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Dragonflies and Damselflies (Odonata) of the Bois Brule River Watershed and Brule River State Forest, with Considerations for Detecting Species

By **Robert B. DuBois**, **Julie M. Pleski**, **Kurt L. Schmude**, and **William A. Smith**

Abstract

Surveys of dragonflies and damselflies (Odonata) were conducted at 94 sites over a 36-year period within the Bois Brule River watershed and Brule River State Forest (BRW&SF). A total of 705 survey visits were made to a wide range of habitats including sections of a large trout stream and a coolwater river, numerous smaller streams, several large lakes, many smaller ponds, and a variety of shallow wetlands including peatlands, swamps, vernal pools, and spring seeps. Our objectives were to summarize all existing information about odonates that occur within the BRW&SF to provide background for future work planning, provide information about rare species and sampling methods, and establish a benchmark of species occurrences against which future data can be compared. We identified 13,249 individual odonates and detected 93 species, including 66 species of dragonflies (Anisoptera) in 29 genera of six families, and 27 species of damselflies (Zygoptera) in nine genera of three families. This total comprises 75% of the species of Odonata known to occur in Douglas County and 56% of the species known to occur in Wisconsin. This high level of species richness is due to the diversity of well-protected habitat types within the BRW&SF. Despite a considerable amount of survey effort in the BRW&SF, this species list is likely incomplete, and further surveying could detect up to 15 additional species. No endangered or threatened species were found, but four species were identified as being of special concern by the Bureau of Natural Heritage Conservation.

Species detection analyses at a small, man-made pond (the US 2 Pond), which was visited 72 times over 25 years, revealed that more than half of the species of dragonflies that occupied the pond were first detected during the first four visits, but that first detections of uncommon or transient species continued throughout most of the sampling period. June was the most productive month for detecting species at the US 2 Pond; three survey visits during favorable weather conditions, one each in mid-June, mid-July, and early September, could have detected the great majority of the species with breeding populations.

Continued

DAN JACKSON

Odonata surveys in northern Wisconsin on properties with diverse habitats like those within the BRW&SF should ideally be designed to detect all identifiable life stages present. Survey efficiency, however, can be optimized by targeting certain life stages depending on taxonomic group. Darners, spiketails, cruisers, and emeralds can be effectively detected as adults (both sexes), nymphs, or exuviae depending on habitat types, weather conditions, and time of year. For other taxa, survey effort should be focused on: the exuviae (primarily) and the nymphs (secondarily) for lotic species of clubtails; adults of both sexes for broad-winged damsels and most genera of skimmers; adult males for most genera of pond damsels; and adult males for most species of pond spreadwings, except that associated pairs be emphasized in the group containing Southern, Northern, and Sweetflag spreadwings (*Lestes* spp.).

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Top front cover photo courtesy of Ryan Brady.

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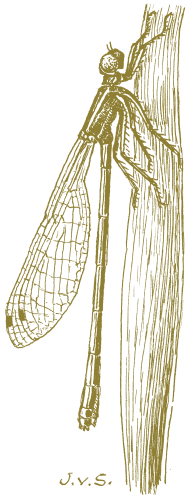
Introduction

The combined waters of the Bois Brule River watershed and the Brule River State Forest (BRW&SF) contain a diverse array of aquatic habitats that provide breeding areas for a rich assemblage of dragonflies and damselflies (Odonata). These habitats include sections of the mainstem of the Bois Brule River, a coldwater trout river with its associated tributary streams and spring seeps, sections of the cool-water St. Croix River, several large lakes, numerous smaller lakes and ponds, and a variety of shallow wetlands including bogs, swamps, vernal pools, and spring seeps. Aspects of the aquatic systems of the BRW&SF have been studied for various purposes since the 1940s (DuBois and Pratt 1994). The aquatic insect community, including the Odonata, has been studied since 1983 (DuBois 1993). The biota of the BRW&SF was further investigated using a nymphal survey of a wide variety of habitats in 1996, as part of a master-planning process to guide management of the state forest (Epstein et al. 1999). Over the past 30 years a number of applied research studies that targeted specific ecological issues within the BRW&SF also addressed odonates, either primarily or secondarily (DuBois and Plaster 1993, DuBois et al. 2004, DuBois et al. 2007, DuBois et al. 2014, DuBois 2015, DuBois and Tennessen 2015). Further, the senior author has had an enduring interest in increasing scientific knowledge about odonates within the BRW&SF and has frequently surveyed habitats while conducting other studies funded by the Wisconsin Department of Natural Resources (Wisconsin DNR) as well as on his own time. Of growing importance, the recently formed Wisconsin Dragonfly Society (**www.widragonflysociety.org**) has used data collected by citizen cooperators to increase knowledge about distributions and critical habitats of odonates statewide through the Wisconsin Odonata Survey (**http://wiatri.net/inventory/odonata**), which includes records from the BRW&SF. Data gained through all of these survey efforts have come in the form of nymph, exuviae, and adult specimen collections, as well as photographs, and sight records of adult odonates by competent observers.

The considerable breadth of information that has been gained about the odonate community of the BRW&SF, however, has not been gathered into a single resource where it would be readily accessible. Therefore, our primary objective in this report is to consolidate and summarize all existing information about odonates in the BRW&SF to provide a background for future work-planning for the property, inform about rare species known to occur in the area, and establish a benchmark against which future data can be compared. The benefits of this summary also include increasing knowledge about distributions and critical habitats of northern odonates and some insights for detecting species in lotic and lentic systems in northern Wisconsin.



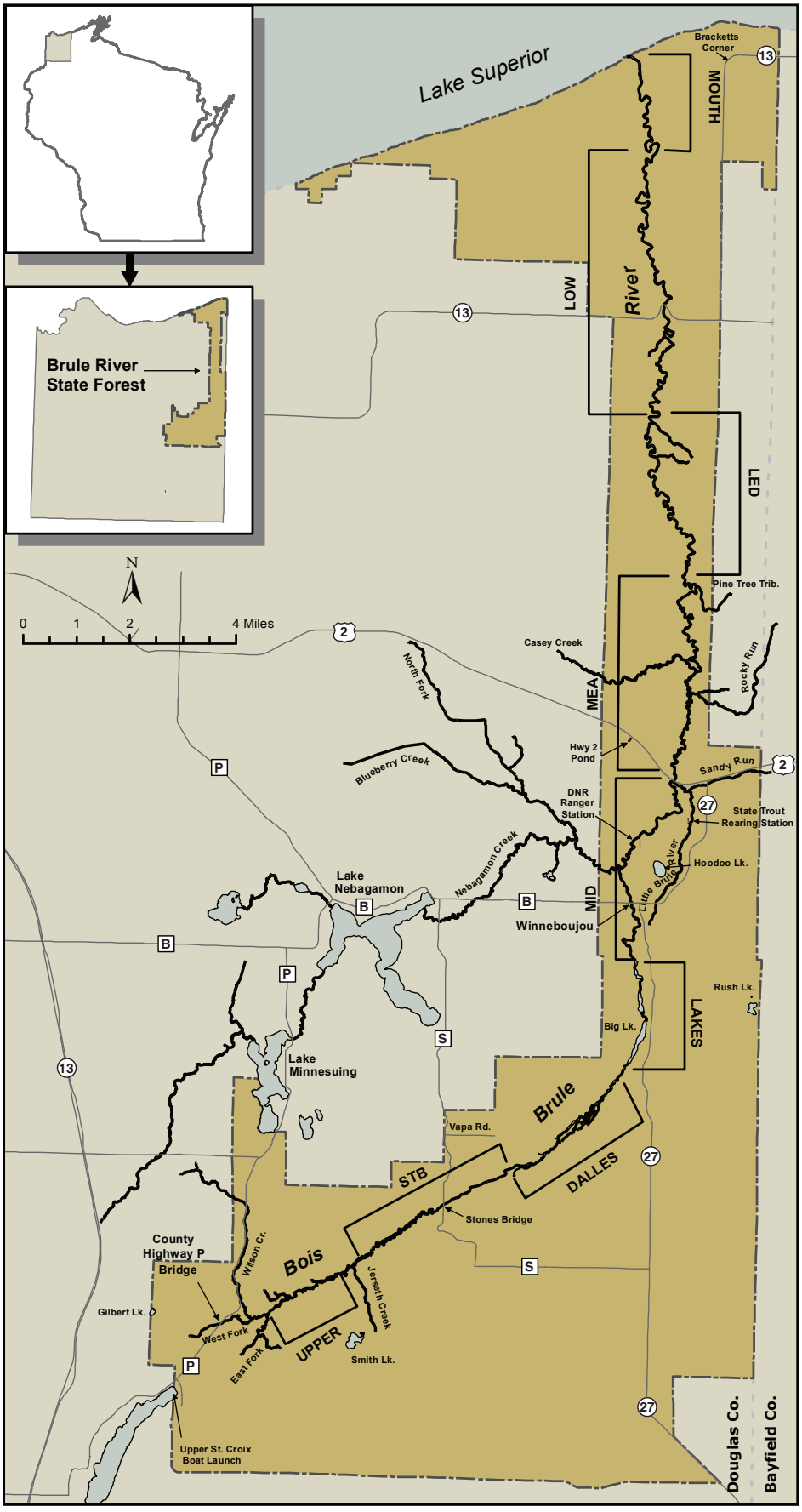


Figure 1. *The Bois Brule River watershed and Brule River State Forest (shaded in gold) in Douglas County, Wisconsin, showing zones of the river mainstem, major tributaries, and some of the most-frequently visited sites where odonates were sampled from 1984 to 2018. Note that the watershed extends well beyond the boundaries of the state forest to the west. Bois Brule River zones: DALLES=Dalles zone; LAKES=lakes zone; LED=ledges zone; LOW=lower river zone; MEA=meadows zone; MID=middle transition zone; MOUTH=mouth of river zone; STB=Stone's Bridge zone; UPPER=upper river zone.*

WISCONSIN DNR FILE PHOTO

Long known as an exceptional trout stream, the Bois Brule River flows 76 km from its spring-fed, headwater source to its mouth at Lake Superior. The river has a considerable diversity of habitats along its length.

Methods

Study Area

The study area was largely defined by the Bois Brule River watershed in Douglas County, which covered about 466 km^2, and also included areas of the Brule River State Forest that were not in the watershed including the north end of Upper St. Croix Lake, the Brule River State Forest Annex (hereafter the Brule Annex), and several tributaries to Lake Superior both east and west of the mouth of the Bois Brule River (Figure 1). Small portions of the watershed extended into Bayfield County, but these areas were not sampled for odonates. Nearly half of the watershed, and the entire mainstem of the Bois Brule River, is encompassed within the Brule River State Forest, a property administered by the Wisconsin DNR that is about 190 km^2 in size. The Brule Annex is a disjunct administrative unit of the Brule River State Forest located near the Village of Gordon about 16 km south of the contiguous portion of the Brule River State Forest (Figure 1 shows the Bois Brule River watershed and most of the Brule River State Forest, but it does not show the Brule Annex).

The Bois Brule River is 76 km-long from its spring-fed, headwater source to its mouth at Lake Superior. Long known as an exceptional trout stream, the river also has a considerable diversity of habitats for aquatic macroinvertebrates along its length. The upper river (southern portion) is a generally low-gradient reach that meanders through a large coniferous bog and is fed by numerous springs. In contrast, the lower river (northern portion) begins a fall of 100 m where it crosses the Copper Range and is characterized by rapids and cascades as it tumbles over cobble, rubble, and rock ledges between steep, red-clay bluffs, in its last 29 km to Lake Superior. Because the river is largely spring fed, it is more stable thermally and with respect to its flow regime than other nearby streams. In addition to the physical description of the watershed and river mainstem given below, other detailed physical descriptions of the geography and aquatic habitats within the Brule River State Forest are also available (DuBois 1993, DuBois and Pratt 1994, Epstein et al. 1999).

For the purposes of this study, we divided the river mainstem into nine zones, each containing physically

CATHY KHALAR

The Stone's Bridge zone of the Bois Brule River has a low gradient, generally soft bottom materials, and an abundant and diverse array of aquatic macrophytes.

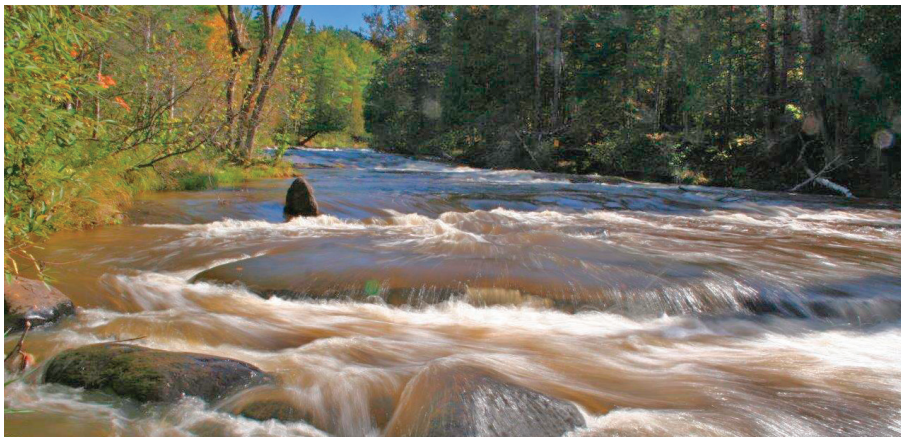
similar habitat characteristics (Figure 1). The upper river zone (UPPER in Figure 1) originates in and flows through a large conifer bog, surrounded by a sandy outwash plain known as the "pine barrens" or Bayfield Sand Barrens. Recharge is delivered through numerous springs. This zone is characterized by a low gradient, extensive muck bottom substrates, and alder-choked banks. The Stone's Bridge zone (STB) is similar to the upper river zone in having a low gradient and generally soft bottom materials, but it has greater mean width and depth and a more abundant and diverse array of aquatic macrophytes. The Dalles zone (DALLES) has numerous fast, high-gradient, rocky rapids and riffles interspersed with low-gradient, widespread areas of reduced velocity. The lakes zone (LAKES) has several low-gradient widespread sections large enough to be called lakes (Big, Lucius, and Spring lakes). These predominantly lentic habitats have short sections of rapids and riffles between them. The middle transition zone (MID) is an ecologically diverse area of various river gradients and substrate types. The sandy loam soils that characterize the uplands surrounding this zone separate the red clay to the north from the sandy pine barrens to the south. The major tributary to the Bois Brule River, Nebagamon Creek, enters the mainstem at the mid-point of the middle zone bringing a contribution of flow from lakes Nebagamon and Minnesuing. The meadows zone (MEA) is a rather uniformly low-gradient reach of alder-lined runs with deep pools (1.5–2.1 m) at bends. Submerged woody debris is abundant here, providing habitat for many types of aquatic insects. The ledges zone (LED) at the Copper Range is a steep, swift, high-gradient reach of nearly continual rapids and riffles. Substrate materials in this zone are mostly cobble, rubble, boulder, and flat-rock ledge. The lower river zone (LOW) is characterized by a continual series of gentle rapids and riffles throughout its length. This zone flows through a region of red clay, called the Lake Superior Clay Plain, the low permeability of which causes high runoff and associated turbidity and siltation after rains and snowmelt. The mouth of river zone (MOUTH) is a low-gradient reach where gentle riffles transition to a low-velocity estuary as the river approaches Lake Superior.

In addition to the mainstem of the Bois Brule River, there are about 265 km of smaller lotic systems in the BRW&SF, with approximately 75 named and unnamed streams and tributaries. These streams run the gamut from spring-fed, coldwater tributaries to warmwater creeks, and include impounded and natural sections of the Eau Claire River where it flows through the Brule Annex. Most of the streams surveyed feed into the Bois Brule River and affect its overall water quality.

Wetlands on the property consist of some very small ponds (some temporary), roadside ditches, river oxbows, a panne near the river's mouth, and some scattered, limited areas of open bog and fen habitat (peatlands). Open wet-sedge-meadow peatland habitats often hold some uncommon, bog-obligate species of odonates, and a few representatives of these species were found in the BRW&SF. Open peatlands within the property that are sufficiently well-hydrated to supply habitat for odonates are not extensive, however, so their potential for holding bog-obligate species is modest.

There are 19 named lakes of various types and sizes within the BRW&SF, as well as many smaller ponds. Most of these lentic waterbodies are small, mostly or entirely undeveloped, soft-water, seepage systems, with the exceptions of lakes Minnesuing and Nebagamon, both of which are drainage lakes greater than 63 ha in size and have extensive areas of lakeshore development. One pond site (P6) was erroneously included in the original dataset and was later excluded from the analyses.

Odonates were repeatedly observed and recorded in a few upland areas as well. These areas were included because they were frequently visited by one of the authors or data cooperators and numerous odonates were recorded. Although our odonates do not breed in upland areas, many species will congregate in favored upland areas to feed, so recording them can give clues to nearby waterbodies that are used by these species for breeding.



CATHY KHALAR

The Dalles zone of the Bois Brule River has numerous fast, high-gradient, rocky rapids and riffles interspersed with low-gradient, widespread areas of reduced velocity.

KIRK OLSON

The lakes zone of the river has several low-gradient widespread sections large enough to be called lakes, including Big Lake shown here.

CATHY KHALAR

Water from Lake Nebagamon flows through Nebagamon Creek and enters the mainstem of the Bois Brule River in the middle zone.

CATHY KHALAR

The ledges zone of the Bois Brule River is a steep, swift, high-gradient reach of nearly continual rapids and riffles. Substrate materials in this zone are mostly cobble, rubble, boulder, and flat-rock ledge.

Sample Timing and Site Selection

Odonate surveys were made on 705 visits to 94 sites within the BRW&SF at irregular intervals from 1984 through 2018 (Table 1; see Appendix 1 for latitude and longitude coordinates of sites sampled). Most sites were visited in the spring, summer, or autumn, but a few sampling efforts for nymphs were made in winter as well. We did not attempt to make an equal number of visits to all sites, rather, we sought to sample as many different habitat types as feasible and to make repeated visits to sites that were particularly productive for odonates. Overall, we averaged eight visits to a site, but some sites were visited much more frequently while others were visited only once or a few times.

Our goals in selecting survey sites were to pick productive areas that spanned as wide a range of habitat conditions as could be found on the property and to make repeated visits to sites within habitat categories. We prioritized particularly productive sites and sites where we thought we had the best chances of finding rare species. Ease of access and proximity to areas frequented for other work duties were also considerations in sampling site selection. Sites were sampled in the following habitat categories (Table 1):

- Bois Brule River, mainstream (numerous sites within 9 zones; data from all sites within a zone were pooled)
- Tributaries, warm- and coldwater streams
- Springs and seeps
- Wetlands and bogs
- Ponds, <2 ha
- Small lakes, 2–63 ha
- Large lakes, >63 ha
- Upland areas
- Eau Claire River, impounded and free-flowing sections

We made an average of 78 survey visits to each of the habitat categories. About 84% of the survey visits targeted only adult specimens (Table 1); the remainder of the survey visits primarily targeted either nymphs or exuviae, although some visits targeted all life stages. The nymph survey in 1996 encompassed 37 visits to 33 sites in all habitat categories except the Bois Brule River mainstem and upland areas.

We sampled a small (0.15 ha), man-made pond, located on the south side of United States Route 2 about two km WNW of the Town of Brule (hereafter the US 2 Pond), more frequently than other sites because it was productive for odonates, was located near the home and work place of the senior author, and was easily accessible. For these reasons the site was an efficient location to survey, as well as a convenient place to check for early- or late-season records and to collect nymphs or adult specimens when needed for lab studies or educational outreach. The US 2 Pond appeared to be fishless based on visual observations and a lack of fish caught with angling gear or in any of the nymph nets, and it certainly did not have centrarchids (sunfishes [*Lepomis* spp.] or black basses [*Micropterus* spp.]), which are known to exert community-restructuring predation pressures on odonate nymphs (Stoks et al. 2003). Aquatic and wetland plants commonly found at the US 2 Pond included common duckweed (*Spirodela polyrrhiza*), water-shield (*Brasenia schreberi*), floating crystalwort (*Riccia fluitans*), flat-leaved bladderwort (*Utricularia intermedia*), common bladderwort (*U. vulgaris*), common forget-me-not (*Myosotis scorpioides*), common yellow lake sedge (*Carex utriculata*), bald spikerush (*Eleocharis erythropoda*), and broad-leaved cattail (*Typha latifolia*).

The US 2 Pond was visited on 72 occasions from 1994 to 2018 including all months except December through February (Table 2). Of these visits, 51 were intended to be 'full surveys,' by which we mean that an effort was made to detect all dragonfly species present during a non-trivial part of the flight season (generally mid-May through mid-October). The additional 21 visits were considered 'targeted visits' rather than full surveys for one or more of the following reasons:

- They targeted only early-season migrants in April or early May.
- They targeted late-season records in late October or November when only one species, at most, was anticipated to be flying.
- They targeted only nymphs, usually early or late in the flight season.
- They occurred late in the day or during inclement weather.
- Only one or few species were being targeted for specific scientific purposes.

During full survey visits to the US 2 Pond, nymphs and exuviae were often sampled as well as adults and tenerals. We did not attempt to detect damselflies there initially; rather we began to survey for them regularly in June 1999 (the 16th survey visit). Therefore, only 29 of the 51 full survey visits targeted damselflies. Because of the extensive dataset for the US 2 Pond, these data were subjected to more detailed examination than data from other sites to learn about the species-detection characteristics at a small, structurally simple site. The US 2 Pond was sampled most frequently in the months of May, June, July, and October (Table 2).

Sampling Procedures

Odonates were sampled by visual observations of adult specimens, netting adult specimens with aerial nets, collecting nymphs with dip nets and drift nets, and hand-picking exuviae. Additionally, some photographs of adult odonates were taken by citizen cooperators. These photographs were vetted by the senior author and have been included in the statewide Odonata database that is managed by the Wisconsin DNR's Bureau of Natural Heritage Conservation. Visual records of easily identified species were accepted from demonstrably competent observers. Most of the visual records were made by the senior author.

MITCHEL PAULEY

A small, man-made pond located on the south side of United States Route 2 was an efficient location to survey for early- and late-season records and to collect nymphs or adult specimens.

Table 1. *Number of sites, number of site visits, percentages of visits when life stages were targeted, and number of species detected within habitat categories when sampling for odonates in the BRW&SF, 1984–2018. Percentages in the 'Adults' column refer to visits when only adult odonates were sampled. Adult odonates were sometimes also recorded when nymphs and exuviae were sampled.*

Habitat Category Code	Habitat Category	Number of Sites	Number of Site Visits	Percentage of Visits when the Life Stage was Targeted			Number of Species Detected
				Adults	Nymphs	Exuviae	
R	Bois Brule River mainstem	9	142	80	4	16	47
T	Tributaries (streams)	29	148	87	9	4	56
S	Springs and seeps	5	18	89	4	7	25
W	Wetlands and bogs	12	50	90	0	10	52
P	Ponds (<2 ha)	18	159	83	9	8	65
SL	Small lakes (2–63 ha)	10	94	80	16	4	53
LL	Large lakes (>63 ha)	5	57	82	9	9	41
U	Upland areas	4	35	100	0	0	21
EC	Eau Claire River (Gordon)	2	2	0	100	0	12
Total		94	705				94
Habitat Category Average		10	78	84	8	8	41

Table 2. *Total and monthly visit summary for odonates at the US 2 Pond in the BRW&SF, 1994–2018. The numbers of full survey visits for dragonflies, in total and by month, are given in parentheses (other visits were targeted); all visits that targeted damselflies were full survey visits. Visit totals for adult odonates, nymphs, and exuviae exceed the total number of visits because all life stages were targeted on some visits.*

	Total	March	April	May	June	July	August	Sept.	Oct.	Nov.
Number of visits	72	1	7	17	14	10	5	7	9	2
Visits that targeted dragonflies	72 (51)	1 (0)	7 (0)	17 (12)	14 (12)	10 (9)	5 (3)	7 (7)	9 (8)	2 (0)
Visits that targeted damselflies	29	0	0	9	5	5	2	3	5	0
Visits that targeted adult Odonata	65	0	6	16	13	9	5	7	7	2
Visits that targeted nymphs	17	1	5	3	2	3	0	0	3	0
Visits that targeted exuviae	6	0	0	2	3	1	0	0	0	0

RYAN BRADY

Adult odonates were sampled by visual observations and netting adult specimens with aerial nets. Here, Bob DuBois examines a recently netted specimen.

UW-SUPERIOR FILE PHOTO

Odonate nymphs were sampled with dip nets and drift nets and by hand-picking exuviae. Here, Dr. Kurt Schmude examines recently collected material.

Surveys of adult odonates were primarily designed to determine overall species richness (presence or absence) rather than to rigorously quantify abundance, although numbers of individuals were roughly tallied to give an indication of relative abundance. We did not conduct point counts or measure transects; rather, experienced observers walked slowly through prime odonate habitat at each site, focusing on those areas they judged to be most likely to be productive, and recorded all species identified. The data for each species were tabulated in two ways according to: 1) the number of records, and 2) the number of individuals recorded. A record was defined as the documented occurrence of a species at a given site on a given date, regardless of the numbers of individuals observed or collected. The numbers of individuals of each species observed or collected at a site were counted unless a number was six or greater, in which case the number was reported as 6+ (at least six). If the number of individuals present was clearly more than twelve, then their number was estimated in increments of a dozen and was reported as being at least as many as the increment (e.g., 12+, 24+, 36+). We did not attempt to estimate the number of individuals present if the number was clearly more than 36. When tallying total records in tables, we report the minimum of the number estimated for each record (e.g., 12+ was tallied as 12, even though more individuals than that were likely present). Field notes usually included the time of the start of sampling, but not the duration, and some basic weather information was often noted (primarily temperature and cloud cover), but this information was not collected rigorously.

The identities of adult odonates that could not be firmly determined without capturing them were always verified by netting them and examining diagnostic body parts under magnification, either with a hand lens in the field or with a stereomicroscope in the lab, depending on the level of identification difficulty involved. Odonate nymphs and exuviae were similarly examined under magnification and determined using appropriate dichotomous keys, and representative nymphs of nearly all species were reared through emergence in captivity to confirm determinations.

One hard to distinguish species pair, the Vernal Bluet (*Enallagma vernale*) and the Northern Bluet (*E. annexum*), were determined based on four structural aspects of the male cercus (Donnelly 1989). These species are thought to intergrade extensively in the Upper Midwest, producing morphologically intermediate forms that have created problems with identification. Although some authors have given some measure of guidance for distinguishing "pure" forms of the two species (Gloyd 1943; Walker 1953; Donnelly 1989, 1998; Lam 2004; Westfall and May 2006; Paulson 2011), only Donnelly (1989, 1998) has attempted to categorize the intermediate forms. In a series of personal communications with the senior author in 2002–2003, Donnelly elaborated on a somewhat subjective six-point system he developed to categorize specimens within this species complex. This system was based on the scoring of four structural characteristics of the cercus of male specimens. Because intermediate specimens were found in the BRW&SF, as well as relatively "pure" specimens of both species, and

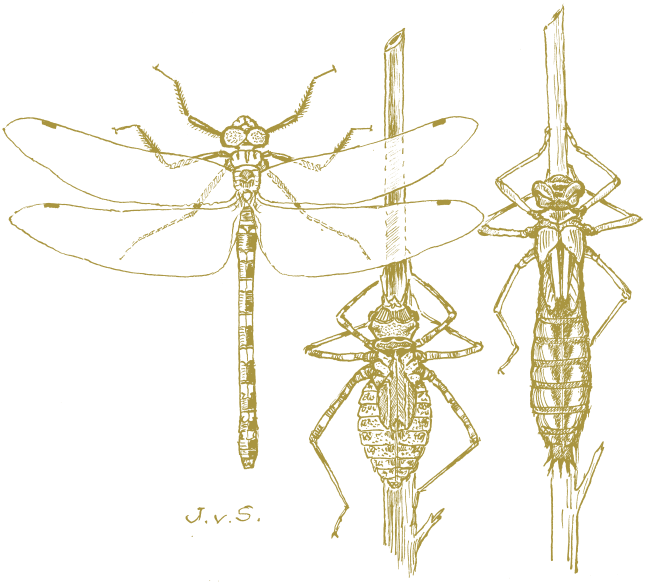
no published guidance for determining the intermediate forms was available, we used the unpublished six-point system described by Donnelly. This system was based on a continuum of combined characteristics from V0 to V5; we somewhat arbitrarily determined specimens in categories V0 and V1 as Northern Bluet, those in categories V2 and V3 as intermediates, and those in categories V4 and V5 as Vernal Bluet. Donnelly had determined eleven specimens we sent to him in 2002; the determinations of these specimens by Donnelly and the determinations of the same specimens by the senior author agreed to within one point on each specimen.

Because most damselfly nymphs and exuviae were time-consuming and uncertain to identify, records of damselflies are largely based on in-hand examinations (usually) or photographs of adult specimens, except that about 200 damselfly nymph determinations were contracted out to Dr. Ken Tennessen for the 1996 nymph survey. Additionally, the senior author made a small number of species determinations of nymphs and exuviae of broad-winged damsels (*Calopteryx*).

All retained adult odonate specimens, including reared tenerals, were soaked in acetone overnight, dried for several hours, and stored in polypropylene envelopes along with 3" X 5" index cards on which the collection information was written (date, location, species, collector, and determiner). Nymphs and exuviae were stored in vials containing 80% ethanol along with date and location labels. Thousands of representative adult specimens, nymphs, and exuviae (both reared and unassociated) were retained and are housed in the Odonata Collection of the Wisconsin DNR in Superior, which is managed by the senior author. Upon his retirement, these specimens will be curated in the Wisconsin Insect Research Collection (WIRC) at the University of Wisconsin-Madison.

Detection Effectiveness According to Life Stage

Odonate Surveys on the property were not designed to test any specific hypotheses about detection of taxa based on targeting the various life stages (adults, nymphs, or exuviae, which are representative of pharate adults); rather, we used inductive inference to arrive at likely explanations afforded by a large dataset. Specifically, we sought to examine relationships between survey effort and effectiveness in detecting life stages of the most common families and genera of dragonflies in the BRW&SF (genera with less than 50 individuals detected were excluded from this analysis). Damselflies were also excluded from this analysis because only adult damselflies were regularly targeted. Survey visits were usually not timed, so survey effort was approximated by the number of surveys, and results are accordingly only suggestive. We also note that most surveys were non-random in that they were skewed towards sampling life stages that we thought *a priori* would be most productive given the type of habitat, species of primary interest, and time of year. Further, all conclusions about detection are based only on the primary sampling methods used in this study; binoculars and cameras with various types of telephoto and close-up lenses were usually not used.



Results and Discussion

Taxonomic Summary

Ninety-three species of Odonata (66 species of dragonflies, 27 species of damselflies) were documented during 705 visits to 94 sites within the BRW&SF over a 36-year period (Table 3). This total comprises about 75% of the species known to occur in Douglas County, and 56% of the species known to occur in Wisconsin (**http://wiatri.net/inventory/odonata/**). The most commonly documented odonate species, arranged both according to the number of records and the number of individuals reported, are given in Table 4. In a combined assessment of commonness that considered both how widespread a species was on the property and how abundant the species was at sites where it occurred, the most commonly documented dragonflies in the BRW&SF were White-faced Meadowhawk (*Sympetrum obtrusum*), Chalk-fronted Corporal (*Ladona Julia*), and Boreal Snaketail (*Ophiogomphus colubrinus*), all with more than 80 records and with more than 700 individuals of each recorded. The most commonly documented damselflies were Sedge Sprite (*Nehalennia irene*), Marsh Bluet (*Enallagma ebrium*), Hagen's Bluet (*E. hageni*), and Eastern Forktail (*Ischnura verticalis*), all with more than 50 records and more than 300 individuals of each recorded.

No state or federally threatened or endangered odonates were found in the BRW&SF, but the following species of special concern were documented (Table 3): Mottled Darner (*Aeshna clepsydra*), Pronghorn Clubtail (*Phanogomphus graslinellus*), Plains Emerald (*Somatochlora ensigera*), and Forcipate Emerald (*S. forcipata*). The special concern status assigned to all four species (SC/N) does not carry with it any laws regulating use, possession, or harvesting of specimens.

Despite the extensive survey effort directed at a wide array of habitat types on the property, this list of species is almost certainly not complete. Based on the known preferred habitats and distributions of all odonate species known to occur in Wisconsin, it is probable that up to 15 species that occupied habitat on the property were not detected. Summaries of odonates recorded by family, along with taxonomic and habitat notes, and alerts to species that could yet be found on the property, are provided below.

KEN TENNESSEN

*A Springtime Darner (*Basiaeschna janata*), a species that occurs at least occasionally at a variety of ponds, lakes and other slow-flowing waters.*

Darners (Aeshnidae) – Ten species in four genera of these large, strong-flying dragonflies were recorded in the BRW&SF, with 1,409 individuals documented (Table 3). This total includes the SC/N Mottled Darner, one adult of which was collected at Smith Lake (SL3). It is not known if a breeding population of this species was present or has persisted at the site, or if the individual was a vagrant. Canada Darner (*Aeshna canadensis*), Variable Darner (*Aeshna interrupta*), Black-tipped Darner (*Aeshna tuberculifera*), Common Green Darner (*Anax junius*), and Springtime Darner (*Basiaeschna janata*) occur at least occasionally at a variety of ponds, lakes and other slow-flowing waters in northern Wisconsin and all were found to have numerous breeding populations in the BRW&SF. Canada Darner and Common Green Darner were the most common species of darners. Lance-tipped Darner (*Aeshna constricta*) and Lake Darner (*Aeshna eremita*) occurred uncommonly in the BRW&SF; both are fairly common in their restricted habitat types in northern Wisconsin. Fawn Darner (*Boyeria vinosa*) and Shadow Darner (*Aeshna umbrosa*) are well-known denizens of forested streams and small rivers statewide, and both were common in the BRW&SF. Similar in appearance to the Fawn Darner is the Ocellated Darner (*Boyeria grafiana*), which quite surprisingly has never been found in Wisconsin despite considerable efforts made to look for it; it is common in tributaries to Lake Superior along the Minnesota north shore as far south as the City of Duluth. It inhabits clear, rocky streams on granitic landscapes and could possibly turn up in the BRW&SF. Other uncommon darners that could yet be found in the BRW&SF include Zigzag Darner (*Aeshna sitchensis*), Subarctic Darner (*Aeshna subarctica*), Green-striped Darner (*Aeshna verticalis*), and Harlequin Darner (*Gomphaeschna furcillata*). Although populations of all four of these species are known to occur within an 80-km radius of the Town of Brule, they all require pools, ponds, or alder swamps within or near extensive, open, and well-hydrated peatlands, which are largely lacking in the BRW&SF.

DAN JACKSON

*A Zebra Clubtail (*Stylurus scudderi*), a distinctively marked species that occurs commonly in the BRW&SF but not in many other places.*

Clubtails (Gomphidae) – Thirteen species in seven genera of these attractively patterned dragonflies were recorded in the BRW&SF, with 1,916 individuals documented (Table 3). This total includes a robust population of the uncommon Pronghorn Clubtail (SC/N) at the north end of Upper St. Croix Lake; this species was also found to occur in Lake Nebagamon. Clubtail dragonflies can be conveniently divided into primarily lentic and primarily lotic groups. Among the primarily lentic species found in the BRW&SF were two that are common or occasional statewide–Horned Clubtail (*Arigomphus cornutus*) and Dusky Clubtail (*Phanogomphus spicatus*); the former was infrequently encountered in small ponds, and the latter was common in lentic systems of various sizes throughout the BRW&SF. Among primarily lotic clubtails were strong populations of Zebra Clubtail (*Stylurus scudderi*) and Boreal Snaketail, both of which were well-represented throughout the Bois Brule River mainstem and in some tributaries. We note that the nymphs of snaketail dragonflies (genus *Ophiogomphus*) are difficult to identify to species (Smith and Tennessen 2016), and that in an earlier publication on aquatic insects of the Bois Brule River watershed (DuBois 1993), nymphs of Boreal Snaketail were misidentified as Riffle Snaketail (*O. carolus*), which was not found in the BRW&SF. Riffle Snaketail does occur in nearby tributaries to Lake Superior in Douglas County (the Amnicon and Middle rivers have robust populations), so it could occur in the BRW&SF. Other lotic clubtails found in the Bois Brule River mainstem included Mustached Clubtail (*Hylogomphus adelphus*), Green-faced Clubtail (*H. viridifrons*), Ashy Clubtail (*Phanogomphus lividus*), Rusty Snaketail (*Ophiogomphus rupinsulensis*), and Arrow Clubtail (*Stylurus spiniceps*). These species were infrequently encountered, except for Ashy Clubtail, which was fairly common. Most clubtail dragonflies that inhabit lotic systems prefer larger, warmwater or coolwater rivers, a type of habitat lacking in the BRW&SF. Dragonhunter (*Hagenius brevistylus*), Black-shouldered Spinyleg (*Dromogomphus spinosus*), and Lancet Clubtail (*Phanogomphus exilis*) are ubiquitous species statewide in both lentic and slower lotic habitats; these species were occasionally found in the BRW&SF. Other clubtail dragonflies that likely occupy habitat on the property include Lilypad Clubtail (*Arigomphus furcifer*), which inhabits ponds with dense areas of aquatic vegetation, especially waterlilies; Common Sanddragon (*Progomphus obscurus*), which inhabits lentic or slow-flowing waterbodies with extensive sand substrates; and Eastern Least Clubtail (*Stylogomphus albistylus*), which inhabits small, forested rivers and streams with moderate current.

DAN JACKSON

*An Arrow Spiketail (*Cordulegaster obliqua*), a large dragonfly that frequents tiny forested streams.*

Spiketails (Cordulegastridae) – Spiketails are large dragonflies, strikingly patterned in black and yellow, that are found in forested flowing waters statewide, except in Wisconsin's extreme southern counties. Two species of spiketails in the genus *Cordulegaster* were found in the BRW&SF (Table 3). Twin-spotted Spiketail (*Cordulegaster maculata*) was common in small to large streams, including the Bois Brule River mainstem, which is consistent with its common distribution in forested lotic systems. The much less common Arrow Spiketail (*Cordulegaster obliqua*) was found in several small forested tributaries and seeps, and along one section of the Bois Brule River mainstem near the mouth of a small tributary. No other species of spiketails are likely to be found within the BRW&SF.

Cruisers (Macromiidae) – Two species of cruisers in two genera are widespread in cool to warmwater rivers, larger streams, and larger lakes in Wisconsin; both were occasionally found in the BRW&SF (Table 3). Swift River Cruiser (*Macromia illinoiensis*) was uncommonly found in the river mainstem and occasionally in the larger lakes. Stream Cruiser (*Didymops transversa*) was limited to the larger lakes. Both species were likely limited in their distribution in the BRW&SF by the coldwater habitats, which they do not favor. No other species of cruisers are likely to be found in the BRW&SF.

Emeralds (Corduliidae) – Fifteen species in five genera of these often secretive and elusive dragonflies were recorded in the BRW&SF, with 1,277 individuals documented (Table 3). The most important genus, both numerically and in terms of uncommon species, and perhaps the most interesting, is the striped emeralds (*Somatochlora*), eight species of which were recorded. The striped emeralds are generally uncommon throughout their North American ranges, and their breeding sites can be frustratingly hard to find. They can be placed in two groups: those that inhabit streams, and those that inhabit shallow, usually open peatlands (bogs and fens). Within the stream-inhabiting group were Ski-tipped Emerald (*Somatochlora elongata*), Plains Emerald, and Ocellated Emerald (*S. minor*), all of which require slower-flow areas, such as undercut banks, quiet runs, pools, and backwaters, for nymph development. Ski-tipped Emerald is uncommon statewide, preferring slow sections of trout streams and beaver impoundments; it was well represented in slow reaches of the upper portion of the Bois Brule River's mainstem. Plains Emerald is rare statewide (SC/N) in the lower reaches of Lake Superior tributaries and a few other widely separated areas of the state. It appears to need undercut bank areas for nymph habitat (DuBois and Tennessen 2008) and was limited in the BRW&SF to the lower section of Pearson Creek (T22) in the red clay lake plain. Ocellated Emerald is the most common species of *Somatochlora* statewide and was the most common *Somatochlora* in the BRW&SF, occurring consistently in small, forested streams. Peatland-inhabiting species of *Somatochlora* were limited in the BRW&SF because the open, well-hydrated peatland habitats in which they thrive are not extensive here. The peatland-obligate species found were Delicate Emerald (*S. franklini*), Forcipate Emerald, and Kennedy's Emerald (*S. kennedyi*), but they were infrequently encountered. Brush-tipped Emerald (*S. walshii*) is restricted to habitats of slowly flowing water through peatlands (DuBois et al. 2015); adults were found at only two locations in the BRW&SF, so exact locations of breeding sites on the property are unknown. Williamson's Emerald (*S. williamsoni*) is unusual for a *Somatochlora* in that the nymphs can use a wide range of habitats including peatlands, small ponds, and slow streams; a few adults were found at scattered locations within the BRW&SF.

Among other emeralds, American Emerald (*Cordulia shurtleffii*) and Racket-tailed Emerald (*Dorocordulia libera*) were both common in lentic habitats throughout the BRW&SF (Table 3). Four species of Baskettail (genus *Epitheca*) were similarly common in lentic habitats; Beaverpond Baskettail (*Epitheca canis*), Common Baskettail (*E. cynosura*), Prince Baskettail (*E. princeps*), and Spiny Baskettail (*E. spinigera*) are all common statewide as well. Ebony Boghaunter (*Williamsonia fletcheri*) is a small, uncommon, bog-obligate emerald that was found at two small peatlands within the BRW&SF. No other species of emeralds are expected to be found in the BRW&SF, but unexpected discoveries within this family are certainly possible.

DAN JACKSON

*A Halloween Pennant (*Celithemis eponina*), a species that is fairly common statewide, but uncommon in the BRW&SF.*

Skimmers (Libellulidae) – Twenty-four species in ten genera of these often showy, lentic-system dragonflies were recorded in the BRW&SF, with the 5,142 individuals documented being more than twice that of any other family of Odonata (Table 3). None of the skimmers found in the BRW&SF were uncommon or ranked as being of special concern. Halloween Pennant (*Celithemis eponina*), Eastern Pondhawk (*Erythemis simplicicollis*), Widow Skimmer (*Libellula luctuosa*), Blue Dasher (*Pachydiplax longipennis*), Wandering Glider (*Pantala flavescens*), Spot-winged

Glider (*Pantala hymenaea*), and Band-winged Meadowhawk (*Sympetrum semicinctum*) are all species that are common or fairly common statewide, but they were uncommon in the BRW&SF, either because they are near the northern edge of their current ranges, or because their preferred habitats were not abundant. Calico Pennant (*Celithemis elisa*) was fairly common at a variety of lentic and slow-flowing habitats. Chalk-fronted Corporal is a gregarious species that was abundant at many lentic habitats.

The genus of whitefaces (*Leucorrhinia*) comprises a generally northern group of small skimmers with five Upper Midwestern species that were all well-represented in the BRW&SF: Belted Whiteface (*Leucorrhinia proxima*), Crimson-ringed Whiteface (*L. glacialis*), Dot-tailed Whiteface (*L. intacta*), Frosted Whiteface (*L. frigida*), and Hudsonian Whiteface (*L. hudsonica*). Nymphs of Belted Whiteface were not detected during the 1996 nymph survey, not because they were not present in the BRW&SF, but because available keys to the genus needed improvement (DuBois 2003).

Twelve-spotted Skimmer (*Libellula pulchella*) and Four-spotted Skimmer (*L. quadrimaculata*) are relatively large species within the genus of king skimmers (*Libellula*) that are common statewide; they were common in the BRW&SF as well. Elfin Skimmer (*Nannothemis bella*) is a tiny, uncommon dragonfly statewide due to its restricted, shallow-peatland habitat, and just one individual was found at a small peatland near Lake Nebagamon. Common Whitetail (*Plathemis lydia*) is common statewide in its generally shallow, mud-bottomed habitat, as it was in the BRW&SF.

Meadowhawks (genus *Sympetrum*) are small, often abundant skimmers of generally shallow, often fishless ponds and wetlands; seven species were found in the BRW&SF. Variegated Meadowhawk (*Sympetrum corruptum*) is an irregular migrant in northern Wisconsin that was seen only once in the BRW&SF at the US 2 Pond. It is unlikely to breed consistently in the BRW&SF. White-faced Meadowhawk and Autumn Meadowhawk (*S. vicinum*) are common species statewide that were common here as well. Band-winged Meadowhawk, which often favors habitats with some spring-fed input, was surprisingly uncommon here, with only one individual found in a wetland near the mouth of the Bois Brule River. Saffron-winged Meadowhawk (*S. costiferum*), Black Meadowhawk (*S. danae*), and Cherry-faced Meadowhawk (*S. internum*) were all found occasionally in appropriate habitats throughout the BRW&SF.

Other species of skimmers that could occur in the BRW&SF include Eastern Amberwing (*Perithemis tenera*), which inhabits a wide variety of mud-bottomed lentic systems, usually in open landscapes, and several species of saddlebags (genus *Tramea*). Most saddlebags are known to be migratory or are capable of dispersing for considerable distances; in any case, the BRW&SF is near or just beyond the known northern edge of the ranges of several species. A red-colored species of saddlebags was seen at a small peatland along After Hours Road; it could have been either Red Saddlebags (*T. onusta)* or Carolina Saddlebags (*T. carolina*), but efforts to net it were unsuccessful and the presence of a consistent breeding population of either species on the property is unlikely.

Broad-winged Damsels (Calopterygidae) – This family of large, showy damselflies features four species in two genera in Wisconsin that inhabit flowing waters. Two of these, in the genus of jewelwings (*Calopteryx*), were found in the BRW&SF (Table 3). Ebony Jewelwing (*Calopteryx maculata*) was abundant in forested and semi-open reaches of flowing waters of all sizes throughout the BRW&SF. River Jewelwing (*C. aequabilis*) was common in the Bois Brule River mainstem and in larger tributaries. No other species of broad-winged damsels are expected to occur in the BRW&SF.

Spreadwings (Lestidae) – Pond spreadwing damselflies (genus *Lestes*) were well-represented in the BRW&SF, with nine of the ten species known from Wisconsin occurring on the property (Table 3). Pond spreadwings inhabit lentic systems that span the full range of water permanence from temporary (vernal) pools to large lakes, and they can be roughly divided into groups depending on the extent to which they are able to coexist with fish. Emerald Spreadwing (*Lestes dryas*) thrives in small, usually temporary ponds that lack both fish and dragonfly predators; one specimen was found in the Brule Bog near the east end of Stone Chimney Road where a breeding site (not found) was presumed to be nearby. Northern Spreadwing (*L. disjunctus*), Sweetflag Spreadwing (*L. forcipatus*), Slender Spreadwing (*L. rectangularis*), and Lyre-tipped Spreadwing (*L. unguiculatus*) all occurred commonly or occasionally in the BRW&SF; they do best in ponds and wetlands that occasionally dry up and that therefore lack fish. Of this group, Northern and Slender spreadwings were the most common, the latter preferring shaded pond and wetland margins. Amber-winged Spreadwing (*L. eurinus*) requires permanent, shallow ponds that either lack fish or have them at low densities. Spotted Spreadwing (*L. congener*) is a common and widespread species that is sometimes overlooked because of its late-season flight period. Swamp Spreadwing (*L. vigilax*) and the uncommon Elegant Spreadwing (*L. inaequalis*, S2S3) were infrequently found in the larger lakes at the opposite end of the water permanence spectrum because they have a greater tolerance for fish predators than most species of pond spreadwings. No other species of pond spreadwings are expected to have breeding populations in the BRW&SF, although Southern Spreadwing (*L. australis*), a generally southern species in the United States, evidently disperses widely and a single specimen was found about 12 km west of the BRW&SF.

Pond Damsels (Coenagrionidae) – Sixteen species in seven genera in this most common family of damselflies were recorded in the BRW&SF, with 2,208 individuals documented (Table 3). There were no special concern pond damsels, but two species complexes, and the rarity status of a third species, merit some discussion.

Western Red Damsel (*Amphiagrion abbreviatum*) was uncommonly found at four sites within the BRW&SF, but its taxonomic status remains somewhat uncertain. Individuals within this transcontinental genus differ from east to west–in coloration, morphology and their preferred habitats. Currently, two species are recognized

by most Odonata specialists, the Western Red Damsel and Eastern Red Damsel (*A. saucium*), but specimens in the Upper Midwest are intermediate in some characteristics between the two species, which has caused some discussion that a third species be named, while others argue that all red damsels in North America should be considered a single, highly variable species. The most recent genetic and morphologic evidence suggests that the species in the BRW&SF is most like the Western Red Damsel (and so it is listed here), but not long ago the reverse was thought to be correct. More study of this species complex is warranted.

A second species of taxonomic concern is the Vernal Bluet, which is considered a valid species by most specialists, but only a variant or subspecies of Northern Bluet by others. In some areas the two forms appear to behave as distinct, valid species, differing in habitat, habits, and flight period, but in other areas, including the Upper Midwest, they appear to intergrade (hybridize) extensively, and are sometimes found at the same sites on the same dates. It has not been proven, however, that the intermediate forms are truly hybrids, and more study of this species complex is clearly warranted. Pure or relatively pure forms of both species (aka end-point forms), as well as intermediate forms, were found at ten sites in the BRW&SF, with both species being found at four sites. Of 65 specimens collected within this species complex, 34 specimens were determined as Northern Bluet, 15 specimens as Vernal Bluet, and 16 specimens were considered intergrades (*Enallagma* spp.). We note, however, that most specimens of Vernal Bluet had some shading of characteristics toward Northern Bluet and vice versa. Vernal Bluet is generally considered to have an earlier flight period than Northern Bluet, and we found some evidence of that in the BRW&SF; seven specimens collected in May were all determined as Vernal Bluet. However, both species, and numerous intergrades, were found in June and July. All three forms were found in waterbodies that lacked centrarchid fishes, but only Vernal Bluet was found in lakes with those fishes. Vernal Bluet is currently state-ranked as S1Q in Wisconsin.

The third point of discussion regarding pond damsels involves the Alkali Bluet (*Enallagma clausum*), which is common in the western United States west of the Mississippi River where it occurs in mostly alkaline lakes of various sizes. At the eastern part of its range in Minnesota and Wisconsin it is only known to inhabit the shorelines of a few very large lakes with typical water chemistry. In Wisconsin, it is known only from the western shoreline of Lake Superior in Douglas and Bayfield counties (DuBois et al. 2004). It has not yet been found within the boundaries of the BRW&SF, and therefore is not included in Table 3, but it has been found both to the east and to the west of the mouth of the Bois Brule River, and it is likely just a matter of time before it is found within the boundaries of the Brule River State Forest. It is state-ranked as S1 because of extreme rarity, but it has not yet been given a formal rarity designation because more information is needed about its distribution and nymphal habitat.

Beyond these concerns, the most important genus of pond damsel in the BRW&SF, both in general abundance and in number of species, is the American bluets (*Enallagma*), with ten species within the genus known to occur on the property (Table 3). Marsh Bluet and Hagen's Bluet are abundant at lentic habitats both statewide and in the BRW&SF. Boreal Bluet (*E. boreale,* similar in appearance and closely related to the Northern and Vernal bluets discussed above), which has a very early and short flight period, was occasionally found in a variety of lentic systems on the property. Tule Bluet (*E. carunculatum*) and Orange Bluet (*E. signatum*) are mostly found in the larger lakes in the BRW&SF. Familiar Bluet (*E. civile*) is known to rapidly colonize newly made ponds and has a bimodal flight period in northern Wisconsin; it was infrequently encountered in various habitat types in the BRW&SF. Vesper Bluet (*E. vesperum*) was documented only at Gander Lake in the BRW&SF, but it is likely under-detected because of its crepuscular habits, and would be expected in well-vegetated parts of most of our lakes. Stream Bluet (*E. exsulans*) is very common in flowing waters throughout most of Wisconsin, but it is not commonly seen near the northern edge of its range in northern Wisconsin. Sparse populations were found in the upper portion of the Bois Brule River mainstem and in Lake Nebagamon.

KEN TENNESSENN

*A Variable Dancer (*Argia fumipennis violacea*), a species not yet documented in BRW&SF but likely to be found there with more survey effort.*

Aurora Damsel (*Chromagrion conditum*) is a mostly flowing water species that was occasionally encountered in streams and tributaries of the BRW&SF. Dancers (genus *Argia*) are an additional flowing-water group of damselflies that prefer warmer waters and are largely absent from cold-water systems like the Bois Brule River. A few scattered adults of Powdered Dancer (*Argia moesta*) were observed on the southern portion of the river's mainstem. Eastern Forktail and Sedge Sprite were two of the most common damselflies at a wide variety of habitat types in the BRW&SF; both species are abundant throughout northern Wisconsin. In addition to Alkali Bluet, several other pond damsels, including Variable Dancer (*Argia fumipennis violacea*), Subarctic Bluet (*Coenagrion interrogatum*), Azure Bluet (*Enallagma aspersum*), and Skimming Bluet (*E. geminatum*) are likely to be found in the BRW&SF with more survey effort.

Table 3. *Numbers of records of odonates documented by species, their global and state status (based on NatureServe; na=not applicable), the number of individuals identified (total numbers of individuals in parentheses; A=adults, T=tenerals, N=nymphs, E=exuviae), and sites where they were found within the BRW&SF (site codes defined in Appendix A), 1984–2018. A record is the documented occurrence of a species at a site on a given date, regardless of the number of individuals observed or collected.*

Common Name	Scientific Name	Status		Number of Records (A&T/N&E)	Sites Where Recorded
		Global	State		
ANISOPTERA					
Darners (Family Aeshnidae)					
Canada Darner	*Aeshna canadensis*	G5	S5	79 (247/48)	R1, R2, R4, R5, R7, R9, T4, T24, W3, W10, P2, P5, P8, P10, P11, P13, P18, SL2, SL3, SL6, SL7, LL2, LL3, U1, U2, U4
Mottled Darner	*Aeshna clepsydra*	G4	S2S3*	1 (1/0)	SL3
Lance-tipped Darner	*Aeshna constricta*	G5	S4	1 (0/1)	W9
Lake Darner	*Aeshna eremita*	G5	S3	7 (9/6)	W10, P8, U1
Variable Darner	*Aeshna interrupta*	G5	S5	30 (108/68)	R2, R3, R5, T10, S3, P5, P8, P10, SL2, SL3, SL4, U1
Black-tipped Darner	*Aeshna tuberculifera*	G4	S3	25 (32/51)	T17, P2, P5, P8, P11, P18, SL3, SL4, SL8
Shadow Darner	*Aeshna umbrosa*	G5	S5	65 (142/69)	R1, R2, R3, R4, R5, R7, R8, R9, T3, T4, T6, T7, T8, T10, T12, T13, T14, T15, T16, T18, T20, T22, T23, T24, T25, T26, S2, S3, W7, P5, P8, P10, P14, LL1, U2, EC2
Common Green Darner	*Anax junius*	G5	S5	103 (335/81)	R4, R5, R8, T4, T15, T16, S3, W2, W7, W9, P8, P10, P15, SL2, SL3, SL4, SL5, SL6, SL7, LL1, LL2, LL3, U1, U2
Springtime Darner	*Basiaeschna janata*	G5	S4	14 (7/13)	T7, SL5, SL7, LL1, LL2, LL3, LL4, LL5, EC2
Fawn Darner	*Boyeria vinosa*	G5	S5	51 (131/61)	R1, R2, R3, R4, R5, R6, R7, R8, R9, T1, T10, T12, T16, T17, T20, W6, P10, EC1
Darner totals	**10 species**			**372 (1012/397)**	**(R=9; T=21; S=2; W=6; P=9; SL=7; LL=5; U=3; EC=2) 64 sites**
Clubtails (Family Gomphidae)					
Horned Clubtail	*Arigomphus cornutus*	G4	S3S4	10 (13/5)	T21, P8, P10
Black-shouldered Spinyleg	*Dromogomphus spinosus*	G5	S4	14 (22/10)	R4, R5, P10, SL7, LL1, LL2, EC1
Dragonhunter	*Hagenius brevistylus*	G5	S4	5 (14/3)	R5, T17, T19, LL2, EC2
Mustached Clubtail	*Hylogomphus adelphus*	G4	S3S4	5 (1/4)	R2, R6, R7, T7
Green-faced Clubtail	*Hylogomphus viridifrons*	G3G4	S4	1 (0/1)	R9
Boreal Snaketail	*Ophiogomphus colubrinus*	G5	S4	83 (140/592)	R1, R2, R3, R4, R5, R6, R7, R8, R9, T3, T4, T10, T16, T17, W6, P10, EC1

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Table 3. *Continued.*

Common Name	Scientific Name	Status		Number of Records (A&T/N&E)	Sites Where Recorded
		Global	State		
Clubtails (Family Gomphidae) *continued*					
Rusty Snaketail	*Ophiogomphus rupinsulensis*	G5	S4	6 (5/1)	R2, R5, R8, EC2
Lancet Clubtail	*Phanogomphus exilis*	G5	S4	6 (0/70)	SL3, SL4
Pronghorn Clubtail	*Phanogomphus graslinellus*	G5	S2S3*	11 (12/51)	LL1, LL2
Ashy Clubtail	*Phanogomphus lividus*	G5	S4	19 (24/19)	R5, R7, T7, T17, T29, P5, LL1, EC2
Dusky Clubtail	*Phanogomphus spicatus*	G5	S5	62 (225/545)	R5, T15, T16, T20, S1, W3, W7, P5, P8, P10, SL2, SL3, SL5, SL6, SL7, SL9, SL10, LL1, LL2, LL3, U2
Zebra Clubtail	*Stylurus scudderi*	G4	S3	45 (86/70)	R1, R3, R5, R7, R9, T4, T9, T14, T15, T16, T17, W6, P10, EC1
Arrow Clubtail	*Stylurus spiniceps*	G5	S4	3 (0/3)	R5, EC1, EC2
Clubtail Totals	**13 species**			**270 (542/1374)**	**(R=9; T=14; S=1; W=3; P=3; SL=8; LL=3; U=1; EC=2) 44 sites**
Spiketails (Family Cordulegastridae)					
Twin-spotted Spiketail	*Cordulegaster maculata*	G5	S4	76 (121/155)	R1, R3, R5, R6, R7, R8, R9, T1, T3, T9, T10, T12, T14, T15, T16, T17, T27, T28, S5, P10, EC1
Arrow Spiketail	*Cordulegaster obliqua*	G4	S3	6 (6/3)	R7, T3, T10, T13, S5
Spiketail Totals	**2 species**			**82 (127/158)**	**(R=7; T=12; S=1; W=0; P=1; SL=0; LL=0; U=0; EC=1) 22 sites**
Cruisers (Family Macromiidae)					
Stream Cruiser	*Didymops transversa*	G5	S4	11 (10/30)	W2, P18, SL7, LL1, LL2, LL5
Swift River Cruiser	*Macromia illinoiensis*	G5	S4	5 (3/2)	R4, R8, T7, P10, LL2
Cruiser Totals	**2 species**			**16 (13/32)**	**(R=2; T=1; S=0; W=1; P=2; SL=1; LL=3; U=0) 10 sites**
Emeralds (Family Corduliidae)					
American Emerald	*Cordulia shurtleffii*	G5	S5	63 (111/124)	R2, R5, T1, T3, T15, T20, T29, W1, W10, P3, P4, P5, P7, P8, P11, SL1, SL2, SL3, SL6, SL7, SL10, LL2, U2
Racket-tailed Emerald	*Dorocordulia libera*	G5	S5	17 (70/10)	T3, T4, P8, P11, P13, P15, SL2, SL6, SL7, LL1

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Table 3. *Continued.*

Common Name	Scientific Name	Status		Number of Records (A&T/N&E)	Sites Where Recorded
		Global	State		
Emeralds (Family Corduliidae) *continued*					
Beaverpond Baskettail	*Epitheca canis*	G5	S5	58 (177/35)	R2, R3, R4, R8, R9, T3, T4, T6, T7, T9, T12, T13, T15, T16, T18, T21, S1, W10, P3, P8, P10, P12, SL1, SL5, LL1
Common Baskettail	*Epitheca cynosura*	G5	S5	42 (226/55)	R2, R3, R4, R5, R7, T4, W3, W7, P10, SL2, SL5, SL6, SL7, LL1, LL2, LL3
Prince Baskettail	*Epitheca princeps*	G5	S5	26 (70/24)	R2, R3, T4, S2, W4, P4, SL5, SL7, LL1, LL2, LL4
Spiny Baskettail	*Epitheca spinigera*	G5	S5	29 (31/165)	R2, R5, T4, P8, P10, SL2, SL5, SL7, SL10, LL1, LL4, U4
Ski-tipped Emerald	*Somatochlora elongata*	G5	S2S3	15 (17/9)	R1, R2, T2, T4, T15, T16, T26, S4, P10, P14, U2
Plains Emerald	*Somatochlora ensigera*	G4	S2S3*	2 (0/12)	T22
Forcipate Emerald	*Somatochlora forcipata*	G5	S2S3*	5 (3/2)	T4, W4, W5, W12, U4
Delicate Emerald	*Somatochlora franklini*	G5	S3	4 (4/0)	T4, T16, U2
Kennedy's Emerald	*Somatochlora kennedyi*	G5	S3	10 (10/23)	R3, R5, W5, W7, W12, P10
Ocellated Emerald	*Somatochlora minor*	G5	S4	21 (17/61)	R1, T1, T3, T5, T7, T8, T9, T10, T12, T13, T21, T26, T29, S5, P5
Brush-tipped Emerald	*Somatochlora walshii*	G5	S4	3 (4/0)	T4, W4
Williamson's Emerald	*Somatochlora williamsoni*	G5	S4	6 (2/6)	T29, W10, P2, P5, P8, P18
Ebony Boghaunter	*Williamsonia fletcheri*	G4	S3S4	6 (2/7)	W2, W7
Emerald Totals	**15 species**			**307 (744/533)**	**(R=8; T=20; S=4; W=8; P=12; SL=7; LL=4; U=2) 65 sites**
Skimmers (Family Libellulidae)					
Calico Pennant	*Celithemis elisa*	G5	S5	23 (71/19)	T11, T15, T16, W3, W5, W7, P10, P13, SL3, SL5, SL9, LL1
Halloween Pennant	*Celithemis eponina*	G5	S4	1 (1/0)	LL1
Eastern Pondhawk	*Erythemis simplicicollis*	G5	S5	2 (2/0)	R5, LL3
Chalk-fronted Corporal	*Ladona julia*	G5	S5	96 (699/106)	R5, T4, T5, T15, S1, W5, W7, W10, P1, P4, P5, P8, P9, P10, P13, P19, SL2, SL3, SL4, SL5, SL6, SL7, SL10, LL1, LL2, LL3, LL4, U4
Frosted Whiteface	*Leucorrhinia frigida*	G5	S4	39 (182/25)	T4, S1, W1, W2, W10, P8, P11, P12, P13, SL2, SL3, SL6, SL7, SL8, SL10
Crimson-ringed Whiteface	*Leucorrhinia glacialis*	G5	S4	33 (280/12)	R2, W2, W7, P8, P10, P11, P13, SL2, SL3, SL5, SL6, SL10, LL2

Continued on next page

Table 3. *Continued.*

Common Name	Scientific Name	Status		Number of Records (A&T/N&E)	Sites Where Recorded
		Global	State		
Skimmers (Family Libellulidae) *continued*					
Hudsonian Whiteface	*Leucorrhinia hudsonica*	G5	S4	48 (107/149)	R2, T4, S1, W1, W2, W3, W5, W7, W12, P3, P4, P5, P7, P8, P11, P19, SL1, SL3, SL6, SL10
Dot-tailed Whiteface	*Leucorrhinia intacta*	G5	S5	78 (263/295)	T3, T4, T15, W1, W5, W10, P2, P3, P4, P5, P8, P10, P11, P12, P16, P18, SL2, SL3, SL5, SL7, SL10, LL1, LL3
Belted Whiteface	*Leucorrhinia proxima*	G5	S4	49 (481/79)	T4, W2, W3, W5, W7, W8, P1, P4, P5, P8, P11, P13, SL2, SL3, U4
Widow Skimmer	*Libellula luctuosa*	G5	S5	4 (6/0)	W5, W10, P17, LL1
Twelve-spotted Skimmer	*Libellula pulchella*	G5	S5	63 (293/42)	R4, R5, T4, T10, T11, T12, T15, T16, T18, T19, T20, T21, T22, S1, S3, S4, W8, W10, P5, P7, P8, P10, P12, P15, P16, P17, SL2, SL3, SL5, SL6, SL7, LL1, U3
Four-spotted Skimmer	*Libellula quadrimaculata*	G5	S5	83 (397/52)	R1, R2, R3, R4, R5, T3, T4, T6, T11, T15, T18, T19, T21, T22, T27, S1, S3, W2, W3, W5, W7, W8, W10, W11, P3, P4, P5, P8, P10, P11, P12, P16, SL2, SL3, SL5, SL6, SL7, SL10, LL1, U2, U3
Elfin Skimmer	*Nannothemis bella*	G4	S3	1 (1/0)	W2
Blue Dasher	*Pachydiplax longipennis*	G5	S5	5 (38/0)	SL6, LL1, LL3
Wandering Glider	*Pantala flavescens*	G5	S4	4 (2/10)	W9, P14
Spot-winged Glider	*Pantala hymenaea*	G5	S4	2 (0/3)	W9
Common Whitetail	*Plathemis lydia*	G5	S5	59 (229/9)	R1, R2, R3, R4, R5, R6, T4, T10, T11, T15, T16, T18, S3, S4, S5, P8, P10, P11, P15, P19, SL2, SL3, SL5, LL1, LL3
Variegated Meadowhawk	*Sympetrum corruptum*	G5	S4	1 (7/0)	P8
Saffron-winged Meadowhawk	*Sympetrum costiferum*	G5	S4	31 (56/22)	T6, T14, T15, W7, W9, W10, P2, P5, P8, P9, P10, P15, P18, SL2, SL3, SL5, U1, U2
Black Meadowhawk	*Sympetrum danae*	G5	S3	15 (73/0)	R1, T4, T15, S3, P8, P15, SL3, U2
Cherry-faced Meadowhawk	*Sympetrum internum*	G5	S4	8 (8/0)	W4, W5, P15, SL7, U4
White-faced Meadowhawk	*Sympetrum obtrusum*	G5	S5	96 (721/3)	R1, R2, R5, T3, T4, T6, T10, T11, T15, T18, S3, S4, W2, W5, W7, W10, P1, P2, P5, P8, P9, P10, P11, P12, P13, P15, P18, SL2, SL3, SL5, SL6, SL7, SL8, LL1, LL3, U1, U2

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Table 3. *Continued.*

Common Name	Scientific Name	Status		Number of Records (A&T/N&E)	Sites Where Recorded
		Global	State		
Skimmers (Family Libellulidae) *continued*					
Band-winged Meadowhawk	*Sympetrum semicinctum*	G5	S4	1 (1/0)	W10
Autumn Meadowhawk	*Sympetrum vicinum*	G5	S5	57 (395/3)	R1, R9, T4, T14, T15, T20, W2, W9, W10, P5, P8, P12, P13, P15, P17, SL2, SL3, SL6, SL7, SL8, LL1, LL3, U1, U2
Skimmer Totals	**24 species**			**799 (4313/829)**	**(R=7; T=16; S=3; W=11; P=18; SL=10; LL=4; U=4) 73 sites**
Dragonfly Totals	**66 species**			**1846 (6751/3323)**	**(R=9; T=29; S=5; W=12; P=18; SL=10; LL=5; U=4; EC=2) 94 sites**
ZYGOPTERA					
Broad-winged Damsels (Family Calopterygidae)					
River Jewelwing	*Calopteryx aequabilis*	G5	S5	16 (84/3)	R2, R5, T4, T12, T14, T16, T22, P10, SL2, EC1
Ebony Jewelwing	*Calopteryx maculata*	G5	S5	40 (239/4)	R3, R5, R7, R8, T1, T3, T4, T10, T11, T12, T14, T15, T17, T19, T20, T21, P10, SL6
Broad-winged Damsel Totals	**2 species**			**56 (323/7)**	**(R=5; T=14; S=0; W=0; P=1; SL=2; LL=0; U=0; EC=1) 23 sites**
Spreadwings (Family Lestidae)					
Spotted Spreadwing	*Lestes congener*	G5	S5	25 (155/4)	W2, W7, P5, P8, P12, P15, P17, SL2, SL3, U2
Northern Spreadwing	*Lestes disjunctus*	G5	S5	37 (259/4)	W6, W9, W10, P1, P3, P5, P8, P9, P11, P12, P15, P18, SL2, SL3, LL1
Emerald Spreadwing	*Lestes dryas*	G5	S4	2 (2/1)	W4, P18
Amber-winged Spreadwing	*Lestes eurinus*	G4	S3S4	8 (20/33)	W2, W7, P5, SL2, SL3
Sweetflag Spreadwing	*Lestes forcipatus*	G5	S4	8 (22/0)	P5, P8, P15, SL2, SL3
Elegant Spreadwing	*Lestes inaequalis*	G5	S2S3	6 (11/0)	SL2, SL7, LL1
Slender Spreadwing	*Lestes rectangularis*	G5	S5	26 (76/0)	R5, T18, S3, W10, P1, P5, P8, P9, P10, P11, P12, P15, SL2, SL3, SL5, SL6, LL1, LL3
Lyre-tipped Spreadwing	*Lestes unguiculatus*	G5	S5	2 (4/0)	S3, P15
Swamp Spreadwing	*Lestes vigilax*	G5	S3	16 (45/0)	S3, P15, SL5, SL7, LL1, LL3
Spreadwing Totals	**9 species**			**130 (594/42)**	**(R=1; T=1; S=1; W=6; P=11; SL=5; LL=2; U=1) 28 sites**

Continued on next page

Table 3. *Continued.*

Common Name	Scientific Name	Status		Number of Records (A&T/N&E)	Sites Where Recorded
		Global	State		
Pond Damsels (Coenagrionidae)					
Western Red Damsel	*Amphiagrion abbreviatum*	G5	S3S4	5 (86/0)	T15, T18, S3, W2
Powdered Dancer	*Argia moesta*	G5	S5	2 (2/0)	R3, R5
Aurora Damsel	*Chromagrion conditum*	G5	S3S4	12 (40/7)	R2, T4, T7, T11, T16, T18, T22, T26, P1
Taiga Bluet	*Coenagrion resolutum*	G5	S4	12 (15/12)	T29, W1, W10, P4, P5, P8, P11, P16, SL5
Northern Bluet	*Enallagma annexum*	G5	S4	10 (34/2)	W2, P1, P4, P8, P10, P15, SL3
Boreal Bluet	*Enallagma boreale*	G5	S5	23 (26/110)	T29, W1, W7, W10, P4, P5, P7, P8, P15, P19, SL3, SL10, LL1, LL3
Tule Bluet	*Enallagma carunculatum*	G5	S5	18 (94/1)	R4, W7, SL7, LL1, LL3, LL5
Familiar Bluet	*Enallagma civile*	G5	S5	7 (18/0)	W7, P15, SL3
Marsh Bluet	*Enallagma ebrium*	G5	S5	51 (432/22)	R4, T3, T4, T11, T18, T21, S1, W6, W9, W10, P1, P4, P5, P8, P9, P10, P11, P12, P15, P16, P17, SL2, SL3, SL5, SL9, SL10
Stream Bluet	*Enallagma exsulans*	G5	S5	2 (2/0)	R2, LL5
Hagen's Bluet	*Enallagma hageni*	G5	S5	51 (339/18)	R4, T4, T18, T19, W7, W9, W10, P8, P9, P10, P12, P15, P17, SL2, SL3, SL4, SL5, SL7, SL10, LL1, LL3, LL5
Orange Bluet	*Enallagma signatum*	G5	S4	7 (10/3)	SL7, LL1, LL3
Vernal Bluet	*Enallagma vernale*	G4Q	S1Q	9 (15/0)	W2, P8, P10, SL3, SL6, SL7
Vernal/Northern Bluet	*Enallagma* spp. (intergrades)	na	na	4 (16/0)	W2, P1, P8, P10
Vesper Bluet	*Enallagma vesperum*	G5	S4	8 (16/0)	SL7
Eastern Forktail	*Ischnura verticalis*	G5	S5	59 (332/5)	R2, R4, R9, T4, T18, S3, W3, W7, W9, W10, P1, P8, P15, SL2, SL5, SL7, LL1, LL3
Sedge Sprite	*Nehalennia irene*	G5	S5	75 (528/23)	R4, T3, T4, T12, T18, S1, S3, S4, W1, W2, W3, W6, W7, W9, W10, P1, P4, P5, P7, P8, P9, P10, P11, P12, P15, P16, P17, SL1, SL2, SL3, SL6, SL7, SL10, LL1
Pond Damsel Totals	**16 species**			**355 (2007/203)**	**(R=5; T=13; S=3; W=7; P=13; SL=9; LL=3; U=0) 53 sites**
Damselfly Totals	**27 species**			**541 (2924/252)**	**(R=7; T=18; S=3; W=8; P=15; SL=9; LL=3; U=3) 66 sites**
Odonata Total	**93 species**			**2387 (9675/3575)**	**(R=9; T=29; S=5; W=12; P=18; SL=10; LL=5; U=4; EC=2) 94 sites**

*SC/N

Table 4. *The 20 most common odonate species in the BRW&SF, 1984–2018, arranged in order of number of records (at least 50) and the number of individuals (at least 250; a record is the documented occurrence of a species at a site on a given date, regardless of the number of individuals observed or collected).*

Common Name	Number of Records	Common Name	Number of Individuals Recorded
Common Green Darner	103	Chalk-fronted Corporal	805
White-faced Meadowhawk	96	Dusky Clubtail	770
Chalk-fronted Corporal	96	Boreal Snaketail	732
Boreal Snaketail	83	White-faced Meadowhawk	724
Four-spotted Skimmer	83	Belted Whiteface	560
Canada Darner	79	Dot-tailed Whiteface	558
Dot-tailed Whiteface	78	Sedge Sprite	551
Twin-spotted Spiketail	76	Marsh Bluet	454
Sedge Sprite	75	Four-spotted Skimmer	449
Shadow Darner	65	Common Green Darner	416
Twelve-spotted Skimmer	63	Autumn Meadowhawk	398
American Emerald	63	Hagen's Bluet	357
Dusky Clubtail	62	Eastern Forktail	337
Eastern Forktail	59	Twelve-spotted Skimmer	335
Common Whitetail	59	Canada Darner	295
Beaverpond Baskettail	58	Crimson-ringed Whiteface	292
Autumn Meadowhawk	57	Common Baskettail	281
Fawn Darner	51	Twin-spotted Spiketail	276
Hagen's Bluet	51	Northern Spreadwing	263
Marsh Bluet	51	Hudsonian Whiteface	256

Surveys and Species Detections at the US 2 Pond

A total of 39 odonate species were detected during 72 visits to the US 2 Pond, which included 27 species of dragonflies (Table 5) and 12 species of damselflies (Table 6). Only 51 of the 72 visits were considered full survey visits for reasons given in the Methods section. The best represented families were the skimmers (14 Species), pond damsels (8 species), darners (6 species), and pond spreadwings (4 species). The most commonly detected dragonflies were Common Green Darner, Canada Darner, and Belted Whiteface. The most commonly detected damselflies were Sedge Sprite, Marsh Bluet, and Spotted Spreadwing. Two of the species detected, Common Green Darner and Variegated Meadowhawk, are known to have migratory components to their life history; the latter species is likely a vagrant in the BRW&SF. Species requiring flowing waters, large lakes, or bogs and fens (bog-obligate species) were not detected or expected at the US 2 Pond.

Twenty five of the 27 species of dragonflies found at the US 2 Pond were detected as adults, and 12 of those species were detected only as adults (Table 5). One species was detected twice only in the nymph stage (Racket-tailed Emerald) and one species was detected only from a single exuvia (Spiny Baskettail). Darners, clubtails, emeralds, and some skimmers were readily identifiable as adults, nymphs, or exuviae, so all life stages were sought for these groups. Some skimmers, especially those in the meadowhawk genus, were uncertain to identify as nymphs, so adults were targeted in that genus. All damselflies were detected only as adults because nymphs and exuviae of some species were difficult and time-consuming to identify. Male damselflies were more readily identified than females for most species, so males were the sex primarily targeted for identification. A notable exception to the preference to target males was Sweetflag Spreadwing, the male of which is morphologically similar to the Northern Spreadwing, and therefore can be difficult to identify with certainty, but the female is unmistakable because of her elongated ovipositor. Therefore, both males and females of pond spreadwings with morphologic similarity to Sweetflag Spreadwing were examined in hand because identifying one sex tended to reinforce the identity of the other. Vernal Bluet, Northern Bluet, and presumed intergrades between those two species were all represented at the US 2 Pond, which would make this an ideal site for studying this species complex.

June was the most productive month for detecting species that occupied habitat at the US 2 Pond. Just 24% of survey visits to the pond occurred in June, but those survey visits produced 36% of all species detections. June also had a higher mean number of species detections per survey visit for both dragonflies (7.9) and damselflies (6.2) than any other month (Tables 5 and 6). Five of the 12 survey visits to the pond in June detected ten or more species, and two June survey visits each detected 17 species, which is nearly half of the total number of species recorded at the pond (fully half considering that five of the 39 total species were only recorded once at the pond and probably did not have breeding populations there). Further, almost half of the dragonfly species detected at the pond (13 of 27 species) were first detected in June. September was also an important month for surveys at the US 2 Pond, with 11 species detected during seven survey

Table 5. *Numbers of individuals of dragonfly species that were detected by species, by life stage, and in order of frequency of detection, in total and by month, at the US 2 Pond in the BRW&SF, 1994–2018 (A=adults; N=nymphs; E=exuviae). Also shown are the number of species detections, in total and per visit, by month (na=no survey visits; all visits were targeted).*

Species	Total (A/N/E)	March	April	May	June	July	August	Sept.	Oct.	Nov.
Common Green Darner	31 (25/ 5/ 1)	0	2A	13A	9A, 1N	3N	0	1E	1A, 1N	0
Canada Darner	28 (15/ 11/ 2)	1N	3N	3N	2N, 2E	7A	5A	2A	1A, 2N	0
Belted Whiteface	25 (19/ 6/ 0)	1N	3N	3A, 1N	11A	5A	0	0	1N	0
Chalk-fronted Corporal	21 (16/ 4/ 1)	0	1N	3A, 1N, 1E	10A	3A	0	0	2N	0
Dot-tailed Whiteface	20 (14/ 6/ 0)	1N	2N	6A, 2N	8A	0	0	0	1N	0
American Emerald	20 (14/ 4/ 2)	0	2N	5A, 2E	9A, 1N	0	0	0	1N	0
White-faced Meadowhawk	18 (18/ 0/ 0)	0	0	0	2A	4A	3A	7A	2A	0
Four-spotted Skimmer	14 (11/ 2/ 1)	0	1N	1A, 1E	9A	1A	0	0	1N	0
Autumn Meadowhawk	13 (13/ 0/ 0)	0	0	0	0	2A	1A	4A	4A	2A
Beaverpond Baskettail	10 (7/ 1/ 2)	0	0	4A, 1N, 2E	3A	0	0	0	0	0
Frosted Whiteface	9 (7/ 2/ 0)	0	1N	0	5A	2A	0	0	1N	0
Black-tipped Darner	9 (5/ 4/ 0)	0	0	1N	2N	2A	2A	1A	1N	0
Crimson-ringed Whiteface	8 (8/ 0/ 0)	0	0	1A	7A	0	0	0	0	0
Twelve-spotted Skimmer	8 (8/ 0/ 0)	0	0	0	6A	2A	0	0	0	0
Variable Darner	6 (2/ 3/ 1)	1N	0	1N	1N	1E	1A	0	1A	0
Horned Clubtail	6 (4/ 1/ 1)	0	0	1N	4A; 1E	0	0	0	0	0
Black Meadowhawk	5 (5/ 0/ 0)	0	0	0	0	0	0	4A	1A	0
Saffron-winged Meadowhawk	4 (4/ 0/ 0)	0	0	0	0	0	0	2A	2A	0
Lake Darner	3 (2/ 0/ 1)	0	0	0	0	1E	0	1A	1A	0
Racket-tailed Emerald	2 (0/ 2/ 0)	0	0	1N	0	0	0	0	1N	0
Hudsonian Whiteface	2 (2/ 0/ 0)	0	0	1A	1A	0	0	0	0	0
Shadow Darner	1 (1/ 0/ 0)	0	0	0	0	0	0	0	1A	0
Spiny Baskettail	1 (0/ 0/ 1)	0	0	1E	0	0	0	0	0	0
Dusky Clubtail	1 (1/ 0/ 0)	0	0	1A	0	0	0	0	0	0
Common Whitetail	1 (1/ 0/ 0)	0	0	0	1A	0	0	0	0	0
Williamson's Emerald	1 (1/ 0/ 0)	0	0	0	0	1A	0	0	0	0
Variegated Meadowhawk	1 (1/ 0/ 0)	0	0	1A	0	0	0	0	0	0
Total numbers of dragonfly species detections	268 (204/ 51/ 13)	4	15	58	95	34	12	22	26	2
Dragonfly species detections per survey visit	4.8	na	na	4.8	7.9	3.8	4.0	3.1	3.3	na

Table 6. *Numbers of detections of damselfly species, in total and by month, at the US 2 Pond in the BRW&SF, 1994–2018. Also shown are the numbers of detections of all damselfly species, in total and per survey visit, by month.*

Species	Total	May	June	July	August	Sept.	Oct.
Spotted Spreadwing	7	0	0	1	0	3	3
Northern Spreadwing	5	0	1	1	2	1	0
Sweetflag Spreadwing	3	0	1	2	0	0	0
Slender Spreadwing	5	0	0	1	2	1	1
Taiga Bluet	3	0	3	0	0	0	0
Northern Bluet	3	0	3	0	0	0	0
Vernal Bluet	6	5	1	0	0	0	0
Northern/Vernal Bluet intergrades	13	0	13	0	0	0	0
Boreal Bluet	2	1	1	0	0	0	0
Marsh Bluet	7	0	4	2	1	0	0
Hagen's Bluet	2	0	0	2	0	0	0
Eastern Forktail	2	1	1	0	0	0	0
Sedge Sprite	9	1	3	4	1	0	0
Total numbers of damselfly species detections	67	8	31	13	6	5	4
Damselfly species detections per visit	2.3	0.9	6.2	2.6	3	1.7	0.8

MITCHEL PAULY

Twenty-seven species of dragonflies and 12 species of damselflies were detected during 72 visits to the US 2 Pond.

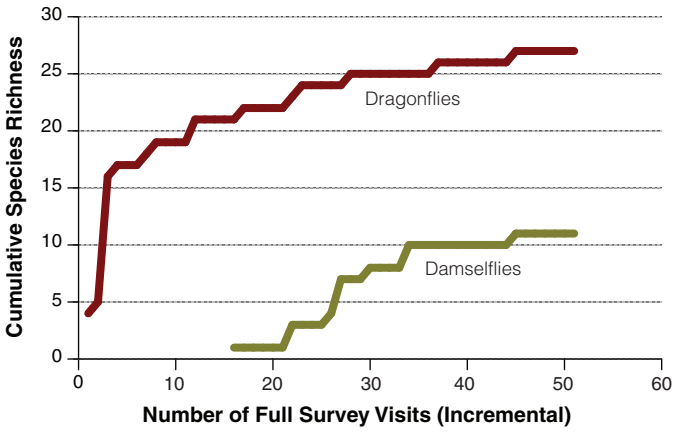

Figure 2. *Species-accumulation curves for dragonflies (red line) and damselflies (green line) based on full survey visits, 1994–2018, to the US 2 Pond. Damselflies were not sampled prior to the 16th full survey visit.*

visits. September survey visits were valuable because they detected species that flew in late summer and autumn and that therefore were not detected in June. Survey visits in July were useful as well because they detected some mid-summer species that were not routinely detected in either June or September, and because they typically detected some late spring-flying species and some early autumn-flying species.

The species accumulation curves for dragonflies and damselflies (Figure 2) show that many species were detected during the first few survey visits to the US 2 Pond, but that uncommon species, migrants, and species that probably strayed from other habitats continued to be detected throughout nearly the entire survey period. This general pattern of odonate species richness accumulations was similar to that reported for five Mass Audubon properties in Massachusetts that were repeatedly sampled by competent observers (Buchsbaum et al. 2016). At one of the Mass Audubon properties, new species were still being detected after 400 visits. In our study, the dragonfly curve for the US 2 Pond shows this front-loaded pattern of first detections most clearly. More than half of the species now known to occupy the site were detected during the first four visits, but continued, sporadic first detections included a species first detected on the 37th survey visit and another on the 45th survey visit. The curve for damselflies shows a stair-step pattern of first species detections that differs from that for dragonflies, probably because the senior author was learning to survey for and identify damselflies as the survey period progressed. Field guides to damselflies were not available during the initial survey years; the first damselfly guides pertinent to the region were by Lam (2004) and DuBois (2005, revised and expanded in 2019).

An analysis of 72 visits to the small, relatively simple lentic habitat represented by the US 2 Pond revealed some general conclusions for surveying for odonates at small lentic habitats in the BRW&SF that can be cautiously extrapolated to similar habitats in northern Wisconsin. Three survey visits, if done at mid-day during favorable weather conditions, could have detected the great majority of odonates that occupied habitat at the US 2 Pond. Survey visits in mid-June, mid-July, and early September would have been ideally timed for detecting the most species. Since weather conditions are imperfectly predictable in advance, we suggest that at least two survey visits be scheduled during each of the three time-periods. Survey visits should primarily target adult odonates, especially for skimmers and pond damsels, which are the two most common families at such habitats in the BRW&SF. Sampling for nymphs and exuviae are likely to detect a few additional species as well, but sampling for them should not be done at the expense of adult surveys at lentic habitats if survey time is greatly limited. It should also be noted that a reasonable number of well-designed survey visits are unlikely to detect all the species that occupy a site because uncommon or transient species are infrequently detected. Any attempt to detect all species occupying even a small lentic habitat would minimally require dozens of survey visits.

Further Considerations for Detecting Species

Obtaining a relatively comprehensive species list of odonates occupying a property with as much habitat diversity as is present in the BRW&SF is a daunting task that would require a great many survey visits to many sites. This point is made evident by the realization that after 705 visits to 94 sites, the species list for the BRW&SF is almost certainly incomplete, and that after 51 full survey visits to the small and relatively simple array of habitats at the US 2 Pond, the species list there is likely incomplete as well. Reasons for difficulties in detecting all species that occupy a site include:

- Times of the year when some species are not present in a detectable form (e.g., when only eggs or early instar nymphs are present)
- Problems with identification tools for various life stages
- Uncertainties about specific habitats at which to look for various life stages, especially nymphs
- Short and often unpredictable persistence times of exuviae
- The fact that adult odonates are usually hard to find during suboptimal weather conditions, or early or late in the day

Further, some species that usually occupy a habitat might not do so every year–transient site occupation is especially prevalent in unstable habitats like shallow ponds or wetlands that can dry up during drought years and therefore require periodic recolonization (Shiffer and White 2014, Schilling et al. 2018).

For these reasons, at certain times of year, times of day, and during certain weather conditions, some species that occupy a site will be effectively undetectable, or at least the amount of time and effort that would be required to detect them would be unrealistic given normal fiscal and logistical constraints. Therefore, odonate specialists will often choose to sample at times, and with a focus on certain life stages and sexes, that are likely to detect the most species in the shortest amount of time, but usually with the realization that the survey will not achieve a complete species list for the site.

In the following analysis we examined the relationship between survey effort and effectiveness in detecting the most common genera of dragonflies in the BRW&SF (see Methods for qualifications). Overall, 84% of our survey visits targeted only adult dragonflies (Table 1). Yet despite this general focus on adults, many genera were detected mostly as nymphs or exuviae (Table 7). About two thirds of all dragonflies (67%) were detected as adults, and about one third were detected as nymphs or exuviae. Thus, dragonflies were more often detected as nymphs or exuviae than would have been expected based solely on survey effort (84%).

Darners were slightly more likely to be detected as adults than other dragonflies (+5%; Table 7), but this result was influenced by the fact that clubtail dragonflies were much more likely to be detected as nymphs and exuviae than adults, which reduced the adult detection percentage of the suborder. When examined from the perspective of sampling effort, all darner genera were more likely to be detected as nymphs or exuviae than expected (Table 7). Our interpretation of this comparison is that while all life stages of darners are readily identifiable, adult darners are large and strong-flying, and therefore can be challenging to net, and most species are difficult to determine to species with the naked eye when in flight. Many species are difficult to find and approach when perched. In contrast, darner nymphs and exuviae are large and relatively easy to collect, and are, in most cases, readily identifiable (Tennessen 2019). An exception to this pattern is the male Common Green Darner, which because of its bright and distinctive coloration is easily recognized in flight even at a considerable distance. We note that binoculars and in-flight photographs can often be used to identify darners while in flight or perched at a distance, which is usually not possible with the naked eye.

Most clubtail dragonflies were much more likely to be detected as nymphs or exuviae than as adults (Table7), particularly those that inhabited lotic systems. Many lotic clubtails are known to either spend much of their time as adults away from water in trees or in clearings, or they fly swift and low over water away from shore making them difficult to approach and net. Many lack distinctive colorations that would allow them to be easily determined in flight. One exception to this general rule is a member of the hanging clubtail genus, the Zebra Clubtail, which perches frequently, is easily approachable and is distinctively marked. Our observations therefore generally support the idea that clubtails inhabiting rivers in northern Wisconsin are most efficiently sampled as exuviae in spring and early summer, and outside of that window of opportunity, as nymphs. Clubtail nymphs can be reared to confirm determinations (DuBois and Tennessen 2016).

Spiketails and cruisers were both more likely to be detected as nymphs or exuviae than as adults (Table 7). Species in both groups are large and strong-flying, and were infrequently seen as adults, but the nymphs are large, easily collected, and were readily determined to species.

Emeralds in some genera were more likely to be detected as nymphs or exuviae, whereas others were more likely to be detected as adults (Table 7). Overall, emeralds were more likely to be detected as nymphs or exuviae than would be expected based on survey effort. This was especially true for the stream-dwelling species of striped emeralds, which are uncommonly seen as adults due to typically low population densities and secretive habits. Keys to emerald nymphs are now generally reliable (Tennessen 2019), although determining nymphs of some striped emeralds remains challenging. Uncertain determinations can sometimes be confirmed by returning to the site and collecting and rearing nymphs (DuBois and Tennessen 2016).

Skimmers were more likely to be detected in the adult stage than as nymphs or exuviae in every case, and usually more likely than would be expected based on survey effort or by the suborder mean (Table 7). This result was due to the great majority of adult skimmers being distinctively marked and easily approached. As a group they tend to be showy, perch often, and have long flight periods, which allows observers plenty of opportunities to identify them by their colors and patterns or to net them and examine diagnostic body parts with loupes. Keys to the nymphs of some skimmer genera have problematic species groups; this is especially true for the meadowhawks (Tennessen 2019).

Table 7. *Percent of dragonflies detected as adults, or as nymphs or exuviae, by genus and family, in the BRW&SF, 1984–2018, and detection percent differences from expected values based on survey visits (84% of all survey visits targeted only adult dragonflies), and from the mean values for the suborder (67% of all dragonflies were detected as adults). A plus sign indicates that the taxon was more often detected in the adult stage than expected; a minus sign indicates the taxon was more often detected as nymphs or exuviae than expected (genera with less than 50 specimens detected were excluded). Percentage of detections as nymphs or exuviae are in parentheses.*

Taxon	Percent Detected as Adults (and as Nymphs or Exuviae)	Detection Percent Difference From	
		Survey Visit Mean	Suborder Mean
Darner family (Aeshnidae)	72 (28)	-12	+5
Mosaic darners (*Aeshna*)	69 (31)	-15	+2
Common Green Darner (*Anax*)	81 (19)	-3	+14
Fawn Darner (*Boyeria*)	68 (32)	-16	+1
Clubtail family (Gomphidae)	28 (72)	-56	-39
Snaketails (*Ophiogomphus*)	20 (80)	-64	-47
American clubtails (*Phanogomphus*)	28 (72)	-56	-39
Hanging clubtails (*Stylurus*)	54 (46)	-30	-13
Spiketails (*Cordulegaster*)	45 (55)	-39	-22
Cruiser family (Macromiidae)	29 (71)	-55	-38
Emerald family (Corduliidae)	58 (42)	-26	-9
American Emerald (*Cordulia*)	47 (53)	-37	-20
Racket-tailed Emerald (*Dorocordulia*)	88 (12)	+4	+21
Baskettails (*Epitheca*)	64 (36)	-20	-3
Striped emeralds (*Somatochlora*)	34 (66)	-50	-33
Skimmer family (Libellulidae)	84 (16)	0	+17
Pennants (*Celithemis*)	79 (21)	-5	+12
Chalk-fronted Corporal (*Ladona*)	87 (13)	+3	+20
Whitefaces (*Leucorrhinia*)	70 (30)	-14	+3
King skimmers (*Libellula*)	88 (12)	+4	+21
Common Whitetail (*Plathemis*)	96 (4)	+12	+29
Meadowhawks (*Sympetrum*)	98 (2)	+14	+31

Conclusions and Recommendations

- Ninety-three species of odonates were detected during 705 survey visits to 94 sites representing a wide array of habitat types in the BRW&SF.
- These 93 species comprise 75% of the odonate species known to occur in Douglas County, and 56% of the species known to occur in Wisconsin. This high level of species richness is attributable to a wide array of well-protected habitat types in the BRW&SF.
- No federal or state threatened or endangered odonate species were found in the BRW&SF, but four species considered to be of special concern were documented, three of which have breeding populations in the area: Pronghorn Clubtail, Plains Emerald, and Forcipate Emerald.
- The list of species currently known to occur within the BRW&SF is almost certainly incomplete; about 15 additional species have breeding populations within an 80-km radius of the Town of Brule, and based on the suitability of habitats, might be found in the BRW&SF with further survey effort (certainly, at least a few species would). These potential species include: Ocellated Darner, Zig-zag Darner, Subarctic Darner, Green-striped Darner, Harlequin Darner, Riffle Snaketail, Lilypad Clubtail, Common Sanddragon, Eastern Least Clubtail, Eastern Amberwing, Subarctic Bluet, Alkali Bluet, Azure Bluet, Skimming Bluet, and Variable Dancer.
- June was the most productive month for detecting species at the frequently surveyed US 2 Pond; three mid-day surveys timed to occur in mid-June, mid-July, and early September during fair weather conditions could have detected the great majority of species at the site.
- Most of the common species of dragonflies that occurred at the US 2 Pond were first detected during the first four survey visits, but occasional first detections of uncommon or transient species occurred throughout most of the survey period up to the 45th survey visit.
- Odonate surveys on properties with habitats like those within the BRW&SF should be designed flexibly enough to detect any life stages that are present in a detectable form at the time. Survey efficiency, however, can be optimized by targeting adults of both sexes of damselflies (but primarily the males of pond damsels) and skimmers. For lotic species of clubtails, the exuviae (primarily, but with a short time frame of availability) and the nymphs (secondarily) should be targeted. Darners, spiketails, cruisers, and emeralds can be effectively detected as adults, nymphs, or exuviae depending on habitat, weather conditions, and time of year. A recent key to dragonfly nymphs (Tennessen 2019) contains numerous improvements over previous keys that are applicable to the BRW&SF.
- The species list currently documented for the BRW&SF can be used as a benchmark against which future surveys can be compared to assess biodiversity changes resulting from climate change, habitat loss, or other factors.

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Survey efficiency can be optimized by targeting adults of both sexes of damselflies (but primarily the males of pond damsels) and skimmers.

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Appendix 1. Dragonfly and Damselfly Data Collection Sites

Table A-1. Dragonfly and damselfly data collection sites in the BRW&SF, 1984–2018. Latitude and longitude coordinates generally indicate the primary collection sites for each waterbody, but collections were sometimes also made at other areas on the same waterbody (CR=County Road, STH=State Highway, US=United States Route).

Site	Site Code	Latitude; Longitude
Bois Brule River Mainstem		
Upper river zone (UPPER)	R1	See Fig. 1
Stone's Bridge zone (STB)	R2	See Fig. 1
Dalles zone (DALLES)	R3	See Fig. 1
Lakes zone (LAKES)	R4	See Fig. 1
Middle transition zone (MID)	R5	See Fig. 1
Meadows zone (MEA)	R6	See Fig. 1
Ledges zone (LED)	R7	See Fig. 1
Lower river zone (LOW)	R8	See Fig. 1
Mouth of river zone (MOUTH)	R9	See Fig. 1
Tributaries (Warm and Coldwater Streams)		
Wilson Creek along CR P	T1	N46.4087; W91.7548
Angel Creek (aka Swamp Angel Creek) and spring	T2	N46.4088; W91.7377
Porcupine Creek	T3	N46.4047; W91.7824
West Fork Bois Brule River near CR P	T4	N46.4004; W91.7617
East Fork Bois Brule River near Rifle Range Road	T5	N46.3967; W91.7474
Hansen Creek	T6	N46.4821; W91.7572
Minnesuing Creek near South Lake Road	T7	N46.5135; W91.6845
Kaspar Creek	T8	N46.4791; W91.7591
Casey Creek at Miller Road	T9	N46.5778; W91.6057
Rocky Run near CR H and nearby Carlson Road	T10	N46.5719; W91.5750
North Fork Blueberry Creek at a beaver meadow	T11	N46.5514; W91.6503
Blueberry Creek near Bellwood Pit Road	T12	N46.5462; W91.6460
Unnamed stream near Bellwood Pit Road	T13	N46.5648; W91.6372
Little Brule River below the Brule Trout Rearing Station	T14	N46.5365; W91.5912
Little Brule River above the Brule Trout Rearing Station	T15	N46.5338; W91.5839
Little Brule River below STH 27	T16	N46.5172; W91.5937
Nebagamon Creek near After Hours Road	T17	N46.5261; W91.6160
Florence Lake – headwaters of Little Brule River	T18	N46.5152; W91.5938
Little Steele Creek near South Cemetery Road	T19	N46.5148; W91.7222
Nebagamon Creek near Lake Nebagamon	T20	N46.5143; W91.6845
Unnamed tributary near Brackett's Corner Road	T21	N46.7545; W91.5814
Pearson Creek (lower) at Bear Branch State Natural Area	T22	N46.7146; W91.7272
Smith Creek east of Green Acres Road	T23	N46.6935; W91.6426
Unnamed intermittent stream near Brackett's Corner	T24	N46.7272; W91.5572
Unnamed intermittent tributary to Fish Creek	T25	N46.7150; W91.5552
Unnamed intermittent stream near Clevedon Road	T26	N46.7169; W91.6195
Outlet creek of Upper St. Croix Lake near CR A	T27	N46.3798; W91.7778
Catlin Creek near Croshaw Road	T28	N46.3973; W91.7914
Unnamed creek between Vapa Road ponds	T29	N46.4548; W91.6681
Springs and Seeps		
Beaupre Springs, seeps	S1	N46.3925; W91.7435
St. Croix Creek, headwater seeps	S2	N46.3872; W91.7669
Tributary spring pond near Stone's Bridge	S3	N46.4315; W91.6740
Blue Spring, feeder to Upper Bois Brule River	S4	N46.4276; W91.6883
Rocky Run headwater area near County Line Road	S5	N46.5828; W91.5533
Wetlands and Bogs		
Unnamed bog pond, south side of Francis Willard Road	W1	N46.4748; W91.6420
Unnamed bog near Lake Nebagamon (southeast corner)	W2	N46.4880; W91.6776
Unnamed bog (Panama Bog) off East Minnesuing Road	W3	N46.4741; W91.7366

Continued on next page

Table A-1. *Continued.*

Site	Site Code	Latitude; Longitude
Wetlands and Bogs *Continued*		
Unnamed swamp near end of Stone Chimney Road	W4	N46.4174; W91.7119
Unnamed bog near Bellwood Pit and After Hours roads	W5	N46.5461; W91.6160
Oxbow along Bois Brule River near Ranger Road	W6	N46.5416; W91.5849
Hoodoo Lake Bog	W7	N46.5255; W91.5954
Small ponds on south side of Railroad Road	W8	N46.5243; W91.6662
Beach wetland (panne) west of mouth of Bois Brule River	W9	N46.7459; W91.6154
Large wetland near mouth of Bois Brule River	W10	N46.7465; W91.6117
Swamp at headwaters of the West Fork Bois Brule River	W11	N46.3970; W91.7736
Well-vegetated bog, Prison Boundary Road, Brule Annex	W12	N46.2368; W91.7475
Ponds (<2 ha)		
Unnamed forest pond along CR P (Brule Bog)	P1	N46.3953; W91.7676
Unnamed pond near north end of Upper St. Croix Lake	P2	N46.3796; W91.7777
Unnamed marsh pond east of County Line Road	P3	N46.4824; W91.5532
Unnamed small pond near Volker and Rush Lake roads	P4	N46.4831; W91.5715
Unnamed ponds off Vapa Road	P5	N46.4539; W91.6695
Unnamed pond near Oakdale and Schaller roads	P7	N46.4439; W91.6934
US 2 Pond, west of Town of Brule	P8	N46.5619; W91.6052
Unnamed wildlife pond at end of Fasteland Road	P9	N46.5650; W91.5993
Ponds at Brule Trout Rearing Station	P10	N46.5361; W91.5818
Unnamed wildlife pond (1), Town of Brule, section 24	P11	N46.5346; W91.5581
Unnamed wildlife pond (2), Town of Brule, section 24	P12	N46.5369; W91.5553
Unnamed wildlife pond (3), Town of Brule, section 24	P13	N46.5409; W91.5609
Pond at Brule River Classics Recreational Vehicle Park	P14	N46.5453; W91.5731
Unnamed wildlife pond near CR FF and Leppala Road	P15	N46.6347; W91.6035
Unnamed pond at north end of Brackett's Corner Road	P16	N46.7554; W91.5797
Unnamed Pond off Clevedon Road near STH 13	P17	N46.6820; W91.6142
Unnamed pond on CR P near CR A intersection (Brule bog)	P18	N46.3870; W91.7764
Unnamed pond on Forest Boundary Road near Rush Lake	P19	N46.4892; W91.5516
Small Lakes (2–63 ha)		
Mills Lake	SL1	N46.4068; W91.7635
Gilbert Lake	SL2	N46.4031; W91.7874
Smith Lake	SL3	N46.3970; W91.7055
Shoberg Lake	SL4	N46.3939; W91.6888
Rush Lake, State Natural Area	SL5	N46.4907; W91.5552
Cream Lake	SL6	N46.4509; W91.7245
Gander Lake	SL7	N46.4537; W91.7313
Unnamed pond west of Schiesser Road (private land)	SL8	N46.5249; W91.6348
Hoodoo Lake (east side)	SL9	N46.5269; W91.5904
Brule Annex Lake, north of Prison Boundary Road	SL10	N46.2404; W91.7433
Large Lakes (>63 ha)		
Upper St. Croix Lake at north end, near wayside	LL1	N46.3796: W91.7793
Lake Nebagamon - private property on southeast shore	LL2	N46.4874; W91.6798
Lake Minnesuing at Park Road	LL3	N46.4590; W91.7470
Lake Minnesuing at Bennett Road	LL4	N46.4530; W91.7479
Lake Nebagamon - private property on northeast shore	LL5	N46.5111; W91.6921
Upland Areas		
Meadow along lower East Fork of Bois Brule River	U1	N46.4016; W91.7426
Private property on Pine Street, Town of Brule	U2	N46.5574; W91.5725
Ditches along Bellwood Pit Road	U3	N46.5287; W91.6584
Roadside along south end of Degerman Road	U4	N46.5209; W91.7212
Eau Claire River (Brule Annex)		
Eau Claire River near Lawler Road	EC1	N46.2256; W91.7377
Eau Claire River impoundment	EC2	N46.2352; W91.7774

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