Final Report, Chapter 1:
Odonata Surveys in Pools 5A–10 of the Upper Mississippi River, 2013–2018

Photograph of a common whitetail (*Plathemis lydia*) by Daniel Jackson.

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Abstract

Surveys of Odonata (dragonflies [Infraorder Anisoptera] and damselflies [Infraorder Zygoptera]) were conducted along the Upper Mississippi River during 2013–2018. Surveys occurred on the Upper Mississippi River National Wildlife Refuge (Upper Mississippi River NWFR), the Trempealeau National Wildlife Refuge (Trempealeau NWR), and adjacent non-refuge locations near the refuges. The surveys consisted of point inventories, with locations based on convenience or opportunistic sampling by foot, vehicle, and boat throughout the pools. Odonates were identified by sight when free-flying or resting, after being captured with a net and subsequently released, by taking photographs and later referring to identification guides, and by collection of specimens, with later reference to identification guides or shipping specimens to taxonomic experts.

Data on all Odonate observations and a field season report were submitted annually to the Upper Mississippi River NWFR. Annual survey data files were combined into a single, comprehensive database that can be queried, filtered, and used to assess species composition, relative abundance, and other metrics across a large geographic region of the Upper Mississippi River. Future observational records of Odonates collected in a manner that replicates or approximates the methodology used by Jackson can be added to the single comprehensive database created during this project.

While survey effort (hours) was not recorded in 2013, nearly 450 hours were expended observing Odonates during 2014–2018. Effort was relatively constant across years with an average of 87.2 hours per year. Cumulative effort observing Odonates was greatest in Pools 7 (142.6 hours and 32.7% of total effort) and 8 (119 hours and 27.3% of total effort). Slightly more than half (50.9%) of all effort was expended in La Crosse County, Wisconsin (221.9 hours).

There were 31,159 individual Odonates observed during the 6 years of surveys (2013–2018), representing 62 species. The tule bluet (*Enallagma carunculatum)* was the species observed most often (n=6,487 individuals observed, 20.8% of all observations), followed by eastern forktail (*Ischnure verticalis*, n=5,408, 17.4%) and orange bluet (*Enallagma signatum*, n=4,455, 14.3%). The black-tipped darner (*Aeshna tuberculifera*), azure bluet (*Enallagma aspersum*), citrine forktail (*Ischnura hastata*), fragile forktail (*Ischnura posita*), northern spreadwing (*Lestes disjunctus*), Williamson's emerald (*Somatochlora williamsoni*), and cherry-faced meadowhawk (*Sympetrum internum*) were each observed only once during the survey. The total number of Odonates observed was highest in 2017 (6,137 individuals observed) followed by 2014 (5,904 individuals observed). Across 2013–2018, the greatest cumulative number of Odonates were observed in July (n=11,726 individuals observed, 37.6% of all individuals observed) and August (n=9,342, 30%). The cumulative number of Odonates observed in July and August may reflect in part the greater amount of effort (hours) expended conducting surveys during those months relative to other months.

Keywords: Anisoptera, citizen science, damselfly, dragonfly, occurrence, survey effort, Zygoptera

Introduction

With limited staff and resources, many state and federal agencies have difficulty conducting field work to adequately inventory and monitor wildlife populations. Volunteers from the public, often referred to as citizen scientists, have assisted agencies in collecting data on a wide range of environmental variables, including water quality, invasive species, as well as the occurrence, abundance, and behavior of wildlife (Silvertown 2009, Dickinson et al. 2010). The U.S. Fish and Wildlife Service (USFWS) has utilized and encourages the collection of citizen scientist data (U.S. Fish and Wildlife Service undated, Ruiz-Gutierrez et al. 2021).

The Order Odonata includes two Infraorders, Anisoptera (dragonflies) and Zygoptera (damselflies), that are commonly seen in terrestrial and aquatic habitats associated with the Upper Mississippi River. Despite many species of Odonata being seemingly abundant, as well as colorful and easily recognized, relatively little is known about their distribution and abundance, compared to other species of wildlife such as birds, mammals, and fish. However, contributions of observational records to various databases by individuals and organizations has increased the body of knowledge concerning Odonata, such that 471 species of Odonata have been documented in North America (Paulson and Dunkle 2021) and 5,912 species of Odonata have been documented worldwide (van Tol 2021). Within Wisconsin, 165 species of Odonates have been documented, many of them through the efforts of citizen scientists (Wisconsin Odonata Survey undated-a; data query of the Wisconsin Odonata Survey database conducted by Jackson in June of 2021). The Wisconsin Dragonfly Society (undated) reported that, since 2002, 5,400 site visits in Wisconsin had been conducted by more than 170 citizen scientists, generating more than 30,000 new Odonate records for the state.

For our project, Daniel Jackson (hereafter Jackson) conducted surveys of Odonates in Pools 5A–10 of the Upper Mississippi River during 2013–2018 as a volunteer for the Upper Mississippi River National Wildlife Fish Refuge (hereafter Upper Mississippi River NWFR) and Trempealeau National Wildlife Refuge (hereafter Trempealeau NWR). Jackson's experience observing and identifying Odonata began in 2009 and he contributed thousands of records to Odonata Central (2020), the Wisconsin Odonata Survey (undated-a), and the Minnesota Dragonfly Society (undated). In addition, he collected and reared Odonate nymphs for the Wisconsin Department of Natural Resources (WDNR) and collected specimens for the Migratory Dragonfly Partnership (2016). Finally, Jackson has reviewed thousands of records and vetted Odonate voucher specimens for Odonata Central (2020), the Wisconsin Odonata Survey (undated-a), and BugGuide.net (undated).

The objectives of our project were to: 1) construct a single comprehensive and functional database of Odonate observation records collected by Jackson during 2013–2018; 2) quantify and characterize the effort expended during the Odonata surveys; 3) calculate summary descriptive statistics of the Odonata communities that were surveyed; and 4) highlight the conservation status of the Odonata species recorded during the surveys.

Methods

Survey Area

The Upper Mississippi River NWFR was established by an act of Congress in 1924 and encompasses more than 244,000 acres (98,743 ha) along a 261-mile (420-km) stretch of the Upper Mississippi River, associated with Navigation Pools 4–14 and the states of Minnesota, Wisconsin, Iowa, and Illinois (Figure 1; U.S. Fish and Wildlife Service 2006, U.S. Fish and Wildlife Service 2019b). The navigation pools are impoundments created by a system of locks and dams, constructed in the 1930s to facilitate navigation. Each pool is numbered in a manner corresponding to the number of the lock and dam that impounds the water in that pool (U.S. Fish and Wildlife Service 2006). Land cover classifications of mapped vegetation communities (i.e., habitats) of the Upper Mississippi River NWFR include open water, submersed aquatic vegetation, deep marsh shrub, shallow marsh shrub, deep marsh annual, deep marsh perennial, rooted floating leaved aquatics, shallow marsh annual, shallow marsh perennial, wet meadow shrub, wet meadow, sedge meadow, lowland forest, floodplain forest, *Salix* community, *Populus* community, and grasslands (Dieck et al. 2015, U.S. Fish and Wildlife Service 2019b). The Upper Mississippi River NWFR is administered by 4 district offices, and one headquarters office. Each of the 4 districts has an area of operations corresponding to a set of navigation pools (Figure 1). The Winona District occurs along river miles 763.5 through 714.5 in Pools 4 through 6, the La Crosse District occurs along river miles 714.5 through 679.5 in Pools 7 through 8, the McGregor District occurs along river miles 679.5 through 583.1 in Pools 9 through 11, and the Savanna District occurs along river miles 583.1 through 502.7 in Pools 12 through 14.

Trempealeau NWR was established by an executive order in 1936 and currently encompasses 6,808 acres (2,755 acres) in Buffalo and Trempealeau Counties, Wisconsin, directly adjacent to Navigation Pool 6 (Figure 2; U.S. Fish and Wildlife Service 2008, 2019a). Land cover classifications of mapped vegetation communities at Trempealeau NWR include open water, submersed aquatic vegetation, deep marsh shrub, shallow marsh shrub, deep marsh annual, deep marsh perennial, rooted floating leaved aquatics, shallow marsh perennial, wet meadow shrub, wet meadow, lowland forest, floodplain forest, *Salix* community, *Populus* community, and grassland (Dieck et al. 2015, U.S. Fish and Wildlife Service 2019a).

The Upper Mississippi River NWFR and Trempealeau NWR are within a region characterized by a sub-humid continental climate, with moist, warm summers and dry, cold winters (U.S. Fish and Wildlife Service 2006). Available (2000–2018) climate data for the La Crosse area (NOWData undated) indicated an average annual temperature for the region of 45.6° F (7.6° C), an average maximum temperature of 91° F (32.8° C), and an average minimum temperature of -16° F (-26.7° C). The hottest month tended to be July with an average temperature of 71° F (21.7° C) and an average high temperature of 89° F (31.7° C). The coldest month tended to be January with an average temperature of 16.8° F (8.4° C) and an average low temperature of -12° F (-24.4° C). The average last date when the temperature was ≤32° F (0° C) was April 26 but ranged between April 9 (2006) and May 15 (2016). The average first date when the temperature was ≤32° F (0° C) was October 14 and ranged between September 23 (2012) and November 9 (2016).

Available Mississippi River streamflow data from the U.S. Geological Survey gage at Winona, Minnesota (Gage 05378500 in Pool 6; U.S. Geological Survey undated) indicate multiple periods of high water (gage height in feet; Figure 3) and high discharge (cubic feet per second; Figure 4) during 2013–2018, particularly in 2013, 2014, 2017, and 2018. Additional streamflow data available from the U.S. Geological Survey gage at McGregor, Iowa, (Gage 05389500 in Pool 10; U.S. Geological Survey undated) indicate similar periods of high water levels across the years surveys were conducted (Figure 5; discharge data not available for comparable years at Gage 05389500).

Data Collection

Nearly all Odonata observations were made by Jackson, during the months of April through November 2013–2018. One other observer, D. Severson, assisted Jackson on 2 days in 2013. Surveys consisted of point inventories, with locations based on convenience or opportunity, and sampling was done by foot, vehicle, and boat. Survey locations were not chosen based on a predetermined study design but were chosen based on Jackson's familiarity with different areas of the Upper Mississippi River, his interest in visiting different locations, and the proximity of locations to his residence and place of employment, as well as ease of access. Surveys were conducted in or near Pools 5A–10 of the Upper Mississippi River, on the Upper Mississippi River NWFR, Trempealeau NWR, and some adjacent non-refuge lands and waters (see Figure 6 for a depiction of the two refuges within the broader region encompassed by Pools 5A–10). Surveys were conducted on refuge lands and waters under several Special Use Permits issued by the Upper Mississippi River NWFR (#32579-13-001, #32579-14-003, #32579-15-002, #32579-16-001, #32579-17-003, and #32579-18-006).

Odonates were identified by sight while they were flying or perched, but sometimes a net was used to collect individuals, or photographs were taken to facilitate identification in the hand or later, on a computer screen. Occasionally, voucher specimens were collected for later examination under a microscope. Identification resources used included Legler and Legler (1998), Lam (2004), Mead (2009), Paulson (2011), and DuBois and Reese (2019). When necessary, photos or voucher specimens were sent to R. DuBois (Aquatic Biologist - retired, WDNR) for assistance with identification. Voucher specimens were provided to the WDNR for accession in their collection of reference specimens. The great majority of individuals recorded during the surveys were Odonates (94%), but occasionally individuals in other taxa were recorded as well (Arthropoda, Coleoptera, Diptera, Hemiptera, Lepidoptera, Hymenoptera, Myrmeleontidae, and Orthoptera). Whereas all Odonates encountered during surveys were recorded, non-Odonates were recorded in an opportunistic and limited manner, constraining the utility of the non-Odonate data.

Data Entry and Comprehensive Database Construction

During each field season, Odonate observations were entered into a MS Excel spreadsheet by Jackson. Upon completion of each field season, the MS Excel spreadsheet and a field season report were submitted by Jackson to the Upper Mississippi River NWFR (Jackson 2013, 2014, 2015, 2016, 2017, 2018).

Individual MS Excel spreadsheets for each field season were combined into a single comprehensive spreadsheet (database) by M. Griffin and provided to S. Hygnstrom at the

University of Wisconsin Stevens Point in June 2019. After that, J. Kerkhoff, in cooperation with S. Winter, conducted a review of the comprehensive database to assess accuracy of data entries and to make modifications as necessary to correct data entry errors or ambiguities. The comprehensive database contains fields (columns) replicating many of the fields in the six original MS Excel field season spreadsheets submitted by Jackson, but several new fields were added to enhance utility of the final comprehensive database. An activity log was maintained that captured all actions taken during construction and modification of the final comprehensive database. Fields contained in the final comprehensive database, and a short description of each field, are as follows:

Original File Name: The name of the original MS Excel field season spreadsheet file.

Original-rec-order: The original order of observation records (rows) in original MS Excel field season spreadsheets.

Original_Date: The date of the observation as recorded in the original MS Excel field season spreadsheet. The date format varies across the individual field season spreadsheets.

Year: The year of the original observation record.

Month: The month of the original observation record.

Day: The day of the original observation record.

Date Code: An eight-digit code (YYYYMMDD) for the date of the original observation record, based on Original_Date.

Higher Taxonomic Rank: A higher taxonomic rank than "Group".

Group: For Odonata, the taxonomic group of the observed individual(s) that was recorded. Recording of Group began in 2014.

Species: The scientific name of the individual(s) observed.

Common Name: A common name for the observed individual(s).

Stage: The most advanced life stage of the species identified in the original observation record.

Adult = Flying adult that has attained mating coloration.
Juvenile = Recently emerged and without mating adult coloration.
Teneral = Just emerged with glassy wings and soft body.
Exuviae = Molted nymph skin left behind after emergence.
Nymph = Non-adult form in life cycle.

Number: The number of individuals of the identified species that were observed.

Refuge: The national wildlife refuge associated with the survey site in the original observation record.

TNWR = recorded while at or adjacent to the Trempealeau National Wildlife Refuge.
UMRNWFR = recorded while at or adjacent to the Upper Mississippi River National Wildlife and Fish Refuge.
UMRNWFR+TNWR = recorded during a survey event and/or location that was at or near the boundary between the two refuges.

Pool: The Mississippi River navigation pool associated with the location of the observation. To facilitate filtering, sorting, and the use of pivot tables in MS Excel, Pool 5A is recorded as Pool 5.5. Some survey events occurred at the boundary of pools, such as on the dam or spillway between Pools 7 and 8. These are recorded in this database as 7.5 to facilitate the use of filtering, sorting and the use of pivot tables in MS Excel.

Adjacent: Indicates whether an observation was made on a property adjacent to or within the boundaries of a refuge.

Yes (Y) = the observation was adjacent to a refuge.
No (N) = the observation was within a refuge.

Distance: If an observation was made on a property adjacent to a refuge, the approximate distance, recorded in meters, between the location of the observation and the refuge boundary.

State: The state (Minnesota or Wisconsin) in which the observation occurred.

County: The county (e.g., Trempealeau, La Crosse, Vernon) in which the observation occurred.

Coordinate Source: The hardware or software used to determine the geographic coordinates of the observation location.

Latitude: The latitude coordinate associated with the observation location.

Longitude: The longitude coordinate associated with the observation location.

Location_1: A description of the observation location (e.g., park, trail, landing, spillway). Some observation records have the same latitude or longitude but have a different entry for Location_1 or Location_2. Examples include when observations were made at several locations along a trail, but the latitude and longitude was recorded for only the most central location.

Location_2: Additional descriptive information about the observation location (e.g., along trail, at boat landing). Note - only 73 records with Location_2 information are in the database.

Habitat: A description of the habitat at the observation location (e.g., developed areas, open water, floodplain forest).

Comments: A description of the behavior (e.g., perching, flying, patrolling), sex-age class (e.g., male, female, juvenile, adult), or relative number (2, 15, few, several) of individuals associated with the observation record.

Species_Identification_Method: Indicates whether identification was based on a visual observation (O), collection of a specimen (C), with a photograph (P), or by netting and then releasing (N).

Photo ID: The file name of a digital image taken of an individual associated with the observation.

Repository: The facility to which collected individuals were submitted for confirmation and cataloging (e.g., WDNR Collection, Superior, Wisconsin).

Observer: The person who made the observation. DJ = Daniel Jackson; DS = Donald Severson

Effort: The number of hours expended during a survey event. Note that some observation records have the same latitude or longitude but have a different entry for Location_1. Examples include when observations were made at several locations along a trail, but the latitude and longitude was recorded for only the most central location. During surveys, hours of effort were recorded for the time spent at individual discrete locations (indicated by a unique lat/long combination, and/or a unique Location_1). Only one entry for hours of effort was made in the original MS Excel spreadsheets for an individual discrete location, even though several observations may have been made at the location. Hence, several observation records from a single discrete survey location on a single survey day may not have any hours of effort recorded, but there should be at least one observation record from that discrete survey location that does have an entry for hours of effort.

Note - there are seven entries where the hours of effort is recorded as 0.

There also are instances of more than one entry for hours of effort for multiple observation records that have identical date, lat/long, and Location_1 entries. This can be from instances when the observer visited the same exact location during different parts of the day, such as in the morning before work and again in the evening after work.

The final comprehensive database is available in the USFWS ServCat, a secure, centralized web application that compiles, organizes, and archives biological information such as reports, databases, and geospatial data: https://ecos.fws.gov/ServCat/Reference/Profile/116720. This report refers to the database with a filename *UMRNWFR_OdonateSurveysDanJackson_2013-2018_v20210809.xlsx* in ServCat, but data collected in subsequent years will be added to the

database and saved as a new version. Filenames of subsequent versions will be modified to reflect the most recent year of data within the database, as well as the las date when the database was edited. Prior versions of the database will be retained so they can be referred to if needed.

We assessed components of the data using pivot tables in MS Excel spreadsheets. We calculated summary descriptive statistics about the amount of effort expended conducting the surveys and the locations where effort was expended. We also calculated summary descriptive statistics about the number of Odonates observed during surveys, including the number of select species of Odonates.

Results

Surveys were conducted during 342 days across the 6 years (2013–2018). The mean number of survey days per year was 57 and varied between 45 days in 2013 and 75 days in 2018. The mean number of survey days per month was 7.4 and varied between 1 day in a month (March 2017) and 14 days in a month (August 2018). Surveys occurred most frequently in August (67 total survey days across the 6 years), followed by July, September, June, May, October, April, November, and March (63, 53, 47, 38, 34, 27, 12, and 1 total survey days, respectively). The first survey of a given year occurred between March 28 and April 28, depending upon weather and flooding in spring. The last survey of a given year occurred between October 17 and November 18, depending upon weather, especially the first dates when temperatures were ≤32° F (0° C). The duration of the period each year in which surveys were conducted varied from 172 days (2013) to 218 days (2016), and the average duration across all years was 198 days.

Sampling effort (hours) was not recorded in 2013 but during 2014–2018 a total of 435.9 hours were expended conducting surveys, of which 98% of the sampling effort was expended in the state of Wisconsin. The mean amount of effort expended per year during 2014–2018 was 87.2 hours and varied between 79.8 hours expended in 2015 and 93.9 hours expended in 2018 (Figure 6). Across 2014–2018, the cumulative amount of effort expended was greatest for the month of August (95.5 total hours) followed by July, September, June, May, October, April, November, and March (94.5, 70.0, 54.5, 43.8, 34.8, 26.4, 15.5, and 1.0 total hours per month, respectively).

Of the 8 counties where surveys occurred, most effort was expended in La Crosse County, Wisconsin (221.9 hours, 51% of total effort; see Figure 7 results and Figure 1 for a depiction of where the counties are located), followed by Vernon County, Wisconsin (131 hours, 30% of total effort). Effort expended in the other counties was much less, including: 29.8 hours in Grant County, Wisconsin (7% of total effort); 26.8 hours in Trempealeau County, Wisconsin (6%); 9.5 hours in Crawford County, Wisconsin (2%); 8 hours in Buffalo County, Wisconsin (2%); 5 hours in Houston County, Minnesota (1%); and 4 hours in Winona County, Minnesota (1% of total effort; see Figure 7).

Expended effort was highest in Pool 7 (142.6 hours, 33% of total effort) and Pool 8 (119 hours, 27% of total effort). Additionally, 55.8 hours of effort (13% of total effort) were expended on the dam between Pools 7 and 8, and 1 hour of effort was expended on the dam between Pools 8 and 9 (<1% of total effort). Effort expended in the other pools was 51 hours in Pool 9 (12% of effort), 34.3 hours in Pool 10 (8% of total effort), 27.3 hours in Pool 6 (6%), and 5 hours in Pool

5A (1% of total effort). When the Location_1 field in the comprehensive database was used to quantify effort expended at individual discrete survey locations, the mean number of hours expended at individual discrete survey locations during 2014–2018 was 1.1.

During the 6 years of surveys, 3,671 unique observations were recorded of all taxa that were encountered during survey efforts and 80% of these observations were of Odonates (n=2,944; a unique observation was an observation with a unique combination of date and latitude/longitude coordinates). A total of 33,172 individuals were observed, of which 94% were Odonates (n=31,159). Ninety-nine percent of the individual Odonates observed (30,889) were adults, while 235 were juveniles (0.75%), 19 were tenerals (0.06%), 15 were nymphs (0.05%), and 1 exuvia was observed (<0.01%).

A total of 62 species of Odonata were observed (Table 1); 40 species were dragonflies (Infraorder Anisoptera; 40.9% of all Odonates observed) and 22 were damselflies (Infraorder Zygoptera; 59.1% of all Odonates observed). There were 10 records in which dragonflies in the genus *Aeshna* were observed but not identified to species, and 1 instance in which dragonflies in the genus *Gomphurus* were observed but not identified to species. These instances were not included in calculations of the number of species observed across the 6 years of surveys.

The earliest observation of an Odonate was on April 8, 2017, and the three species recorded in April across all years (Figure 8) were common green darner (Anisoptera, *Anax junius*), eastern forktail (Zygoptera, *Ischnura verticalis*), and variegated meadowhawk (Anispotera, *Sympetrum corruptum*). Across all survey years, 265 individual Odonates were observed during April. Across all years, 1,183 individual Odonates representing 18 species were observed during May, while surveys in June resulted in 5,106 individuals representing 41 species. July was the month when the greatest cumulative number of individual Odonates were observed, with 11,726 individuals represented by 47 species, and August surveys resulted in 9,342 individuals representing 45 species. A cumulative total of 3,005 individuals were observed during September surveys (32 species), 396 individuals were observed in October surveys (19 species), and 136 individuals were observed in November surveys (1 species; see Figure 8). The latest observation of an Odonate was on November 18th, 2016, and the only species observed during November surveys was autumn meadowhawk (Anisoptera, *Sympetrum vicinum*).

The tule bluet (Zygoptera, *Enallagma carunculatum*) was the most frequently observed Odonate (n=6,487 individuals observed, 21.0% of all individuals observed; see Table 1 for the number of individuals observed for each species). This was closely followed by the eastern forktail (n=5,408, 17.4%) and orange bluet (Zygoptera, *Enallagma signatum*; n=4,455, 14.3%; Table 1). The 10 Odonate species most frequently observed included the three species previously mentioned as well as the common green darner (3,494, 11.2%), eastern pondhawk (Anisoptera, *Erythemis simplicicollis*; 1,533, 4.9%), eastern amberwing (Anisoptera, *Perithemis tenera*; 1,183, 3.8%), black saddlebags (Anisoptera, *Tramea lacerata*; 1,045, 3.4%), autumn meadowhawk (1,006, 3.2%), blue dasher (Anisoptera, *Pachydiplax longipennis*; 751, 2.4%), and russet-tipped clubtail (Anisoptera, *Stylurus plagiatus*; 537 individuals observed, 1.7% of all individuals observed).

For 58% of the Odonate species observed (n= 36 species), fewer than 100 individuals per species were observed across the 6 years of surveys. Odonates that were observed only once were the black-tipped darner (Anisoptera, *Aeshna tuberculifera*), azure bluet (Anisoptera, *Enallagma aspersum*), citrine forktail (Zygoptera, *Ischnura hastata*), fragile forktail (Zygoptera, *Ischnura posita*), northern spreadwing (Zygoptera, *Lestes disjunctus*), Williamson's emerald (Anisoptera, *Somatochlora williamsoni*), and cherry-faced meadowhawk (Anisoptera, *Sympetrum internum*).

Of the 62 species recorded, 61 have been assigned a NatureServe global rank of G5 (*Secure - at very low risk of extinction or elimination due to a very extensive range, abundant populations or occurrences, and little to no concern from declines or threats*; global [G] and state [S] rank definitions are from Appendix A of Master et al. [2012]; see Table 1 of this report for global and state ranks of species observed during the 2013–2018 surveys). The remaining species, elusive clubtail (Anisoptera, *Stylurus notatus*) has been assigned a NatureServe global rank of G3 (*Vulnerable - at moderate risk of extinction or elimination due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors*). In the state of Wisconsin, 37 of the species have been assigned a NatureServe state rank of S5 (*Secure - at very low or no risk of extirpation in the jurisdiction due to a very extensive range, abundant populations or occurrences, with little to no concern from declines or threats*), while 16 species have been assigned a NatureServe state rank of S4 (*Apparently Secure - at a fairly low risk of extirpation in the jurisdiction due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors*). Tree species were observed (jade clubtail [*Arigomphus submedianus*], plains clubtail [*Gomphurus externus*], red saddlebags [*Tramea onusta*], all in the Infraorder Anisoptera) that have been assigned a NatureServe state rank of S3 (*Vulnerable - at moderate risk of extirpation in the jurisdiction due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors*), and 3 other species (royal river cruiser [Anisoptera, Macromia taeniolata], azure bluet, fragile forktail) have been assigned a NatureServe state rank of S2 (*Imperiled - at high risk of extirpation in the jurisdiction due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors*).

The royal river cruiser also has been assigned a state element rank of S2S3 and a state status of SC/N by the Wisconsin Natural Heritage Program (Wisconsin Department of Natural Resources 2021a). A state element rank of S2 indicates the species is "*Imperiled in Wisconsin due to a restricted range, few populations or occurrences, steep declines, severe threats, or other factors*", and a state element rank of S3 indicates a species is "*Vulnerable in Wisconsin due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors*". A state element range rank (i.e., S2S3) is used to indicate a range of uncertainty regarding the rank of a species. A Wisconsin state status of SC/N indicates a Special Concern species with no laws regulating use, possession, or harvesting.

Five species recorded during the surveys are considered "Most Wanted Species" by the Wisconsin Dragonfly Society, including jade clubtail, royal river cruiser, blue-eyed darner (Anisoptera, *Rhionaeschna multicolor*), azure bluet, and citrine forktail (Wisconsin Odonata Survey undated-b). A Most Wanted Species is an Odonate that has been previously documented

in Wisconsin but more information about that species is needed (Wisconsin Odonata Survey undated-b).

There were 17 species for which observations constituted the first instance of that species being recorded in the county where it was observed (data query of the Wisconsin Odonata Survey database conducted by Jackson in June of 2021; Table 2). The counties where first records occurred, and the species observed, are as follows: Houston County, Minnesota – calico pennant (Anisoptera, *Celithemis elisa*), stream bluet (Zygoptera, *Enallagma exsulans*), wandering glider (Anisoptera, *Pantala flavescens*), saffron-winged meadowhawk (Anisoptera, *Sympetrum costiferum*); Buffalo County, Wisconsin – Canada darner (Anisoptera, *Aeshna canadensis*), shadow darner (Anisoptera, *Aeshna umbrosa*), wandering glider (Anisoptera, *Pantela flavescens*); La Crosse County, Wisconsin – Williamson's emerald; Trempealeau County, Wisconsin – Canada darner, cobra clubtail (Anisoptera, *Gomphurus vastus*), ruby meadowhawk (Anisoptera, *Sympetrum rubicundulum*); Vernon County, Wisconsin – black-tipped darner, green-striped darner (Anisoptera, *Aeshna verticalis*), calico pennant, plains clubtail, citrine forktail, and cyrano darner (Anisoptera, *Nasiaeschna pentacantha*).

Discussion

The data described in this report are a substantial contribution to the state of knowledge regarding Odonate communities along the Upper Mississippi River, and exemplifies the high value of citizen science efforts. These Odonate surveys used what could be considered accessibility, convenience, haphazard, or opportunistic sampling, whereby the surveys were conducted without a probability-based sampling design dictating when and where sampling would occur to facilitate appropriate statistical inferences (Anderson 2001, Nusser et al. 2007, Pierce et al. 2012). Opportunistic sampling should be avoided in many monitoring scenarios because it can introduce bias (Pierce et al 2012, Neyens et al. 2019). It is important to note, however, the surveys described in this report were not meant to monitor population abundances, trends through space or time, or to compare data across locations or time periods. They were meant to document the presence of Odonate species along the Upper Mississippi River and data obtained from the surveys are appropriate for compiling a species list of an organismal group, Odonates, for which relatively little baseline information exists. While we limited our assessment of the data to basic descriptive statistics, there is potential to gain further insight into relative abundance of Odonate species if the abundance data were standardized by effort (observations per hour, individuals per hour, etc.). In addition, opportunistically collected data can be used for occupancy modelling and habitat suitability modelling when appropriate analyses are used (Bradter et al. 2017, Dennis et al. 2017, Rapacciuolo et al. 2017, Niemuth et al. 2018, Altwegg and Nichols 2019, Henckel et al 2020).

Reflecting on the opportunistic nature of these Odonate surveys, most survey effort was expended in Pools 7 and 8 which are the closest pools to Jackson's residence and place of employment. The increased effort expended in Pools 7 and 8, relative to the other pools surveyed (Pools 5A, 6, 9, and 10) likely is the primary reason why the number of Odonate species recorded, as well as the number of Odonates observed, was highest in those two pools.

The 62 species of Odonata recorded during these surveys (Table 1) represent 38% of the species documented in Wisconsin (Wisconsin Odonata Survey undated-a; data query of the Wisconsin Odonata Survey database conducted by Jackson in June of 2021). While this represents a notable proportion of what has been previously recorded in Wisconsin, there are likely many species documented in other areas of Wisconsin that are not likely to be found in Upper Mississippi River habitats. Nonetheless, additional surveys on the Upper Mississippi River would be justified to further delineate Odonate communities present there. The species reported in these surveys represent substantial proportions of what has been previously recorded, but the 17 new county records (Table 2) illustrate the need for continued surveillance and monitoring for expanding the body of knowledge concerning Odonata species ranges, both regionally and int the counties bordering the Upper Mississippi River. Jackson has documented other new county records during surveys in this area both before and after the 2013–2018 surveys described in this report.

Most species recorded during the surveys conducted during 2013–2018 were not of conservation concern, but some have been classified by various entities as deserving the attention of conservationists. Three species (jade clubtail, plains clubtail, and red saddlebags) have been assigned a NatureServe state rank of S3 (Vulnerable) for the state of Wisconsin, and another three species (royal river cruiser, azure bluet, and fragile forktail) have been assigned a NatureServe state rank of S2 (Imperiled) for the state of Wisconsin. The State of Wisconsin has assigned a state element range rank of S2S3, and a state status of SCN (Special Concern with no laws regulating use, possession, or harvesting) to one species, the royal river cruiser. The only Odonate protected by the federal Endangered Species Act is the Hine's emerald dragonfly, a species that occurs in Illinois Michigan, Missouri, and Wisconsin (Somatochlora hineana; U.S. Fish and Wildlife Service 2001); Hine’s emerald dragonfly was not observed during the surveys conducted by Jackson and has not been previously documented in the area of Wisconsin where Jackson conducted surveys (U.S. Fish and Wildlife Service 2001).

In summary, the surveys conducted by Jackson during 2013–2018 represent a substantial contribution to the current state of knowledge concerning Odonata occurrence along the Upper Mississippi River and in the Upper Midwest. Additional surveys promise to further increase the state of knowledge about this group of organisms for which relatively little information exists. Toward that end, Jackson has continued to conduct Odonate surveys on the Upper Mississippi River beyond 2018. Well planned and executed citizen science efforts, such as those conducted by Jackson in cooperation with the Upper Mississippi River NWFR and Trempealeau NWR, can play a valuable role in obtaining useful data.

Acknowledgments

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Literature Cited

Altwegg, R and JD Nichols. Occupancy models for citizen-science data. Methods in Ecology and Evolution 10:8–21.

Anderson, DR 2001. The need to get the basics right in wildlife field studies. Wildlife Society Bulletin 29:1294–1297.

Bradter, U, L Mar, M Jönsson, J Knape, A Singer, and T Snäll. 2018. Can opportunistically collected Citizen Science data fill a data gap for habitat suitability models of less common species? Methods in Ecology and Evolution 9:1667–1678.

BugGuide.net. Undated. BugGuide.net Home page. Available: https://bugguide.net/node/view/15740 (June 2021).

Dennis, EB, BJT Morgan, SN Freeman, MS Rideout, TM Brenton, R Fox, GD Powney, and DB Roy. 2017. Efficient occupancy model-fitting for extensive citizen-science data. PLoS ONE 12: e0174433. https://doi.org/10.1371/journal.pone.0174433 (June 2021).

Dickinson, JL, B Zuckerberg, and D Bonter. 2010. Citizen science as an ecological research tool: challenges and benefits. Annual Review of Ecology, Evolution and Systematics 49:149–172.

Dieck, JJ, J Ruhser, EE Hoy, and LR Robinson. 2015. General classification handbook for floodplain vegetation in large river systems (Version 2.0), U.S. Geological Survey Techniques and Methods. La Crosse, Wisconsin. 51 pp. Available: https://pubs.er.usgs.gov/publication/tm2A1 (May 2021).

DuBois, R and M Reese. 2019. Damselflies of Minnesota, Wisconsin, and Michigan. 2nd Edition. Kollath-Stensaas Publishing. Duluth, MN. 154 pp.

Henkel, LU Bradter, M Jönsson, NJ Isaac, and T Snäll. Assessing the usefulness of citizen science data for habitat suitability modelling: Opportunistic reporting versus sampling based on a systematic protocol. Diversity and Distributions 202:1276–1290.

Jackson, DE. 2013. 2013 Survey of Odonata on the Upper Mississippi and Trempealeau National Wildlife Refuges. Unpublished report on file at the Headquarters office of the Upper Mississippi River National Wildlife and Fish Refuge, Winona, Minnesota. 8 pp. Available: https://ecos.fws.gov/ServCat/Reference/Profile/134117 (August 2021).

Jackson, DE. 2014. 2014 Survey of Odonata of the Upper Mississippi and Trempealeau National Wildlife Refuges. Unpublished report on file at the Headquarters office of the Upper Mississippi River National Wildlife and Fish Refuge, Winona, Minnesota. 7 pp. Available: https://ecos.fws.gov/ServCat/Reference/Profile/134117 (August 2021).

Jackson, DE. 2015. 2015 Survey of Odonata of the Upper Mississippi and Trempealeau National Wildlife Refuges. Unpublished report on file at the Headquarters office of the Upper Mississippi

River National Wildlife and Fish Refuge, Winona, Minnesota. 9 pp. Available: https://ecos.fws.gov/ServCat/Reference/Profile/134117 (August 2021).

Jackson, DE. 2016. 2016 Survey of Odonata on the Upper Mississippi and Trempealeau National Wildlife Refuges. Unpublished report on file at the Headquarters office of the Upper Mississippi River National Wildlife and Fish Refuge, Winona, Minnesota. 8 pp. Available: https://ecos.fws.gov/ServCat/Reference/Profile/134117 (August 2021).

Jackson, DE. 2017. 2017 Survey of Odonata on the Upper Mississippi and Trempealeau National Wildlife Refuges. Unpublished report on file at the Headquarters office of the Upper Mississippi River National Wildlife and Fish Refuge, Winona, Minnesota. 10 pp. Available: https://ecos.fws.gov/ServCat/Reference/Profile/134117 (August 2021).

Jackson, DE. 2018. 2018 Survey of Odonata on the Upper Mississippi and Trempealeau National Wildlife Refuges. Unpublished report on file at the Headquarters office of the Upper Mississippi River National Wildlife and Fish Refuge, Winona, Minnesota. 8 pp. Available: https://ecos.fws.gov/ServCat/Reference/Profile/134117 (August 2021).

Lam, E. 2004. Damselflies of the Northeast: A Guide to the Species of Eastern Canada and the Northeastern United States. Biodiversity Books. Forest Hills, New York. 94 pp.

Legler, K, and D Legler. 1998. Color Guide to Common Dragonflies of Wisconsin. Privately published. 62 pp.

Master, LL, D Faber-Langendoen, R Bittman, GA Hammerson, B Heidel, L Ramsay, K Snow, A Teucher, and A Tomaino. 2012. NatureServe Conservation Status Assessments: Factors for Evaluating Species and Ecosystem Risk. NatureServe, Arlington, Virginia. 45 pp + Appendices A–E.

Mead, K. 2009. Dragonflies of the Northwoods, 2nd Edition. Kollath-Stensaas Publishing, Duluth, Minnesota. 214 pp.

Migratory Dragonfly Partnership. 2016. Migratory Dragonfly Partnership Report of Accomplishments 2011 to 2015. Migratory Dragonfly Partnership. Available: http://www.migratorydragonflypartnership.org/uploads/_ROOT/File/MDP_Annual_Report_2016_Final_Websec.pdf (May 2021).

Minnesota Dragonfly Society (undated). Minnesota Dragonfly Society Homepage. Available: http://www.mndragonfly.org/index.html (June 2021).

Neyens, T, PJ Diggle, C Faes, N Beenaerts, T Artois, and E Giorgi. 2019. Mapping species richness using opportunistic samples: a case study on ground-floor bryophyte species richness in the Belgian province of Limburg. Scientific Reports 9(1), 19122. https://doi.org/10.1038/s41598-019-55593-x (June 2021).

Niemuth, ND, AJ Ryba, AT Pearse, SM Kvas, DA Brandt, B Wangler, J. E> Austin, and M. J. Carlisle. 2018. Opportunistically collected data reveal habitat selection by migrating Whooping Cranes in the U.S. Northern Plains. The Condor 120:343–356.

NOWData. Undated. NOWData – NOAA Online Weather Data. Available: https://nowdata.rcc-acis.org/arx/ (June 2021).

Nusser, SM, WR Clark, DL Otis, and L Huang. 2007. Sampling considerations for disease surveillance in wildlife populations. Journal of Wildlife Management 72:52–60.

Odonata Central. undated. Odonata Central Records. https://www.odonatacentral.org/app/#/data/records/?filterqs=%7Cexcludedotmap (June 2021).

Odonata Central. 2020. User Guide. Available https://www.odonatacentral.org/user-guide/#/ (August 2021).

Paulson, D. 2011. Dragonflies and Damselflies of the East. Princeton University Press, Princeton, New Jersey. 576 pp.

Paulson, DR, and SW Dunkle. 2021. A Checklist of North American Odonata Including English Name, Etymology, Type Locality, and Distribution. Originally published as Occasional Paper No. 56, Slater Museum of Natural History, University of Puget Sound, June 1999; Updated February 2021.

Pierce, BL, RR Lopez, and NJ Silvy. 2012. Estimating Animal Abundance. Pages 284–310 in N. J. Silvy, editor. The Wildlife Techniques Manual. The Johns Hopkins University Press, Baltimore, Maryland. 686 pp.

Rapacciuolo, G, JE Ball-Damerow, AR Zeilinger, and VH Resh. Detecting long-term occupancy changes in Californian Odonates from natural history and citizen science records. Biodiversity Conservation 26:2933–2949.

Ruiz-Gutierraz, V, ER Bjerre, MC Otto, GS Zimmerman, BA Milsap, D Fink, EF Stuber, M Strimas-Mackey, OJ Robinson. 2021. A pathway for citizen science data to inform policy: A case study using eBird data for defining low-risk collision areas for wind energy development. Journal of Applied Ecology 58:1104–1111.

Silvertown, J 2009. A new dawn for citizen science. Trends in Ecology and Evolution 24:467–471.

U.S. Fish and Wildlife Service. undated. USFWS Phenology Network – Monitoring phenology on the National Wildlife Refuge System. Available https://fws.usanpn.org/ (June 2021)

U.S. Fish and Wildlife Service. 2001. Hine's Emerald Dragonfly (*Somatochlora hineana* Williamson) Recovery Plan. Fort Snelling, Minnesota. 120 pp.

U.S. Fish and Wildlife Service. 2006. Upper Mississippi River National Wildlife and Fish Refuge Comprehensive Conservation Plan. Fort Snelling, Minnesota. 228 pp. Available: https://www.fws.gov/midwest/planning/uppermiss/ (May 2021).

U.S. Fish and Wildlife Service. 2008. Trempealeau National Wildlife Refuge Comprehensive Conservation Plan. Fort Snelling, Minnesota. 168 pp. Available: https://www.fws.gov/midwest/planning/Trempealeau/index.html (June 2021)

U.S. Fish and Wildlife Service. 2019a. Trempealeau National Wildlife Refuge Habitat Management Plan. U.S. Fish and Wildlife Service. Bloomington, Minnesota. 89 pp + Appendices A–I. Available: https://ecos.fws.gov/ServCat/Reference/Profile/115017 (June 2021)

U.S. Fish and Wildlife Service. 2019b. Upper Mississippi River National Wildlife and Fish Refuge Habitat Management Plan. U.S. Fish and Wildlife Service. Bloomington, Minnesota. 127 pp + Appendices A–F. Available: https://ecos.fws.gov/ServCat/Reference/Profile/115578 (June 2021).

U.S. Geological Survey. Undated. USGS Water Data for the Nation. Available: https://waterdata.usgs.gov/nwis/%5d (July 2021).

van Tol, J. 2021. Odonata: Global Species Database of Odonata (version Dec 2011). In: Catalogue of Life, (2021). Species 2000 & ITIS Catalogue of Life, 2021-06-10. Species 2000: Naturalis, Leiden, the Netherlands. ISSN 2405-8858. Available: https://www.catalogueoflife.org/ (June 2021).

Wisconsin Department of Natural Resources. 2021. Wisconsin Natural Heritage Working List. Wisconsin Natural Heritage Program, Bureau of Natural Heritage Conservation, Madison, Wisconsin. 24 pp.

Wisconsin Dragonfly Society. undated. Get Involved! Available: http://widragonflysociety.org/html/get-involved.html (June 2021).

Wisconsin Odonata Survey. undated-a. Report Odonate Observations. Available: https://wiatri.net/inventory/odonata/ (June 2021).

Wisconsin Odonata Survey. undated-b. 'Most Wanted' and 'Possible' Wisconsin Dragonfly and Damselfly Species. Available: https://wiatri.net/inventory/odonata/SpeciesAccounts/mw.cfm (June 2021).

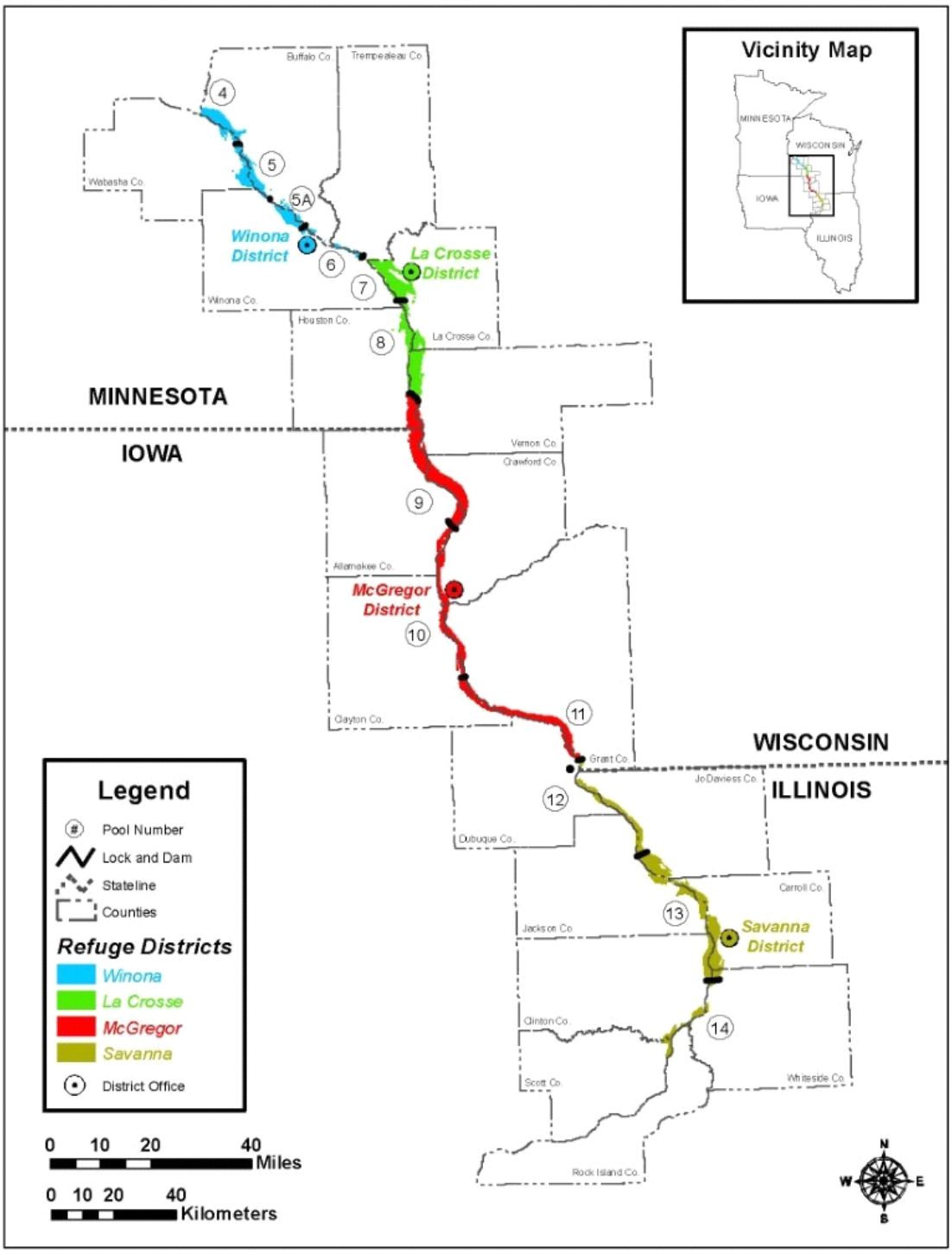

Figure 1. The Upper Mississippi River National Wildlife and Fish Refuge, including locations of Pools 4–14, locks and dams, and refuge districts. Figure from U.S. Fish and Wildlife Service (2006).

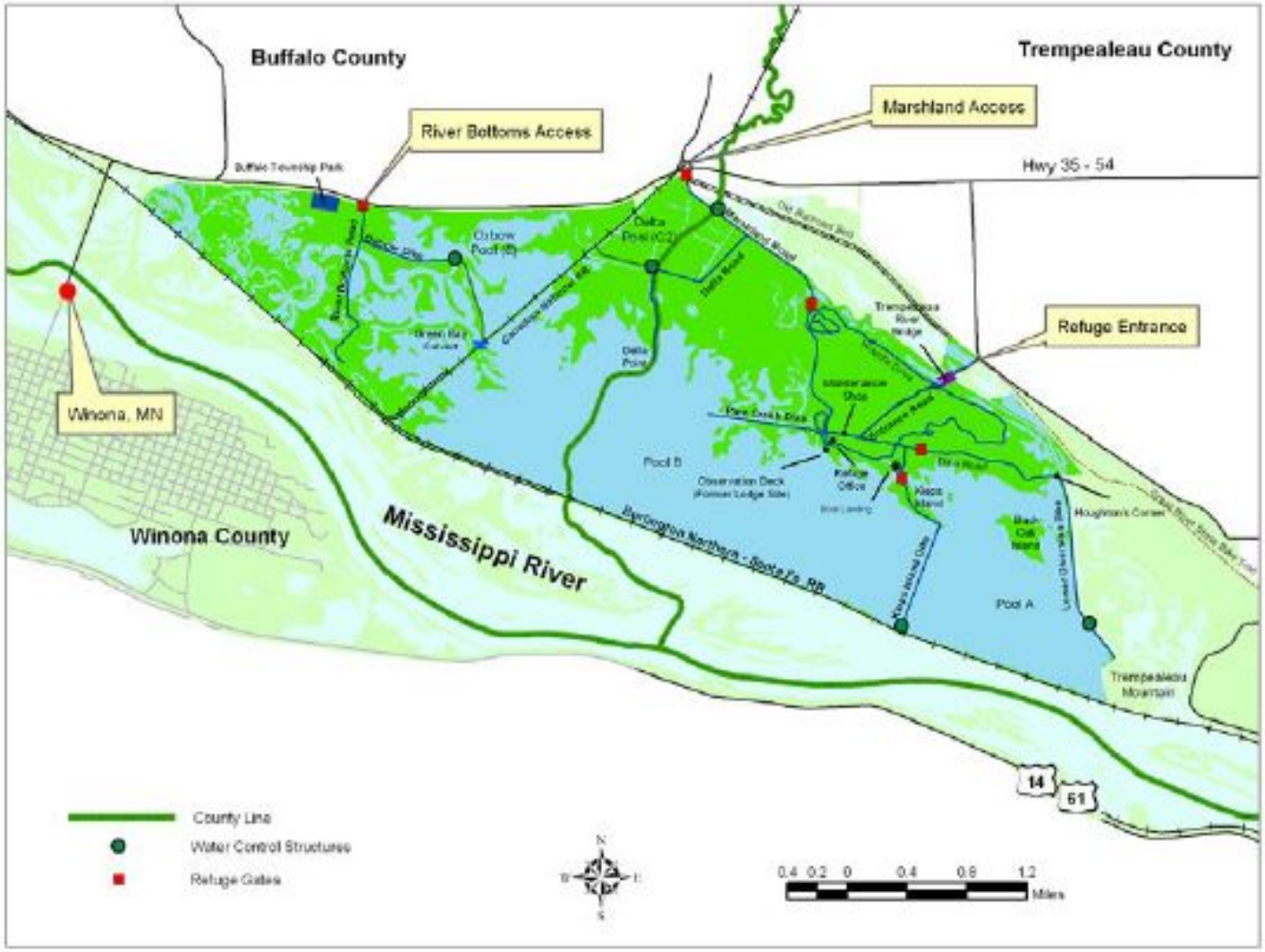

Figure 2. Trempealeau National Wildlife Refuge in Buffalo and Trempealeau Counties, Wisconsin, and adjacent to Pool 6 of the Upper Mississippi River. Figure from U.S. Fish and Wildlife Service (2019a).

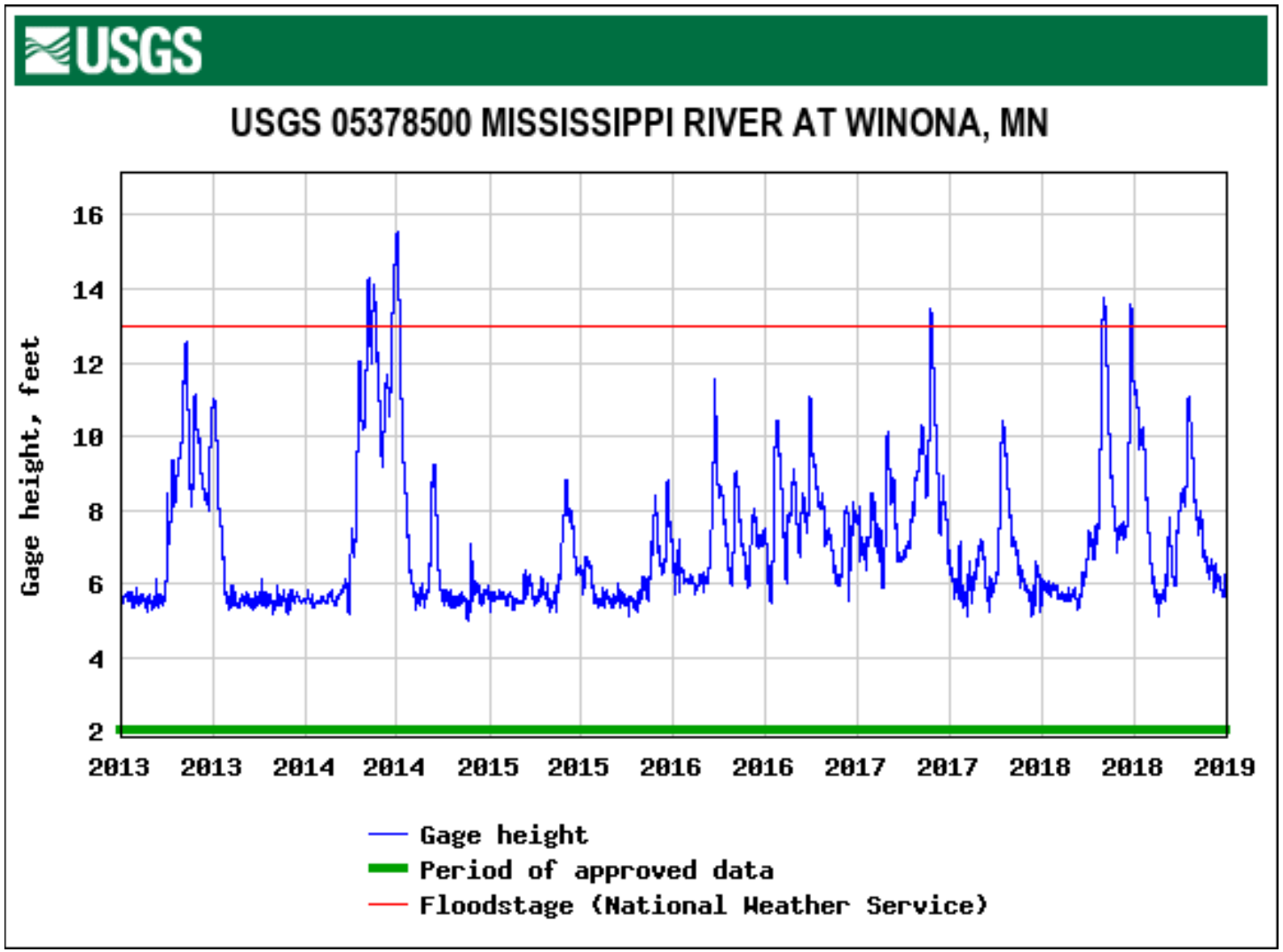

Figure 3. Upper Mississippi River water levels (gage height in feet) recorded by U.S. Geological Survey Gage 05378500 in Pool 6 at Winona, Minnesota, during 2013–2018. Figure obtained from U.S. Geological Survey (undated).

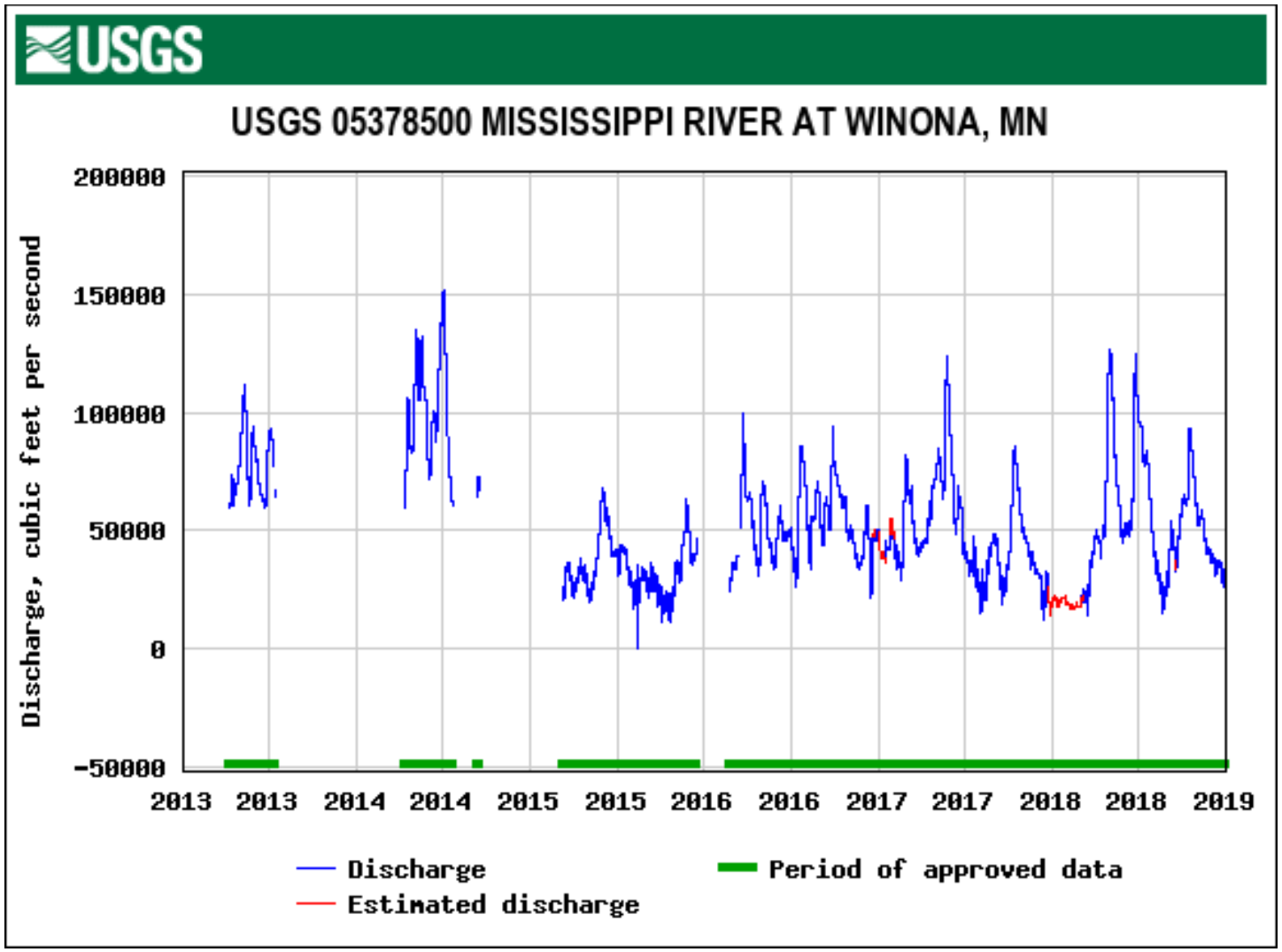

Figure 4. Upper Mississippi River discharge (cubic feet per second) recorded by U.S. Geological Survey Gage 05378500 in Pool 6 at Winona, Minnesota, during 2013–2018. Figure obtained from U.S. Geological Survey (undated).

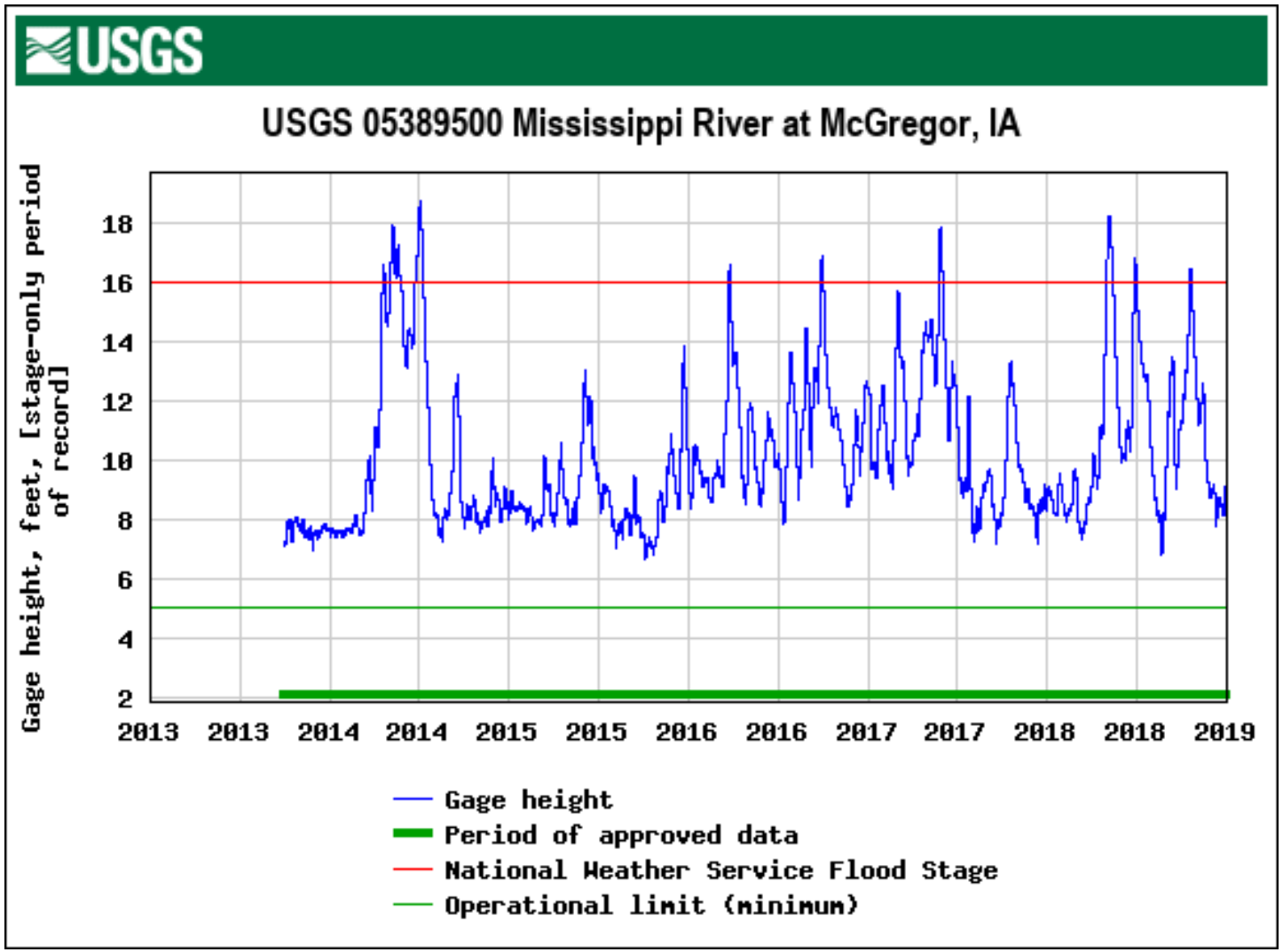

Figure 5. Upper Mississippi River water levels (gage height in feet) recorded by U.S. Geological Survey Gage 05389500 in Pool 10 at McGregor, Iowa, during 2013–2018. Figure obtained from U.S. Geological Survey (undated).

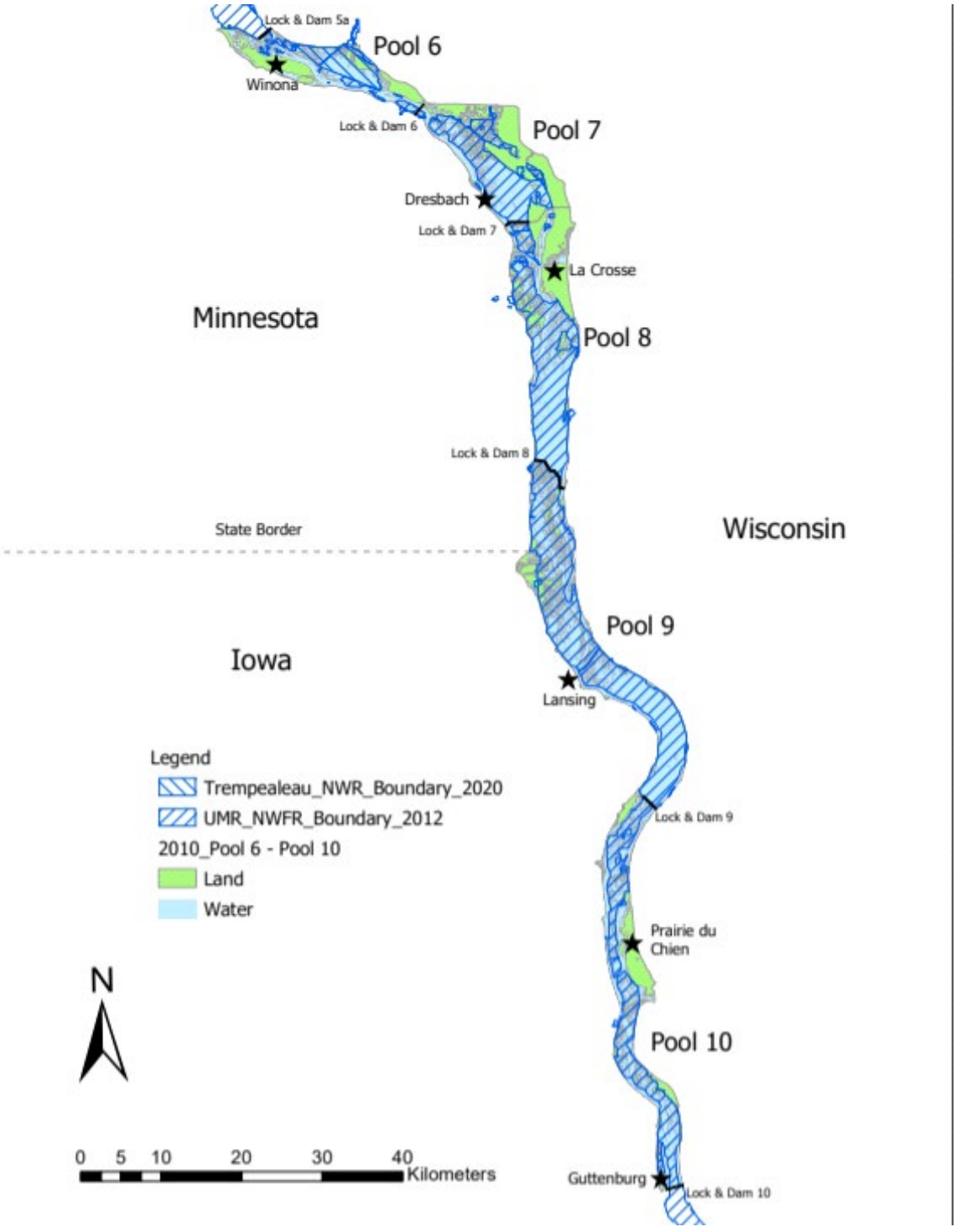

Figure 6. The portions of the Upper Mississippi River National Wildlife and Fish Refuge, as well as Trempealeau National Wildlife Refuge, occurring along Pools 5A-10 of the Upper Mississippi River.

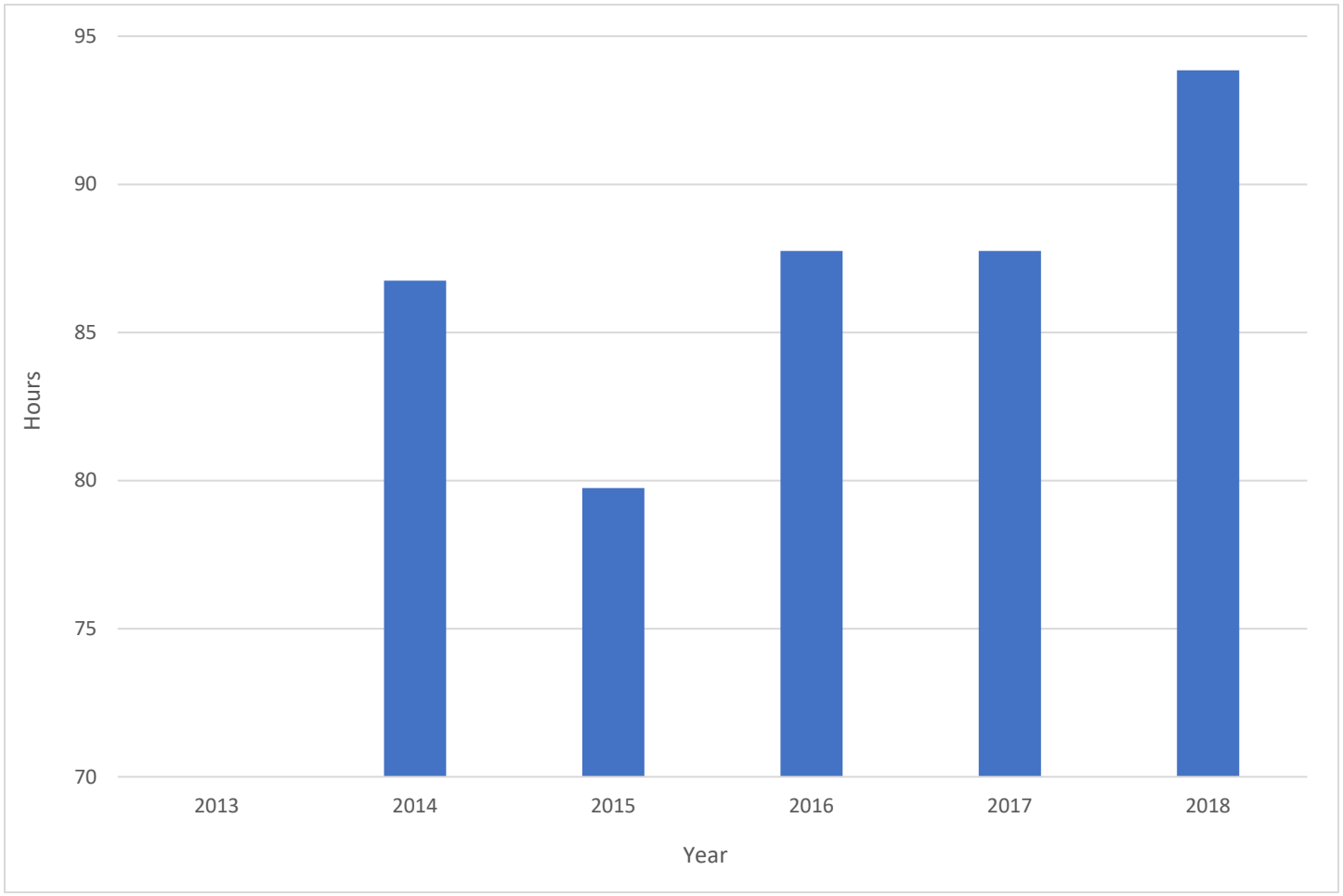

Figure 6. Effort (hours) expended per year conducting Odonata surveys in Pools 5A-10 of the Upper Mississippi River during 2014–2018 (effort was not recorded during 2013).

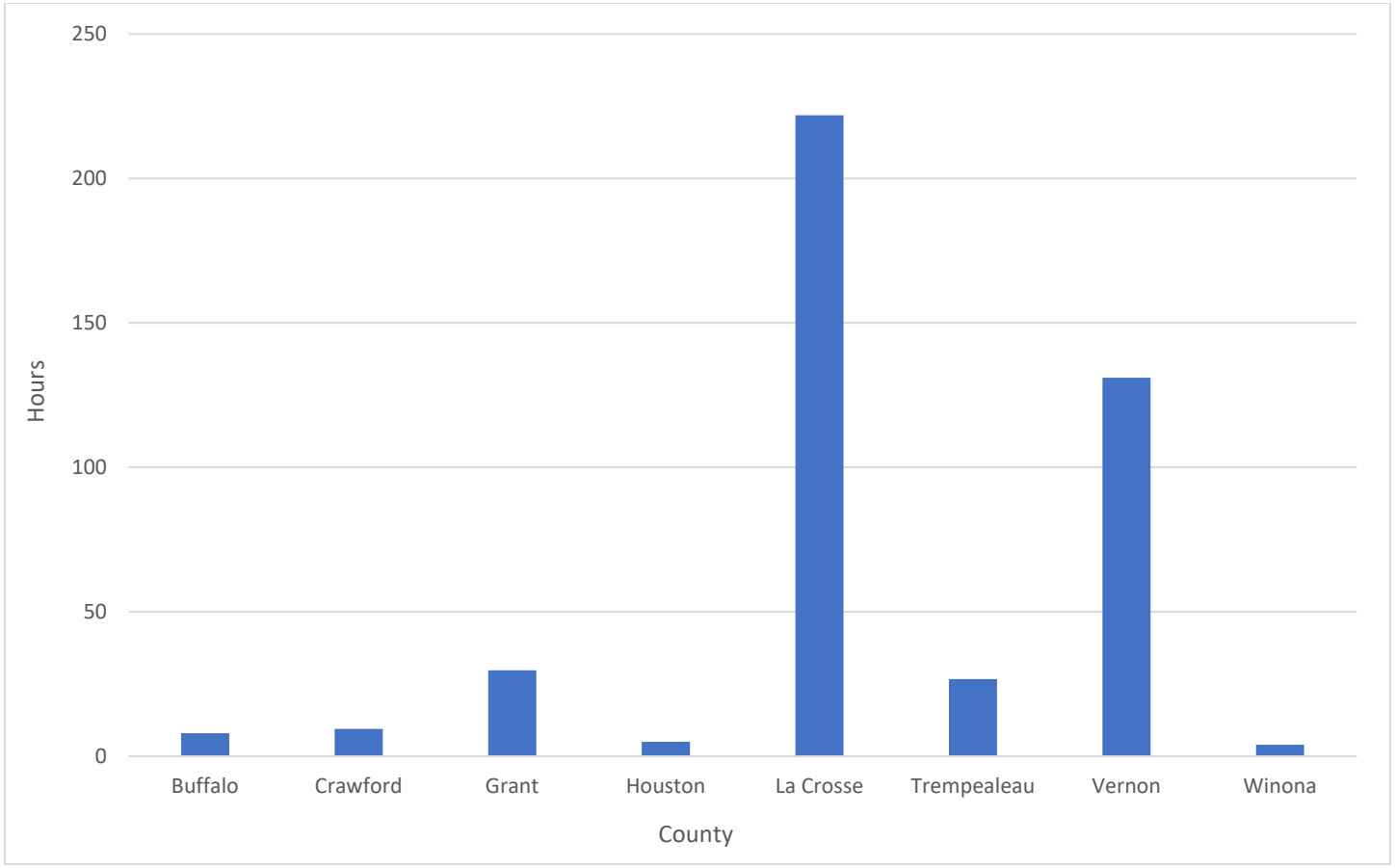

Figure 7. Effort (hours) expended per county conducting Odonata surveys in Pools 5A-10 of the Upper Mississippi River during 2013–2018.

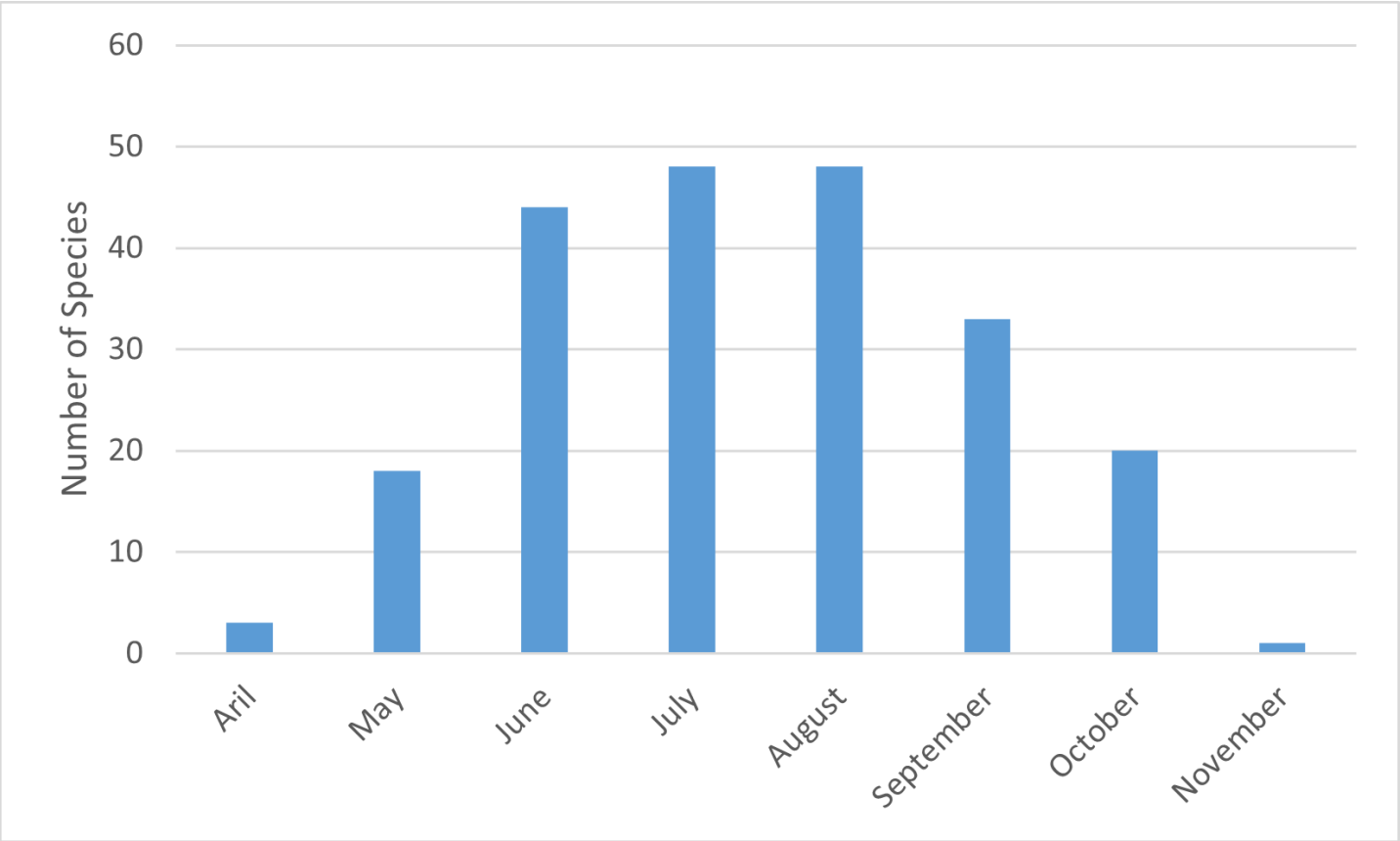

Figure 8. The number of Odonate species observed per month during Odonata surveys conducted in Pools 5A-10 of the Upper Mississippi River, 2013–2018.

Table 1. Odonates observed during surveys of Pools 5A–10 of the Upper Mississippi River during 2013–2018, the cumulative number of individuals observed, and their NatureServe global and state ranks. Scientific and common names are from Paulson and Dunkle (2021), definitions of global[1] and state[2] ranks are from Appendix A of Master et al. (2012).

Infraorder	Scientific name	Common name	Cumulative Number of Individuals Observed During All Years	NatureServe Global Rank[1]	NatureServe WI State Rank[2]
Anisoptera	*Aeshna canadensis*	Canada darner	27	G5	S5
Anisoptera	*Aeshna constricta*	lance-tipped darner	276	G5	S4
Anisoptera	*Aeshna sp.*	darner	14		
Anisoptera	*Aeshna tuberculifera*	black-tipped darner	1	G5	S4
Anisoptera	*Aeshna umbrosa*	shadow darner	18	G5	S5
Anisoptera	*Aeshna verticalis*	green-striped darner	12	G5	S4
Anisoptera	*Anax junius*	common green darner	3494	G5	S5
Anisoptera	*Arigomphus submedianus*	jade clubtail	36	G5	S3
Anisoptera	*Celithemis elisa*	calico pennant	3	G5	S5
Anisoptera	*Celithemis eponina*	Halloween pennant	351	G5	S5
Anisoptera	*Epitheca cynosura*	common baskettail	107	G5	S5
Anisoptera	*Epitheca princeps*	prince baskettail	443	G5	S5
Anisoptera	*Erythemis simplicicollis*	eastern pondhawk	1533	G5	S5
Anisoptera	*Gomphurus externus*	plains clubtail	2	G5	S3
Anisoptera	*Gomphurus fraternus*	midland clubtail	38	G5	S4
Anisoptera	*Gomphurus sp.*	clubtail	2		
Anisoptera	*Gomphurus vastus*	cobra clubtail	39	G5	S4
Anisoptera	*Leucorrhinia intacta*	dot-tailed whiteface	162	G5	S5
Anisoptera	*Libellula luctuosa*	widow skimmer	256	G5	S5
Anisoptera	*Libellula pulchella*	twelve-spotted skimmer	255	G5	S5
Anisoptera	*Libellula quadrimaculata*	four-spotted skimmer	13	G5	S5
Anisoptera	*Macromia taeniolata*	royal river cruiser	59	G5	S2
Anisoptera	*Nasiaeschna pentacantha*	cyrano darner	6	G5	S4
Anisoptera	*Pachydiplax longipennis*	blue dasher	751	G5	S5
Anisoptera	*Pantala flavescens*	wandering glider	204	G5	S5
Anisoptera	*Pantala hymenaea*	spot-winged glider	15	G5	S4
Anisoptera	*Perithemis tenera*	eastern amberwing	1183	G5	S5
Anisoptera	*Plathemis lydia*	common whitetail	77	G5	S5
Anisoptera	*Rhionaeschna multicolor*	blue-eyed darner	9	G5	SU
Anisoptera	*Somatochlora williamsoni*	Williamson's emerald	1	G5	S4
Anisoptera	*Stylurus notatus*	elusive clubtail	142	G3	S4
Anisoptera	*Stylurus plagiatus*	russet-tipped clubtail	537	G5	S4
Anisoptera	*Sympetrum corruptum*	variegated meadowhawk	85	G5	S4
Anisoptera	*Sympetrum costiferum*	saffron-winged meadowhawk	40	G5	S5
Anisoptera	*Sympetrum internum*	cherry-faced meadowhawk	1	G5	S5
Anisoptera	*Sympetrum obtrusum*	white-faced meadowhawk	452	G5	S5
Anisoptera	*Sympetrum rubicundulum*	ruby meadowhawk	11	G5	S4
Anisoptera	*Sympetrum semicinctum*	band-winged meadowhawk	9	G5	S4
Anisoptera	*Sympetrum vicinum*	autumn meadowhawk	1006	G5	S5
Anisoptera	*Tramea calverti*	striped saddlebags	6	G5	SU
Anisoptera	*Tramea lacerata*	black saddlebags	1045	G5	S5
Anisoptera	*Tramea onusta*	red saddlebags	37	G5	S3
Zygoptera	*Argia apicalis*	blue-fronted dancer	516	G5	S5
Zygoptera	*Argia moesta*	powdered dancer	88	G5	S5

Infraorder	Scientific name	Common name	Cumulative Number of Individuals Observed During All Years	NatureServe Global Rank[1]	NatureServe WI State Rank[2]
Zygoptera	*Argia tibialis*	blue-tipped dancer	30	G5	S4
Zygoptera	*Calopteryx aequabilis*	river jewelwing	15	G5	S5
Zygoptera	*Calopteryx maculata*	ebony jewelwing	16	G5	S5
Zygoptera	*Enallagma aspersum*	azure bluet	1	G5	S2
Zygoptera	*Enallagma boreale*	boreal bluet	5	G5	S5
Zygoptera	*Enallagma carunculatum*	tule bluet	6487	G5	S5
Zygoptera	*Enallagma civile*	familiar bluet	154	G5	S5
Zygoptera	*Enallagma ebrium*	marsh bluet	173	G5	S5
Zygoptera	*Enallagma exsulans*	stream bluet	385	G5	S5
Zygoptera	*Enallagma geminatum*	skimming bluet	443	G5	S4
Zygoptera	*Enallagma signatum*	orange bluet	4455	G5	S5
Zygoptera	*Heaterina americana*	American rubyspot	34	G5	S5
Zygoptera	*Ischnura hastata*	citrine forktail	1	G5	SU
Zygoptera	*Ischnura posita*	fragile forktail	1	G5	S2
Zygoptera	*Ischnura verticalis*	eastern forktail	5408	G5	S5
Zygoptera	*Lestes disjunctus*	northern spreadwing	1	G5	S5
Zygoptera	*Lestes inaequalis*	elegant spreadwing	6	G5	S4
Zygoptera	*Lestes rectangularis*	slender spreadwing	164	G5	S5
Zygoptera	*Lestes unguiculatus*	lyre-tipped spreadwing	6	G5	S5
Zygoptera	*Nehalennia irene*	sedge sprite	12	G5	S5

[1]G5 = *Secure - at very low risk of extinction or elimination due to a very extensive range, abundant populations or occurrences, and little to no concern from declines or threats*.

[1]G3 = *Vulnerable - at moderate risk of extinction or elimination due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors*.

[2]S5 within the state of Wisconsin = *Secure - at very low or no risk of extirpation in the jurisdiction due to a very extensive range, abundant populations or occurrences, with little to no concern from declines or threats*.

[2]S4 within the state of Wisconsin = *Apparently Secure - at a fairly low risk of extirpation in the jurisdiction due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors*.

[2]S3 within the state of Wisconsin = *Vulnerable - at moderate risk of extirpation in the jurisdiction due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors.*

[2]S3 within the state of Wisconsin = *Imperiled - at high risk of extirpation in the jurisdiction due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors*).

[2]SU within the state of Wisconsin = *Unrankable – currently unrankable due to lack of information or due to substantially conflicting information about status or trends.*

Table 2. Odonate species observed in Pools 5A–10 of the Upper Mississippi River, while conducting surveys during 2013–2018 that represent new county records. Location information is from the *Location_1* field in the comprehensive database described in this report.

State	County	Group	Species	Common Name	Date	Location	Latitude	Longitude	Stage
MN	Houston	Anisoptera	*Celithemis elisa*	calico pennant	August 25th, 2013	Dike on the top end of the Reno Bottoms	43.601	-91.2616	A
MN	Houston	Zygoptera	*Enallagma exsulans*	stream bluet	August 25th, 2013	Dike on the top end of the Reno Bottoms	43.601	-91.2616	A
MN	Houston	Anisoptera	*Pantala flavescens*	wandering glider	August 25th, 2013	Dike on the top end of the Reno Bottoms	43.601	-91.2616	A
MN	Houston	Anisoptera	*Sympetrum costifeum*	saffron-winged meadowhawk	August 25th, 2013	Dike on the top end of the Reno Bottoms	43.601	-91.2616	A
WI	Buffalo	Anisoptera	*Aeshna canadensis*	Canada darner	September 26th, 2013	Refuge land adjacent to Buffalo Park on west side of Hwy 35	44.0678	-91.6017	A
WI	Buffalo	Anisoptera	*Aeshna umbrosa*	shadow darner	September 26th, 2013	Refuge land adjacent to Buffalo Park on west side of Hwy 35	44.0678	-91.6017	A
WI	Buffalo	Anisoptera	*Pantala flavescens*	wandering glider	July 29th, 2017	Merrick State Park on Mississippi River backwaters	44.15953	-91.76368	A
WI	La Crosse	Anisoptera	*Somatochlora williamsoni*	Williamson's emerald	August 6th, 2018	L.B. White	43.91207	-91.23877	A
WI	Trempealeau	Anisoptera	*Aeshna canadensis*	Canada Darner	September 26th, 2014	South end of Marshland Road (north access to Tremp. NWR)	44.0598	-91.5375	A
WI	Trempealeau	Anisoptera	*Gomphurus vastus*	cobra clubtail	June 17th, 2016	Boat landing at Lock and Dam 6	43.9981	-91.4328	A
WI	Trempealeau	Anisoptera	*Sympetrum rubicundulum*	ruby meadowhawk	July 26th, 2013	Prairie at start of north wildlife loop of Trempealeau NWR	44.0508	-91.5222	A
WI	Vernon	Anisoptera	*Aeshna tuberculifera*	black-tipped darner	September 9th, 2017	Genoa Power Plant Boat Landing	43.55074	-91.23516	A
WI	Vernon	Anisoptera	*Aeshna verticalis*	green-striped darner	August 22nd, 2013	Sand prairie area just south and east of the sewage ponds in Stoddard, Vernon Cty, WI	43.6529	-91.2234	A
WI	Vernon	Anisoptera	*Celithemis elisa*	calico pennant	June 22nd, 2013	Sand prairie area just south and east of the sewage ponds in Stoddard, Vernon Cty, WI	43.6529	-91.2234	A
WI	Vernon	Anisoptera	*Gomphurus externus*	plains clubtail	June 11th, 2017	Blackhawk Park	43.45663	-91.22535	A
WI	Vernon	Zygoptera	*Ischnura hastata*	citrine forktail	September 16th, 2013	Sand prairie area just south and east of the sewage ponds in Stoddard, Vernon Cty, WI	43.6529	-91.2234	A
WI	Vernon	Anisoptera	*Nasiaeschna pentacantha*	cyrano darner	June 11th, 2017	Road To Blackhawk Park	43.46594	-91.21862	A