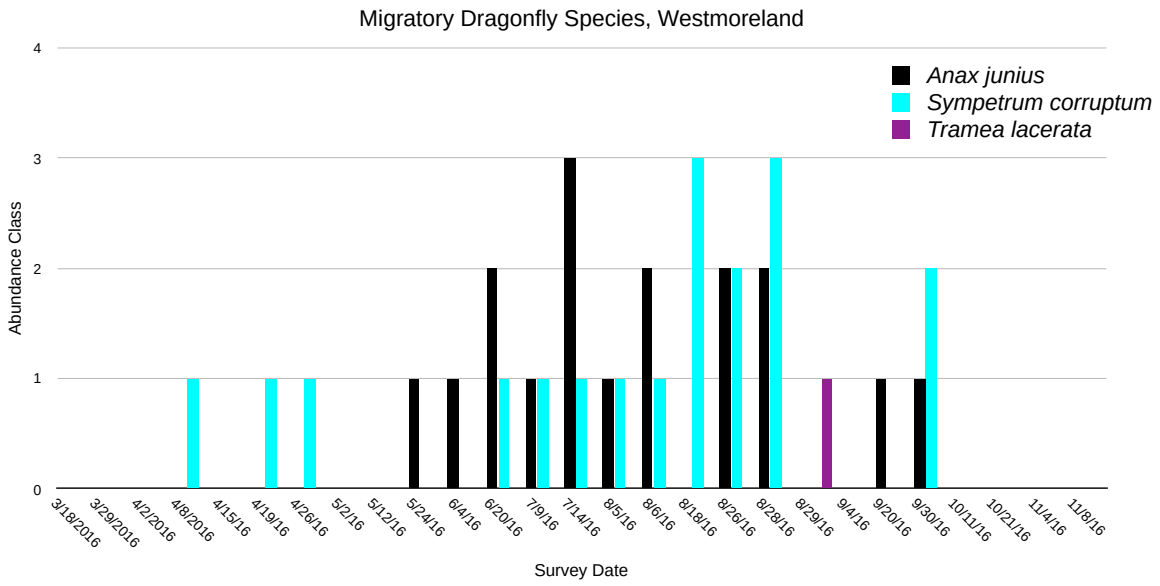
Migratory Species

Three of North America's five main migratory dragonfly species were among those seen at both sites: Common Green Darner (*Anax junius*), Variegated Meadowhawk (*Sympetrum corruptum*), and Black Saddlebags (*Tramea lacerata*) (Figure 2). The other two migratory species, Wandering Glider (*Pantala flavescens*) and Spot-winged Glider (*P. hymenaea*) were not expected; though both are known in Oregon, there are only a handful of scattered records for *P. flavescens* in the state, and *P. hymenaea*, while more widespread and known from still water habitats in the Willamette Valley, is not common here (Kerst & Gordon, 2011). Black Saddlebags was found in greater abundance and across a longer time period at Brookside, while Variegated Meadowhawk and Common Green Darner were more abundant and persistent at Westmoreland. At Westmoreland, teneral (newly-emerged) adults of Common Green Darner were seen on 14 and 28 July, indicating that this species is breeding successfully at the park; in contrast, only patrolling males were ever reported at Brookside. Teneral adults of Variegated Meadowhawk were observed across a longer period (9 July - 26 August), with a large emergence occurring around mid-to late August. Although large numbers of Variegated Meadowhawks were seen at Westmoreland Park on 26-28 August, this species was found again on only one of the seven survey dates afterwards. This behavior is consistent with reported late-season emergences of adults in the northern part of this species' range, and these young adults soon disappear, presumably migrating to the south (Paulson, 2009). Variegated Meadowhawks were observed on only two survey dates at Brookside, suggesting that this habitat is less suitable. Black Saddlebags were seen

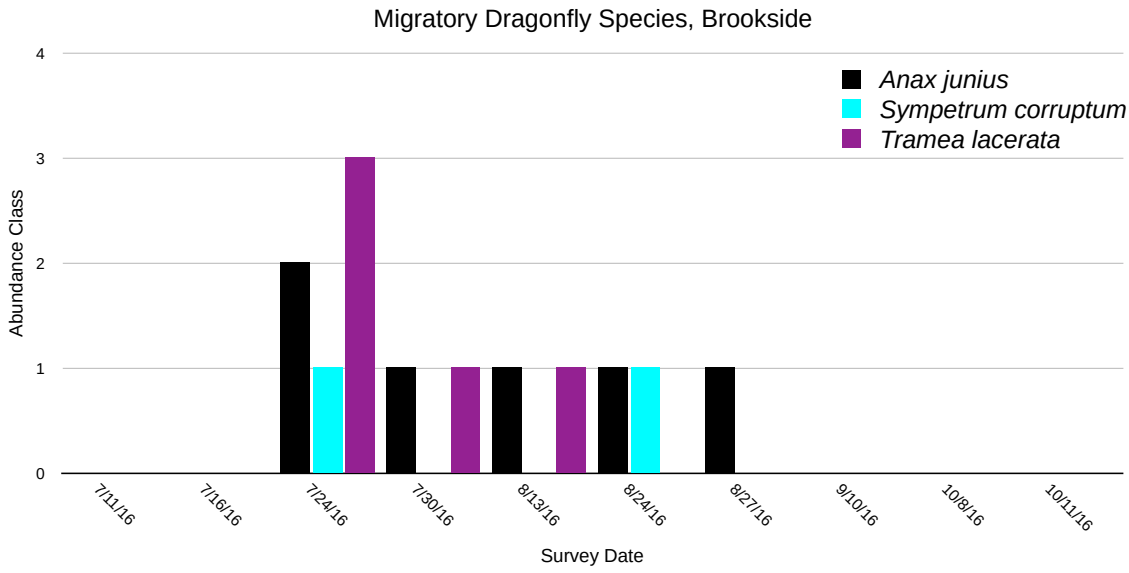
mating at both parks and were abundant at Brookside in late July, but no egg-laying or teneral adults were reported, suggesting that this species is breeding at other sites in the area.

Figure 2. Migratory species at Westmoreland (A) and Brookside (B) Parks. Abundances categories: 1 (uncommon, 1-4 individuals); 2 (frequent, 5-20 individuals); 3 (common, 21-100 individuals); 4 (abundant, >100 individuals)

A. Westmoreland Park



B. Brookside Park



New Records

In 2015, 38 species of odonates were known from Multnomah County (Abbott, 2006-2016). That species list has increased as a result of this project, with the first report of Autumn Meadowhawk (*Sympetrum vicinum*) for the county (Figure 3A). In addition, a report of a Black Meadowhawk (*S. danae*), which was accompanied by a photo, provided the the first vouchered, dated, and geo-referenced record for the county (Figure 3B). Interestingly, this species, whose range in Oregon is east of the Willamette Valley, is not expected at low-elevation sites, but was reported on the same date at a wetland in Magnuson Park in Seattle, WA (Dennis Paulson, pers. comm.). In addition, because CASM Environmental conducted surveys early in the year in order to capture the 1st flight dates of the season, a new early-season flight date was recorded for Twelve-spotted Skimmer (*Libellula pulchella*) in Oregon (Figure 4). These photos and records were entered into the OdonataCentral database, which collates records for odonate species in the New World (www.odonatacentral.org).

Figure 3. New Records for Multnomah County

A. Autumn Meadowhawk (Sympetrum vicinum); B. Black Meadowhawk (S. danae). Photos by Phil Nosler

Figure 4. Twelve-spotted Skimmer, new early flight date for OR (12 May 2016). Photo by C.A. Searles Mazzacano

QA/QC

Volunteer feedback included: requests for more extensive training on using iNaturalist; more communication and interaction between volunteers throughout the season; a mid-season season meeting at a park to socialize and receive refresher field training; a quick family-level field guide to help volunteers narrow down their initial identifications; greater flexibility in scheduling survey dates, with volunteers communicating more among themselves and less through JCWC staff; and dividing the field season into early and late sessions with separate scheduling. Overall, volunteers expressed satisfaction with the project and the resource materials and excitement about odonates, and several were willing to participate in future years and act as mentors to incoming volunteers.

Discussion

This project launched a new volunteer-based research initiative for the Johnson Creek Watershed Council to learn more about wetlands and changes in invertebrate biodiversity in response to changes in season, habitat, and climate conditions. Citizen science projects for survey and monitoring have been established for decades in the birding world (i.e., e-Bird, Backyard Bird Count; see Bonney et al., 2009), but there are far fewer long-term citizen science projects in the insect world (i.e. Abbott & Broglie, 2005 [Odonata]; Ries & Oberhauser, 2015 [Monarch butterflies]). Community-based science can be a powerful tool to increase pubic engagement and eduction, and to promote the idea of urban areas as important places for preserving habitats, biodiversity, and ecosystem services (Cooper et al., 2007; Cohn, 2008). Changes in behavior as a result of participation in a citizen science program do not always follow automatically, however (Jordan et al., 2011; Bela et al., 2012; Stepenuck & Green, 2015), and community-gathered research data has been criticized by some as being too prone to error to be reliable (Frietag et al., 2016). However, volunteer-collected data can be of high quality when the project uses clear, standardized protocols and accessible educational materials (Cohn, 2008; Bonney et al., 2009; Frietag et al., 2016). Guidance and training provided by a content-matter expert who also oversees the data to verify records and flag any rare or unexpected records for further investigation are also critical to obtaining accurate data. Adaptive management informed by volunteer feedback and input in how research is done further increases engagement and learning (Jordan et al., 2016). This project incorporated published elements of successful citizen-science programs, with positive results in volunteer engagement and data collection.

Community-based Science

Almost all of the odonate monitoring volunteers rated themselves as having little to no experience with dragonflies prior to the project, although two individuals had been “dragonflyers” for years. Volunteers expressed overall satisfaction with and engagement in the project, and while several expressed a desire to improve their field identification skills, most also said they had learned a great deal about odonates during the project. Several became active in regional odonate Facebook groups and engaged in odonate-hunting in other places. Many seemed eager to continue with the project, including being willing to act as mentors for new volunteers. The main

frustrations voiced at the end of the season included the long duration of the dragonfly season, lack of confidence in their identification skills, problems entering data into the iNaturalist project site, and a desire for more independent communication and coordination among the volunteers. To address these concerns, the following changes are planned for future years:

- separating the season into early and late portions, with a different set of volunteers for each
- extending the training sessions to include time for social interaction among volunteers ("meet and greet")
- developing a quick, pocket-sized field guide to identify odonates to family
- holding a mid-season field event to provide time for social interaction and a refresher training in survey and identification techniques
- expanding training how to enter data in iNaturalist from both the desktop and mobile platform
- exploring list serve, Facebook group, and GoogleDrive options for increasing communication and independent coordination among volunteers

Data Collection and Findings

Insect populations often vary substantially on an annual basis, and long-term monitoring at dedicated sites is needed to detect trends relating to changes in habitat and climate conditions. In 2015, CASM Environmental began regular surveys of odonates at Westmoreland Park to monitor changes in odonate populations following extensive restoration of Crystal Springs Creek (Searles Mazzacano, 2015). Odonate diversity following restoration of Crystal Springs Creek at Westmoreland Park increased about four-fold over that seen in previous years (Searles Mazzacano, 2015), with 16 species see on the wing in 2015. The beginning of the odonate season was virtually the same in both years, with our first resident species Pacific Forktail (*Ischnura cervula*) seen on the wing on 26 May 2015 and 29 May 2016. In contrast, while the onset of continuous rains ended the 2015 flight season in early October, the mild fall weather in 2016 kept dragonflies on the wing at Westmoreland until early November 2016, despite days with substantial rain.

The first migratory species returned to Westmoreland Park in April in 2015, with mature adult Variegated Meadowhawks seen on 9 April, and both Variegated Meadowhawks and Common Green Darners present on 20 April 2015. In contrast, while Variegated Meadowhawks returned to the park on virtually the same day in 2016 (8 April), Common Green Darners arrived a month later (24 May 2016). It is possible that in the West, Common Green Darners overwinter farther south than Variegated Meadowhawks, as there are frequent reports of the latter species but not the former during the winter months in California. If overwintering Common Green Darners have a longer distance to fly before reaching northern Oregon in the spring, their flight dates and distances may be more impacted by different regional weather conditions, but there is not enough data currently from local sites to know whether arrival of the first north-bound migrants occurs within a compressed or extended time span.

Diversity at Westmoreland increased again from 2015 to 2016, with seven species reported in 2016 that had not been seen the previous year: Black Meadowhawk (*Sympetrum danae)*, Autumn Meadowhawk (*S. vicinum*), Four-spotted Skimmer (*Libellula quadrimaculata*), Widow Skimmer (*L. luctuosa*), Blue Dasher (*Pachydiplax longipennis*), Shadow Darner (*Aeshna umbrosa*), and Vivid Dancer (*Argia vivida*). The species composition at Brookside Park was similar, with 18 of the 22 species seen at Westmoreland. However, two species that were present at Westmoreland in 2015 were not seen in 2016: Striped Meadowhawk (*Sympetrum pallipes*) and Northern Bluet (*Enallagma annexum*), and these species were also not observed at Brookside in 2016.

Although odonate diversity at the two parks was similar, these habitats differ in several respects. Both are wetland/stream complexes in a highly urban setting, but Crystal Springs Creek is a small (2.7 mile), narrow, slow-flowing, low-gradient stream, which underwent substantial restoration at Westmoreland in 2014. The stream has gravel substrate in some reaches, but is heavily sedimented throughout much of the park. The wetlands adjacent to the stream are thickly vegetated throughout, mostly with native plants, and were perennial in 2015 but dried down completely for a few weeks in May 2016. The wetland area was also much expanded for most of the summer and fall in 2016, due to re-routing of the stream immediately upstream of the park at SE Bybee Blvd. done as part of a culvert replacement project. Johnson Creek is larger than Crystal Springs (26 miles), with a wider channel, more gravel-cobble substrate, and faster flow, although the flow is affected by beaver dams at Brookside. The perennial wetlands at Brookside were restored several years prior to those at Westmoreland (1997), and are characterized by more open water with muddy substrate and fringing vegetation with a high proportion of reed canary grass. Both sites have fish in the stream and wetlands and are frequented by waterfowl.

Habitat differences may be reflected by the differences in relative abundances for some species between these sites. For example, odonate abundances at Westmoreland were dominated throughout the summer by Pacific Forktail (*Ischnura cervula*) and Tule Bluet (*Enallagma carunculatum*) damselflies, which were often seen at numbers too great to be counted, while these species occurred at lower abundance at Brookside. Both of these species are often found in large numbers in thickly vegetated slow-water habitats, which is more characteristic of the Westmoreland wetlands. In contrast, Blue-eyed Darner (*Rhionaeschna multicolor*), which prefers open marshy lakes, was more abundant throughout the season at Brookside. Detailed comparisons are premature with only one year of data from both sites, but it will be interesting to see if differences in diversity and abundances persist between these two sites, and whether the community at Westmoreland will change again in 2017, when the wetlands return to their usual extent now that the Bybee culvert replacement is completed.

In any community-based science project, there is always the question of data quality. In this project, volunteers were encouraged to submit photo vouchers of all species reported for each date, but many records are sight observations only, which require the data to be accepted with a degree of faith. However, species identifications made by volunteers from photos was usually correct, and the crowd-sourcing aspect of identification on iNaturalist, combined with CASM Environmental overview of photo records, provided additional quality control.

Fortunately, all reports relating to new species and flight dates were accompanied by at least one photo at the site. In addition, the surveys conducted by CASM Environmental at both sites during different parts of the flight season had results similar to the volunteer surveys. Thus, the data from these surveys can be accepted with a high degree of confidence. We can continue to ensure accurate data in years to come through ongoing oversight by subject matter experts and classroom training and field sessions for volunteers, combined with a strong push from project organizers to submit photo- or video-vouchered records whenever possible. This pilot project demonstrates that the use of proven techniques in community-based science, including clear standardized protocols, training and oversight by subject matter experts, and encouraging volunteer feedback for adaptive management, enables collection of new data about an understudied but charismatic group that is helping to expand our knowledge of local biodiversity, impacts of site restoration on local biota, and effects of climate change on local life-history of both resident and migratory dragonfly species.

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Appendix A. JCWC Dragonfly and Damselfly Community-based Monitoring Project Datasheet

DATE _____ **SITE NAME** _____ **START TIME** _____ **END TIME** _____

OBSERVER NAME(S) _____

WEATHER: Temperature _____ ºC / ºF Wind (calm, light, moderate, strong) % cloud cover _____

NOTES _____

_____

Species List: Record the species observed; circle 'M' and/or 'F' to indicate whether males or females were seen. Record abundance category and all ID methods and reproductive stages observed using the appropriate letter codes.

Identification method
(record all that apply)

V (visual)
C (captured)
P (photograph)

Abundance category

N (none, 0)
U (uncommon, 1-4)
F (frequent, 5-20)
C (common, 21-100)
A (abundant, >100)

Reproductive stage
(record all that apply)

W (wheel)
TP (tandem pair)
O (ovipositing)
TA (teneral adult)

Species Name	ID Method	Abundance	Reproductive stages
M F			
M F			
M F			
M F			
M F			
M F			
M F			