Aquatic insects of the Bois Brule River system, Wisconsin. No. 185 1993

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Madison, Wisconsin: Wisconsin Department of Natural Resources, 1993

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Technical Bulletin No. 185
Department of Natural Resources
Madison, Wisconsin
1993

ABSTRACT

Noticeable kills of some species of aquatic insects have accompanied periodic lampricide treatments (3-trifluoromethyl-4-nitrophenol; TFM) within the Bois Brule River (Brule River) drainage since 1959. These kills prompted concern among trout anglers and Department of Natural Resources fisheries personnel about the long-term effects of TFM on the aquatic insect community. This concern was heightened during the early 1980s by declines in several of the river's trout populations that use aquatic insects as a food resource. Hence, benthos collections throughout the drainage basin, and drift-net samples from 3 tributaries, were made between November 1983 and July 1988 to document and assess the status of the aquatic insect fauna of this relatively undisturbed, predominantly spring-fed river system.

Relative abundance and distribution of aquatic insects, and physical and chemical data, are provided for 15 biotic areas, which include 6 mainstem reaches and 9 tributaries. One hundred thirty species were identified; in terms of species richness Trichoptera (35 species) and Ephemeroptera (27 species) were best represented. However, Diptera would have contained the most species had it been possible to identify them (59 genera identified). Ephemeroptera contained the greatest number of individuals in benthos samples; Diptera were predominant in drift-net samples. The drift fauna in tributaries was overwhelmingly dominated by several species each of *Baetis* and *Simulium*. No threatened or endangered species were found; however, a population of *Brachycentrus lateralis*, a caddisfly that is rare in Wisconsin, was identified. Biotic index values in mainstem and tributary areas indicated excellent water quality and no apparent organic pollution. Although TFM treatments probably have caused short-term reductions in abundance of some aquatic insect taxa, no evidence was found to indicate persistent damage to the aquatic insect community.

The Brule River is a unique resource in terms of the aquatic insect habitat it provides. Consequently, strong efforts should continue to protect water and structural habitat quality. I recommend: (1) periodic water quality monitoring using Hilsenhoff's biotic index at some of the sites sampled in this study, (2) maintenance of adequate buffer strips along riparian areas to protect against erosion from logging, and (3) an investigation into the possibility of increased sand sedimentation in the river system.

Key Words: aquatic insects, drift, benthos, biotic index, Bois Brule River.

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by Robert B. DuBois

Technical Bulletin No. 185
Department of Natural Resources
P. O. Box 7921
Madison, Wisconsin 53707
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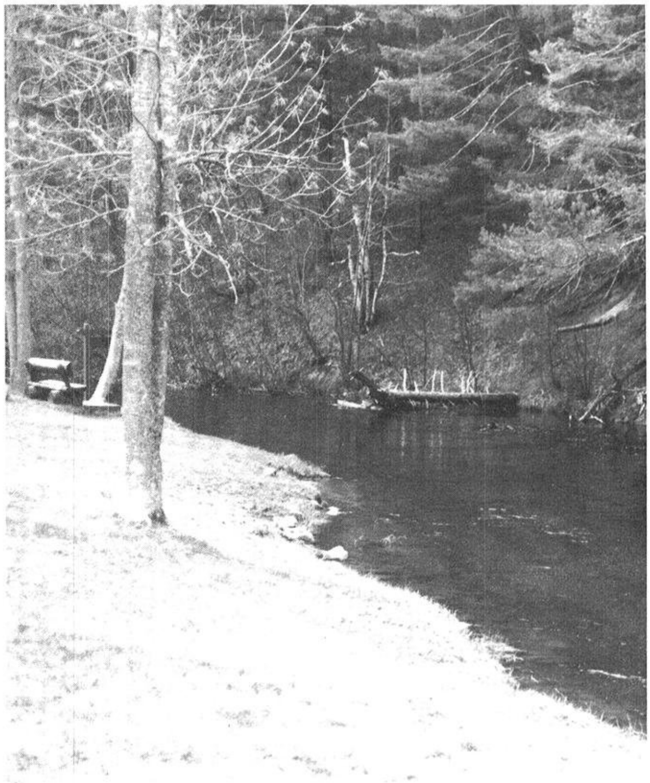


The Brule River canoe landing at the DNR Ranger Station during summer (left) and the river in winter, downstream from Harvey Road (right).

INTRODUCTION

The Bois Brule River (Brule River) in eastern Douglas County is one of the longest and best-known trout streams and canoe trails in the Midwest. The value of the Brule River as a study stream, because of its ecological diversity and relatively pristine condition, has been recognized for many years (Schneberger and Hasler 1944). Its value for study is further enhanced by the wealth of descriptive information available about many of its physical and biological attributes.

The major factor responsible for maintaining the Brule River valley in its relatively unspoiled state has been the continuing protection afforded by public acquisition of land bordering the river and by the commendable preservation efforts of private interests. The entire mainstem is now encompassed within the Brule River State Forest, and dwellings are steadily being removed as the state policy of land acquisition within forest boundaries continues.

In the early 1940s, the Brule River and its watershed were the focus of one of the most comprehensive interdisciplinary studies ever done on a Wisconsin stream. Technical papers subsequently were published on the topography, geology, and aquatic and terrestrial vegetation, as well as information on bottom deposits, physical/chemical aspects, and fishery topics (*The Brule River*, Wis. Conserv. Dep. 1954; papers listed individually in the description of the watershed). However, the only information about the aquatic insect community of this unique resource consists of a study of surface-drift aquatic insects used as food by trout (Hunt 1965) for which identifications generally were limited to taxonomic order.

In 1983 the Wisconsin Department of Natural Resources (DNR) initiated a research project to investigate apparent declines in several of the salmonid populations found in the Brule River and identify remedial management strategies. Part of this effort focused on an assessment of the status of the aquatic insect food base, particularly in light of the potentially severe negative impacts of 3-trifluoromethyl-4-nitrophenol (TFM) lampricide treatments, as deduced from the laboratory and field results that were available at that time (Smith 1967, Torblaa 1968, Haas 1970, Chandler and Marking 1975, Fremling 1975, Maki et al. 1975, Rye and King 1976, Maki and Johnson 1977). The Brule River system had been thoroughly treated periodically (usually at 3-year intervals) since 1959 by the Sea Lamprey Control Unit of the U.S. Fish and Wildlife Service. Anecdotal angler reports suggested that some of the major aquatic insect hatches that usually provided good flyfishing opportunities (e.g., the *Hexagenia limbata* hatch) appeared to be smaller than average the year of, or the year following, lampricide treatment.

During 1983 and 1984, benthos samples were collected throughout the mainstem of the Brule River and in several tributaries using a variety of qualitative and semi-quantitative samplers. Although these samples were taken from a variety of habitat types, most sampling focused on riffle areas with gravel substrates, which are

usually the most important aquatic insect-producing areas in trout streams. In 1986 and 1988, drift-net collections added distributional information on aquatic insects from 3 tributaries. During the preliminary study phase of the project, aquatic insect drift in Blueberry Creek was examined before, during, and after TFM treatment in 1986 (DuBois and Plaster 1993).

Although the primary initial impetus for assessing the status of the aquatic insect community of the Brule River was the concern generated by TFM lampricide treatments, a literature review and preliminary field testing revealed that a definitive evaluation of TFM impacts on aquatic insects in a large and diverse watershed such as the Brule River system would be time-consuming, expensive, and unnecessary. For these reasons, and because published evaluations on other aquatic systems are available (Torblaa 1968, Gilderhus and Johnson 1980, Merna 1985, Dermott and Spence 1984, Jeffrey et al. 1986, Kolton et al. 1986, MacMahon et al. 1987, Lieffers 1990), I made few efforts beyond the preliminary study phase to further investigate this issue.

Documentation of the aquatic insect communities of streams and rivers in northern Wisconsin and elsewhere in the Lake Superior drainage is quite limited; many river systems have not been studied. A comprehensive aquatic insect faunal investigation of the Pine-Popple river system (Pine-Popple system) in Florence and Forest counties described the distribution and relative abundance of aquatic insects in those watersheds (Hilsenhoff et al. 1972). Further descriptions of lotic insect taxa in northern Wisconsin were included in publications on statewide distributions of Baetidae (Bergman and Hilsenhoff 1978), Heptageniidae (Flowers and Hilsenhoff 1975), Baetiscidae (Hilsenhoff 1984*b*), Brachycentridae (Hilsenhoff 1985), aquatic and semi-aquatic Hemiptera (Hilsenhoff 1984*a*, 1986), Perlodidae (Hilsenhoff and Billmyer 1973), Haliplidae (Hilsenhoff and Brigham 1978), and Hydropsychidae (Schmude and Hilsenhoff 1986). A preliminary survey of Ephemeroptera nymphs by Krueger (1969) shed light on their statewide distributions. Several species identifications were available for Bear Creek, a warmwater stream in Barron County (Narf 1985). Additionally, Steven and Jacobi (1978) and Nelson (1979) provided generic identifications and biotic index values for the aquatic invertebrate communities of 40 streams within the Chequamegon National Forest in Ashland County. However, distribution information for many families still was not available.

The purpose of this report is to: (1) describe the distribution, relative abundance, and community composition of the more common aquatic insects in different habitat types (referred to as biotic areas in this report) throughout the Brule River system, (2) provide biotic index values (Hilsenhoff 1987) for various mainstem river reaches and tributaries, and (3) briefly discuss results regarding the impact of TFM on aquatic insects in one tributary in the system.

DESCRIPTION OF THE BOIS BRULE RIVER WATERSHED

The 79-km, 80-ha Brule River drains a watershed of approximately 320 km^2 and flows north into western Lake Superior (Fig. 1). The topography of the Brule River valley is characterized by terminal moraine and glacial till outwash, which are the dominant materials throughout most of the southern two-thirds of the Brule River valley, while the northern one-third consists almost exclusively of red lake clay. The upper Brule River originates in, and meanders through, an extensive, nearly flat conifer bog. The upland area surrounding the bog is a sandy outwash plain known as the "pine barrens." Precipitation rapidly percolates through this large area of sand charging the aquifers that supply much of the flow to the river. The middle section of the Brule River valley generally can be considered a transition zone, where upland soils shift from predominantly sand to sandy loam. This river section has the greatest diversity of gradients, bottom types, aquatic vegetation, and riparian vegetation types. The lower Brule River flows swiftly through a narrow, steep-banked region of heavy red clay, which contributes considerable turbidity and siltation to this section during pluvial periods. Detailed descriptions of the topography of the Brule River valley (Bean and Thomson 1944) and sediments and geology of the river (Dickas and Tychsen 1969) are available.

The largely spring-fed water source of the Brule River contributes to a flow regime that is highly stable for large streams in Wisconsin (Sather and Johannes 1973). The 22-year average flow near the DNR Brule Area Headquarters is 4.78 m^3/sec with extremes ranging from 1.90 to 43.04 m^3/sec (Niemuth 1967, Gebert 1979). The bottom substrate materials of the Brule River vary greatly from reach to reach and include peat, muck and silt, fine and coarse sand, gravel, cobble, rubble, and flat rock, each dominant in some areas (Evans 1945). The Brule River has a unique gradient profile (Bean and Thomson 1944), with 78% of its 126-m drop occurring in the first 24 km above the mouth. The rest of the river has a relatively gentle gradient with scattered stretches of minor rapids. Because of the spring-flow contribution, water temperatures are seasonally moderated, especially in the upper river, where summer temperatures only occasionally exceed 21 C. A longitudinal water temperature gradient exists of gradual warming as the river proceeds to the mouth. There are similar trends (particularly evident during low-flow periods) for chemical parameters such as pH, alkalinity, and total dissolved solids to increase towards the lower reaches of the river (Bahnick et al. 1969). Average chemical concentrations for the Brule River mainstem are presented in Table 1 and were summarized by Bahnick et al. (1969). The specific conductance at 25 C was relatively constant along the mainstem and was typical for high-quality water in northern Wisconsin (Zimmerman 1968).

The climate in the western Lake Superior region is characterized by 4 distinct seasons with extremes of weather throughout the year (Phillips 1978). Weather station records from the DNR Brule Area Headquarters indicate a mean annual air temperature of 4 C and mean annual precipitation of 80 cm.

Predominant forest cover is typical of a boreal forest community (Curtis 1959). Two major forest associations occur depending on riparian soil type. Black ash (*Fraxinus nigra*) and speckled alder (*Alnus rugosa*), with some white cedar (*Thuja occidentalis*) intermingled, dominate poorly drained, low areas in the northern half of the Brule River valley. In the southern half of the valley these species are joined by the swamp conifers black spruce (*Picea mariana*), balsam fir (*Abies balsamea*), and tamarack (*Larix laricina*). Better-drained upland red clay soils support a predominantly aspen (*Populus.* spp.) and balsam fir association. Where upland soils are sand or sandy loam, these species are joined by paper birch (*Betula papyrifera*), white pine (*Pinus strobus*), red pine (*P. resinosa*), jack pine (*P. banksiana*), and various less- abundant hardwoods. Speckled alder and red-osier dogwood (*Cornus stolonifera*) dominate the areas immediately bordering the river throughout much of its length. Aquatic plants are abundant and diverse throughout the mid-section of the river, particularly in the widespreads or "lakes" section and the series of rapids, or "Dalles" above them, but are less common in both the extreme upper section and the lower river north of U.S. Hwy. 2. Additional information on the aquatic and terrestrial vegetation of the Brule River valley can be found in Fassett (1944) and Thomson (1944, 1945).

Table 1. *Average chemical concentrations for the Bois Brule River mainstem (after Bahnick et al. 1969).*

Parameter	Concentration (mg/L, except as indicated)
Ammonia (NH_3-N)	0.06
Copper (Cu)	0.06
Dissolved Oxygen (DO)	92.4% saturation
Nitrite (NO_2^--N)	Trace
Nitrate (NO_3^--N)	0.41
Orthophosphate (PO_4^{-3})	0.06
Polyphosphate (PO_4^{-3})	0.07
Total dissolved solids (TDS)	74
Specific conductance	109 µmhos/cm

METHODS

Sampling Locations

The mainstem of the river was divided into 6 biotic areas based on the gradient, substrate composition, thermal, and water quality differences in these areas. Each of 9 tributaries constituted a separate biotic area. Physical and chemical information available for the Brule River system, including both published (Bahnick et al. 1969; Dickas and Tychsen 1969; Sather and Johannes 1973; Tiegs 1982; Tiegs and St. Amant 1983; Tiegs and Wallace 1980*a*, 1980*b*, 1980*c*; Zimmerman 1968) and unpublished (file) data, was considered prior to making biotic area determinations and is presented in Table 2.

Aquatic insects were collected at 35 sites within the 15 biotic areas (Fig. 1). Collection sites were selected to maximize the diversity of habitat types sampled, and were spaced out roughly evenly throughout the river system.

The following, brief narrative for each biotic area describes exact sampling locations; numbers given in the narrative descriptions correspond with the sampling site numbers in Figure 1.

Table 2. *Physical and chemical characteristics of 15 biotic areas within the Bois Brule River drainage including a comparison of tributary and mainstem averages.*

Biotic Area	Area Code	Area Length (km)	Mean Width (m)	Mean Depth (cm)	Estimated Normal Discharge (m^3/s)	Mean Gradient (m/km)	pH	MPA* (ppm)	Specific Conductance @ 25 C (µmhos)	Predominant Substrate Type
Lower River	LOW	12.0	21.6	n/a	6.26	2.6	7.7	66	119	sand, gravel, cobble, rubble
Ledges Area	LED	7.5	18.0	n/a	n/a	3.8	7.7	n/a	97	gravel, cobble, rubble, large rock
Meadows Area	MEA	10.5	18.0	n/a	n/a	0.9	7.7	n/a	123	mostly sand, some gravel
Midsection Transition Area	MID	9.5	19.2	76	4.78	1.9	7.5	55	112	sand, gravel, cobble, rubble
Big Lake	BIG	1.6	180.0	n/a	n/a	0.2	7.5	40	102	silt, sand, cobble, rubble
Stone's Bridge Area	STB	7.0	16.5	n/a	0.73	0.5	7.5	n/a	101	silt, sand, cobble, rubble
Trask Creek	TRA	11.6	2.1	15	0.06	10.4	7.6	123	237	sand, gravel, cobble, rubble, large rock
Pine Tree Tributary	PNT	1.2	1.0	9	<0.01	50.0	n/a	n/a	n/a	sand, gravel, rubble
Rocky Run	ROC	2.4	3.0	18	0.06	17.0	7.5	105	142	sand, gravel, rubble
Little Brule River	LBR	4.5	5.2	24	0.34	3.8	7.3	66	91	mostly sand, some silt and gravel
Nebagamon Creek	NEB	10.3	6.4	24	0.57	3.8	7.1	41	91	sand, gravel, cobble, rubble
Blueberry Creek	BLU	5.0	3.4	20	0.15	5.5	6.4	26	70	sand and gravel
North Fork Blueberry Creek	NOB	1.9	1.1	10	<0.02	9.5	6.5	24	61	sand and gravel
Wilson Creek	WIL	4.2	1.2	12	0.05	9.5	7.0	36	80	sand and gravel
West Fork	WFK	3.2	4.6	15	0.06	0.9	7.3	66	134	silt and sand
Mainstem avg.		8.0	18.6**	76	3.50	1.7	7.6	54	109	—
Tributary avg.		4.9	3.1	16	0.15	12.3	7.1	61	113	—

* Methyl purple alkalinity.
** Excluding Big Lake.

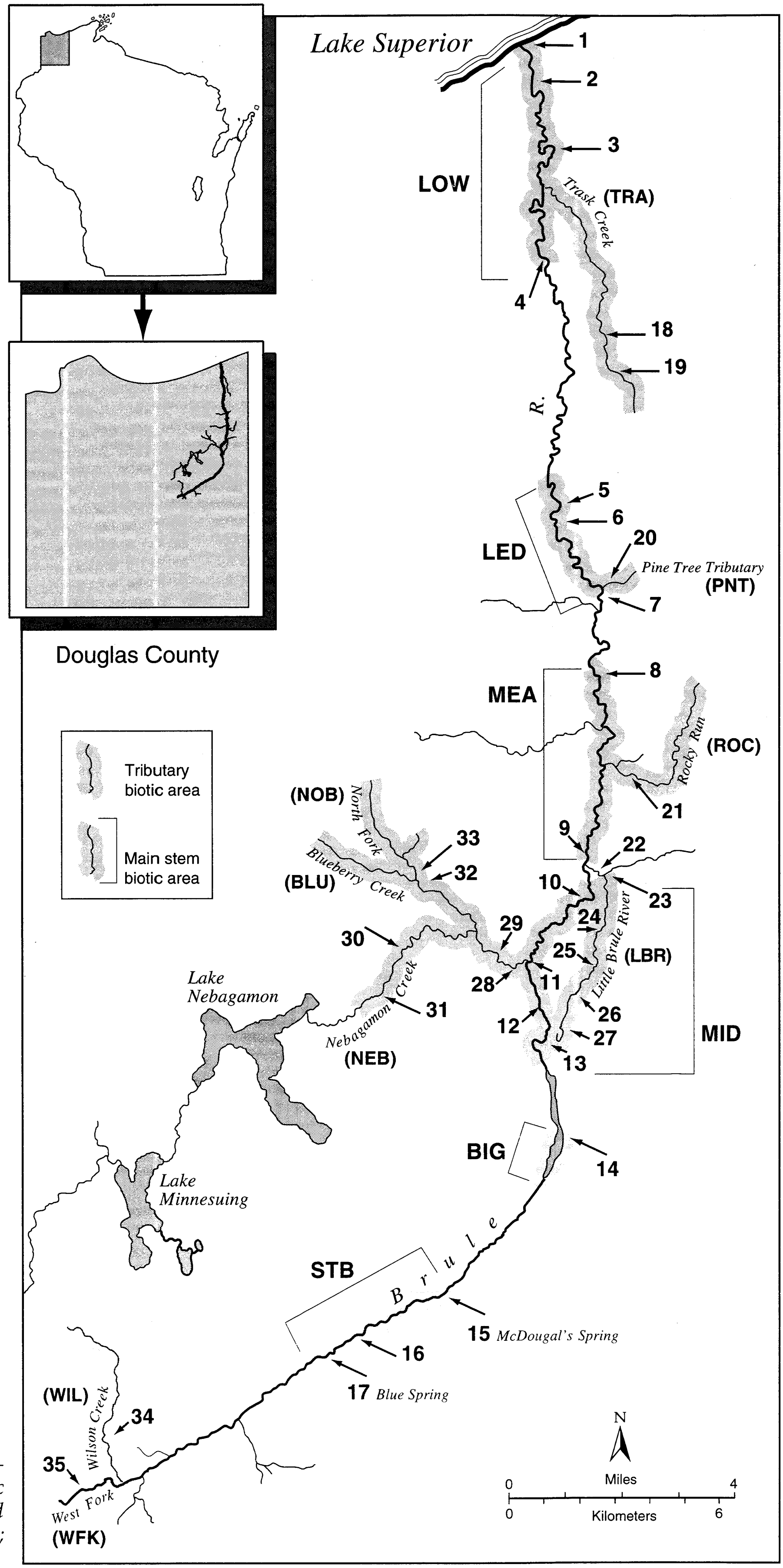
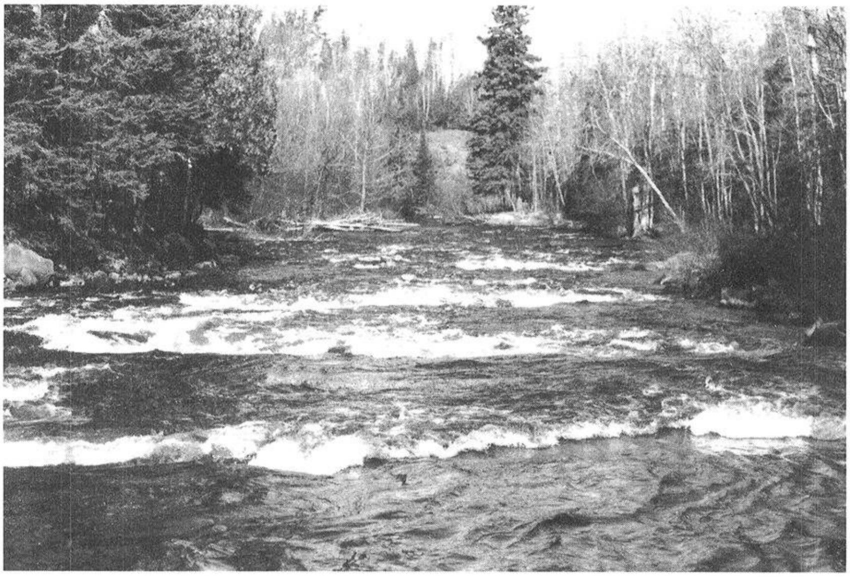


Figure 1. *Map of the Bois Brule River drainage showing the locations of the 35 aquatic insect collection sites within 6 mainstem and 9 tributary biotic areas (indicated by shading; mainstem areas also identified with brackets).*

Lower River (LOW)

This river section is characterized by a continual series of gentle rapids throughout its length; red clay turbidity and sand siltation are continual occurrences. Four sampling locations in this area included a silt bed and shallow-water macrophyte area at the mouth of the river (Site 1), gravel riffles located at the now-discontinued electrical lamprey weir site (Site 2), gravel riffles near the old Harvey Road crossing (Site 3), and gravel riffles immediately below the lamprey barrier (Site 4). These riffles are located about 1.6, 5.0, and 11.0 km above the mouth of the river, respectively. *(Photo: near Harvey Road.)*



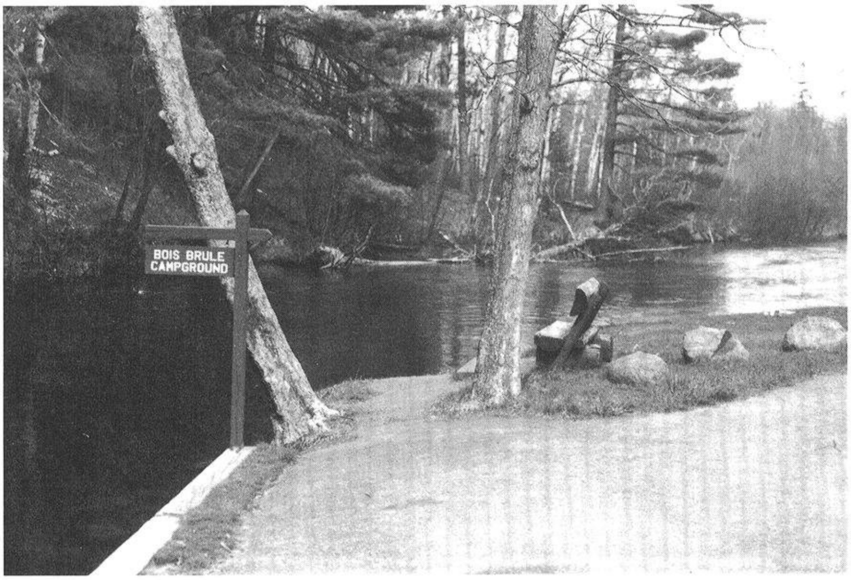
Ledges Area (LED)

This section is steep and swift, with a substrate comprised of cobble, rubble, boulder, and flat rock ledge. Three sampling locations in this area included a cobble and rubble-bottomed rapids area (Skid Mays) less than 1.5 km north of Co. Hwy. FF (Site 5, access off Koski Road), a series of shallow gravel riffles just below the Co. Hwy. FF bridge (Site 6), and a sand and gravel run at the Pine Tree canoe landing (Site 7, Dead End Road). *(Photo: Skid Mays downstream from Flat Rock.)*

Meadows Area (MEA)

This is a low-gradient section of alder-lined runs with deep pools (1.5 to 2.1 m) at bends. Submerged woody debris was abundant and provided habitat for many aquatic insects. The 2 sampling locations in this area included sandy runs located at the lower end of the area (Site 8, access off the first angler access road south of Coop Park Road), and immediately below the U.S. Hwy. 2 bridge (Site 9). *(Photo: downstream from the Hwy. 2 railroad bridge.)*

Midsection Transition Area (MID)



The sandy loam characterizing the uplands here separates the red clay to the north from the sand barrens to the south. The major tributary to the Brule River, Nebagamon Creek, enters the mainstem at the mid-point of this area bringing a contribution of flow from Lakes Nebagamon and Minnesuing. Three riffle sites were sampled including locations near the DNR Ranger Station canoe landing (Site 10), just above the junction with Nebagamon Creek at the lower end of a long series of rapids (Site 11, Hall's Rapids), and near the Co. Hwy. B bridge (Site 12). A sand-bottomed run about 1.5 km south of Co. Hwy. B (Site 13) also was sampled. *(Photo: Ranger Station canoe landing.)*

Big Lake (BIG)

This widespread section of river includes predominantly lentic habitat at the location sampled (Site 14, canoe landing on east side from shore out to a depth of 60 cm). *(Photo: Big Lake canoe landing.)*

Stone's Bridge Area (STB)

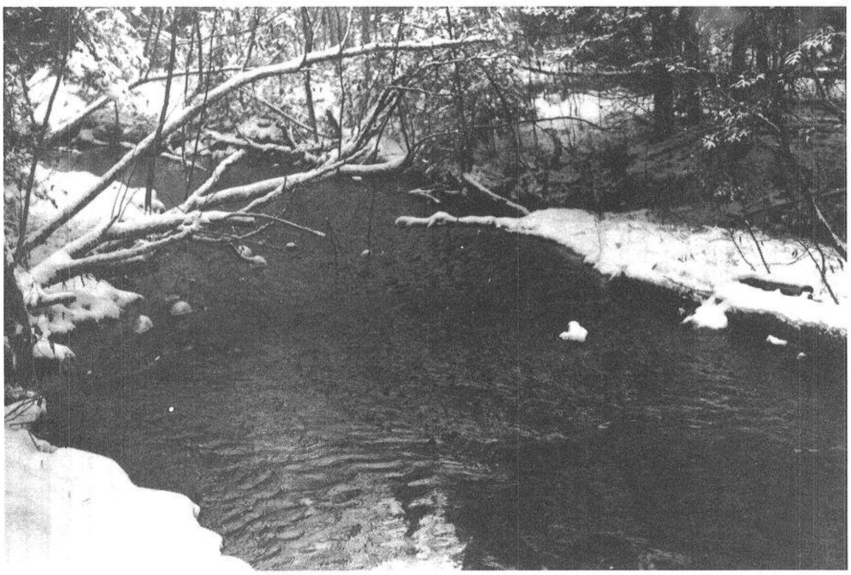
Aquatic macrophytes are abundant and diverse in this deep, low-gradient section, which includes 2 spring pond areas connected to the river. Three sampling sites included a large, deep spring pond (Site 15, McDougal's Spring) several km north of Co. Hwy. S, a sand and cobble run just below the Co. Hwy. S bridge (Site 16), and a smaller spring pond 1 km above Co. Hwy. S (Site 17, Blue Spring). *(Photo: the river below Stone's Bridge.)*

Trask Creek (TRA)

The only major tributary of the lower Brule River, Trask Creek frequently is subject to high turbidity, siltation, and flash flooding. Forty percent of its watershed consists of cleared, marginal farm land. The locations sampled were gravel riffles immediately above the State Hwy. 13 (Site 18) and Co. Hwy. H (Site 19) bridges. *(Photo: Trask Creek downstream from Hwy. 13.)*

Pine Tree Tributary (PNT)

Little physical or chemical information exists for this small, cold, high-gradient tributary located just north of the Pine Tree canoe landing. The mouth area of the creek was sampled (Site 20). *(Photo: near the mouth of the tributary.)*



Rocky Run (ROC)

Rocky Run is a cold tributary subject to seasonal flow extremes. Two gravel riffles (one above and one below Co. Hwy. H) were sampled (Site 21). *(Photo: Rocky Run downstream from Hwy. H.)*

Little Brule River (LBR)

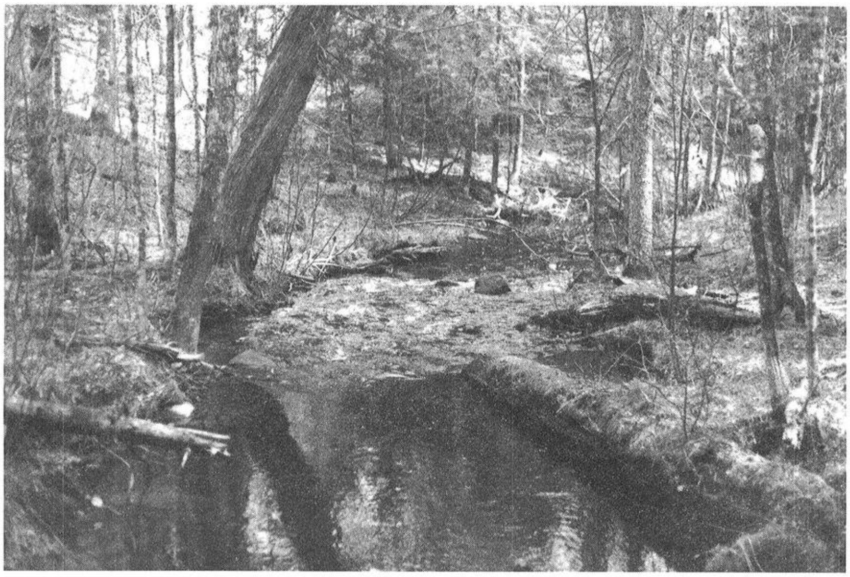
The Little Brule River is a clear, stable stream originating from a large spring pond. A state-owned Trout Rearing Station is operated at the stream's mid-section, just above a reach that was exposed to riparian debrushing for 1.5 km during the early 1980s as a trout habitat development project (DuBois and Schram 1993). Elsewhere, this low-gradient tributary is thickly bordered by alder growth. The debrushed area contains abundant and diverse instream vegetation that generally is lacking elsewhere in the stream. Six locations were sampled including a sand and cobble run at the mouth of the stream (Site 22), a sandy area near the confluence with Sandy Run (Site 23), an area of sand and aquatic vegetation within the debrushed section (Site 24), a sandy run with thick watercress beds on the stream margins just above the trout rearing station (Site 25), a shallow area of sand, gravel, and watercress just below the State Hwy. 27 bridge (Site 26), and a sand and gravel riffle at the outlet of the unnamed spring pond source (Site 27). *(Photo: debrushed reach downstream from the Trout Rearing Station.)*

Nebagamon Creek (NEB)

Nebagamon Creek is a seasonally warm outlet stream that drains Lakes Minnesuing (175 surface-ha) and Nebagamon (370 surface-ha). One major swamp-drainage tributary (Blueberry Creek) contributes stained, acidic flow several km above the mouth of the stream. Four sampling locations included a sandy run above the After Hours Road bridge (Site 29), gravel riffles at the confluence with the Brule River (Site 28), gravel riffles in a deep ravine below the Bellwood Pit Road bridge (Site 30), and gravel riffles upstream of the Co. Hwy. B bridge (Site 31). *(Photo: downstream from Hwy. B.)*

Blueberry Creek (BLU)

This stream drains a large conifer swamp at its headwaters and consequently has brown-stained, acidic water. The creek is very thickly choked with alder growth over most of its length. Two gravel riffles (Site 32) near the confluence with the North Fork were sampled. *(Photo: the creek downstream from Bellwood Pit road.)*



North Fork Blueberry Creek (NOB)

The North Fork is a small tributary that joins Blueberry Creek about 60 m above the Bellwood Pit Road bridge. Drifting aquatic insects were sampled at a sand and gravel riffle about 50 m above the mouth of the creek (Site 33). *(No photo for this site.)*

Wilson Creek (WIL)

Wilson Creek is a small, cool, headwater tributary. The collection site (Site 34) was accessed off Co. Hwy. P about 0.5 km above the mouth of the creek. *(Photo: near collection site.)*

West Fork (WFK)

The West Fork is a low-gradient headwater tributary with a soft bottom and alder-choked banks in the sampling area. Aquatic insects were sampled just above and below the Co. Hwy. P bridge (Site 35). *(Photo: downstream from Hwy. P.)*

Sampling Gear and Techniques

Aquatic insects were sampled between November 1983 and July 1988 using a variety of samplers (Table 3). Sampling primarily was focused in riffle areas < 1 m in depth, which produce most of the aquatic insects used as food by salmonids. Consequently, aquatic insect species that do not usually inhabit riffle areas probably were more common in the river system than the results presented in this report indicate. Although all of the samplers used were to some degree selective (i.e., some aquatic insect species were not as effectively sampled as others), the benthic sampling methods used were only minimally selective, and results from these samplers were used to obtain relative abundance and distribution information. Drift-net collections were more selective (because some aquatic insect species have a propensity to drift while others rarely, if ever, do so) and are, therefore, used in this report only to document the occurrence of taxa in the Little Brule River (LBR), Blueberry Creek (BLU), and the North Fork of Blueberry Creek (NOB, a biotic area from which no benthos samples were taken). All aquatic insects collected were preserved in the field in 70% ethanol or isopropanol and brought to the laboratory for sorting and identification.

Benthos Samples

A D-frame aquatic insect net (Bio Quip Products[1], Santa Monica, Calif.) was used to obtain 65 qualitative standard kick samples (SK, Hilsenhoff 1977). Additional benthos samples were obtained using modified Hess, Ekman, and multi-plate artificial substrate samplers; these quantitative samplers were tested for possible future use in a TFM assessment effort. However, these samplers are discussed in this report only to document the distribution and relative abundances of aquatic insect taxa; this report does not provide an evaluation of these samplers.

Biotic Index Samples

Biotic index values were calculated for 44 of the 65 SK samples described in the preceding section following the procedures of Hilsenhoff (1977), and incorporating recent tolerance values (Hilsenhoff 1987). Hilsenhoff's biotic index is a measure of organic and nutrient pollution, which affects dissolved oxygen levels, which in turn affects the ability of aquatic insects to survive in a particular stream. To calculate the index, each species or genus is assigned a tolerance value of 0 to 10, with 0 assigned to species least tolerant of organic pollution, 10 assigned to the most tolerant species, and intermediate values assigned to species intermediate in their tolerance. The biotic index is the average of the tolerance values for all individuals collected at a site (at least 100 individuals are needed for a valid sample). Chironomidae were relatively scarce in most riffle samples and were excluded from the biotic index analyses. Most biotic index samples were taken during autumn (October-November); however, several also were taken in February and March.

Drift-net Samples

Drift nets (mouth area of 0.9 m^2, length of 76 cm and mesh size of 0.5 mm) were used to collect a total of 86 samples from Blueberry Creek (BLU) and the North Fork of Blueberry Creek (NOB) during the 6-day period 27 June to 2 July 1986 as part of a TFM assessment program (DuBois and Plaster 1993). Five successive 15-minute drift samples were taken each evening beginning 1 hr after dark at both locations. Diurnal drift samples were taken from Blueberry Creek on 29 June at 15 to 30 minute intervals beginning at 10:25 a.m. CST. The data obtained by drift-net sampling are primarily used in this report to describe the distribution of taxa; the methods used to evaluate the effects of TFM and the results received were described in detail by DuBois and Plaster (1993). Drift nets also were used to obtain 5 successive 10-minute drift samples, also beginning 1 hour after dark, during each of 5 evenings (June-July 1988) at 2 locations on the Little Brule River (total of 50 samples).

Aquatic Insect Identification

Identifications were made to the lowest taxa possible, given recently published information. I used the regional key by Hilsenhoff (1981) and the keys in Merritt and Cummins (1984) to make generic determinations. Species identification often was required for the biotic index, and the keys used are listed in the Results and Discussion section for each order. The use of the plural species (spp.) in the tables of this report indicates genera in which more than one species of the genus clearly appeared to be present. The use of the singular species (sp.) indicates those genera in which all specimens appeared to belong to a single species. Representative specimens of all identified taxa have been preserved and are maintained in permanent reference collections housed at the DNR Brule Area Headquarters and the Lake Superior Research Institute, University of Wisconsin-Superior.

Data Presentation

Presentation of the results focuses on providing distribution and relative abundance of aquatic insect species and genera. Numbers of aquatic insects from all benthos samples at each of 33 collection sites were pooled for each species or genus. The totals of benthos at each collection site then were pooled within each of 15 discrete biotic areas throughout the watershed (each area is designated by a 3-letter code in Table 2). Drift-net results were used only to provide distribution information and are designated separately from the benthos results.

[1]Reference to trade names does not imply government endorsement of commercial products.

Table 3. *Site numbers, sampling locations, dates, and methods of aquatic insect collection within the Bois Brule River drainage.*

Site No.	Location	Biotic Area	Collection Dates	Methods* (N in parentheses)
1	Mouth of the Bois Brule River	LOW	17, 18 May 1984	EK(8)
			9 Jul 1984	SK(2)
2	Former electric lamprey weir site	LOW	29 May, 26 Jun 1984	SK(2)
3	Harvey Road access	LOW	11 Nov 1983; 3 May, 31 Oct, 6 Nov 1984	SK(6)
4	Below DNR lamprey barrier	LOW	8 Nov 1984	SK(3)
5	Skid Mays	LED	3 May 1985	SK(1)
6	Below Co. Hwy. FF	LED	17 Oct, 6 Nov 1984	SK(4)
			26 Jun 1984	SK(1)
7	Pine Tree canoe landing	LED	24 Jul 1984	AS(4)
8	Lower Meadows	MEA	15 May, 22 Aug 1984	SK(2)
9	Below U.S. Hwy. 2	MEA	10 Feb 1984	HE(6)
10	DNR Ranger Station area	MID	18 May, 24 Jul 1984	AS(6)
			10 Nov 1983	SK(1)
11	Hall's Rapids	MID	23 Mar 1984	SK(1)
12	Near Co. Hwy. B	MID	15 Nov 1983; 20 Feb, 23 Mar, 7 Nov 1984	SK(6)
			29 May 1984	EK(4)
			20 Feb 1984	HE(3)
			20 Feb, 23 Mar 1984	SK(2)
13	Noye's Lodge	MID	24 Jul 1984	AS(4)
14	Big Lake canoe access	BIG	30 May 1984	AS(2)
			17 May 1984	SK(1)
15	McDougal's Spring	STB	12 May 198	SK(1)
16	Below Stone's Bridge (Co. Hwy. S)	STB	16 Nov 1983	SK(1)
			19 Apr 1985	SK(2)
17	Blue Spring	STB	12 May 1984	SK(1)
18	Trask Creek above State Hwy. 13	TRA	11 Nov 1983	SK(1)
19	Trask Creek near Co. Hwy. H	TRA	15 Oct 1984	SK(1)
20	Mouth of Pine Tree tributary	PNT	9 May 1984	SK(1)
21	Rocky Run near Co. Hwy. H	ROC	15 Oct, 7 Nov 1984	SK(4)
			9 May, 27 Aug 1984	SK(2)
22	Mouth of Little Brule River (LBR)	LBR	16 Nov 1983	SK(1)
23	LBR at Sandy Run confluence	LBR	8, 15, 22, 29 Jun, 8 Jul 1988	DN(25)
24	LBR habitat improvement zone	LBR	17 Oct 1984	SK(1)
			8, 15, 22, 29 Jun, 8 Jul 1988	DN(25)
25	LBR above State trout hatchery	LBR	16 Nov 1983	SK(1)
26	LBR below State Hwy. 27	LBR	16 Nov 1983	SK(1)
27	LBR just below spring pond	LBR	15 Oct, 7 Nov 1984	SK(4)
28	Mouth of Nebagamon Creek (NEB)	NEB	23 Mar 1984	SK(3)
29	NEB below After Hours Road	NEB	29 May 1984	AS(2)
30	NEB below Bellwood Pit Road	NEB	6 Jul 1984	SK(1)
31	NEB above Co. Hwy. B	NEB	16 Nov 1983	SK(1)
32	Blueberry Creek at Bellwood Pit Road	BLU	16 Nov 1983; 15 Oct 1984	SK(2)
			27, 28, 29, 30 Jun, 1, 2 Jul 1986	DN(56)
33	North Fork Blueberry Creek at mouth	NOB	27, 28, 29, 30 Jun, 1, 2 Jul 1986	DN(30)
34	Wilson Creek 0.5 km above mouth	WIL	15 Nov 1983; 16 Feb, 15 Oct 1984	SK(3)
			16 Feb 1984	HE(9)
			16 Feb 1984	SK(1)
35	West Fork near Co. Hwy. P	WFK	30 May 1984	AS(4), EK(6)

*AS = multi-plate artificial substrate sampler (22), DN = drift net (136), EK = Ekman grab (18), HE = modified Hess sampler (18), SK = standard kick sample (65).

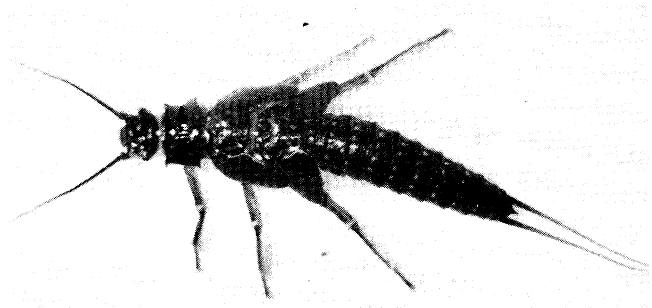
RESULTS AND DISCUSSION

Distribution and Relative Abundance

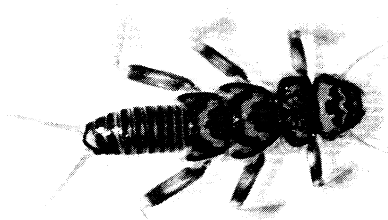
Plecoptera (Stoneflies)
7 families, 14 genera, 19+ species

The distribution and relative abundance of the 19 identified species are listed in Table 4. The number of Plecoptera species in the mainstem was greatest at MID, LED, and LOW, respectively, as expected based on the presence of extensive gravel substrates in those areas. Among the tributaries, Nebagamon Creek (NEB) contained considerably more plecopteran species (13) than any other.

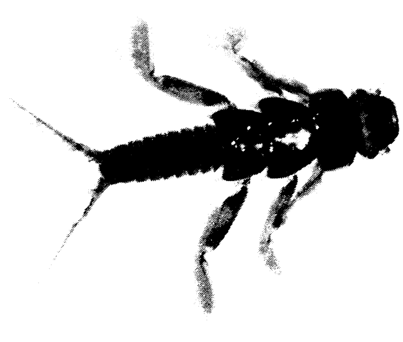
Species identification was possible for all genera within the Brule River drainage except *Zealeuctra*, but often was restricted to mature larvae. I used keys by Fullington and Stewart (1980), Harden and Mickel (1952), Harper and Hynes (1971*a*, 1971*b*, 1971*c*), Hilsenhoff (1982), Hilsenhoff and Billmyer (1973), and Hitchcock (1974). R. Narf, DNR Bureau of Research, confirmed identification of *Zealeuctra*.



Pteronarcys dorsata (×1.06)



Acroneuria lycorias (×1.85)



Pteronarcyidae (Giant Stoneflies). Only larger male larvae within this family could be identified with certainty, and all of those examined were *Pteronarcys dorsata*. I, therefore, listed all larvae of *Pteronarcys* as this species, although some of them could have been *P. pictetii*. Hilsenhoff et al. (1972) found about equal numbers of both species in the Pine-Popple system. Larvae commonly were found only in mainstem sites in 2 biotic areas. Both biotic areas contained fast-water sections with rubble bottoms.

Taeniopterygidae (Winter Stoneflies). Larvae of 2 genera within this family were identified, with *Taeniopteryx* being the most common. *Taeniopteryx burksi* was common in one tributary (NEB), *T. nivalis* was common in riffles of the LOW biotic area, and most *T. parvula* were found in an upper river riffle (STB). A few larvae of *Strophopteryx fasciata* were found in fast-water riffles. Hilsenhoff et al. (1972) found these 4 taeniopterygid species to be fairly common to common in the Pine-Popple system.

Nemouridae (Spring Stoneflies). *Nemoura trispinosa* was the only widely distributed nemourid found in the Brule River drainage, occurring in 5 biotic areas. Larvae of *Amphinemura linda* were not found in benthos samples, but regularly occurred in drift-net samples from 2 of the biotic areas representing larger tributaries.

Leuctridae (Rolled-winged Stoneflies). Larvae of 2 genera were identified but neither was common. Larvae of *Leuctra tenella* were found only in NOB, a small, cold tributary. One small larva from the mainstem was not identified to species. Small numbers of *Zealeuctra* were collected from several tributary biotic areas. Hilsenhoff et al. (1972) also found one species of *Leuctra*, but no *Zealeuctra*, in the Pine-Popple system.

Capniidae (Small Winter Stoneflies). *Paracapnia angulata* was the most common stonefly found in the Brule River drainage and was widely distributed among the tributary biotic areas. Several specimens of *Allocapnia* were found in 2 tributaries; some were *A. pygmaea* but others were too small to be identified.

Paragnetina media (×1.92)

Perlidae (Common Stoneflies). *Acroneuria lycorias* was one of the most common stoneflies in the Brule River system, occurring in one tributary and 4 mainstem biotic areas, but was most common in riffles in the lower river (LOW and LED). Hilsenhoff et al. (1972) also found *A. lycorias* to be dominant in fast-water sections of the Pine-Popple system, but found small numbers of 2 other species as well. *Paragnetina media* occurred in fast-water areas of 3 mainstem and 2 tributary biotic areas. A larva of *Perlesta placida* was collected from both a benthos sample of a mainstem (MID) and a tributary (NEB) biotic area. *P. placida* also occurred occasionally in drift-net collections from another tributary (BLU).

Perlodidae (Perlodid Stoneflies). Larvae of 2 genera were identified and several species were either locally abundant or widespread. *Isogenoides frontalis* was locally abundant in riffles of a cold tributary (ROC), and *I. olivaceus* uncommonly was found in riffles of a mainstem (LED) and a tributary (NEB) biotic area. Four species of *Isoperla* were identified of which *I. transmarina* was the most widely distributed, occurring in 3 mainstem and 3 tributary biotic areas. *Isoperla slossonae* and *I. signata* were found in several biotic areas and each was locally common in one tributary. *Isoperla frisoni* was uncommon in one tributary biotic area (NEB). Hilsenhoff et al. (1972) also found these species of *Isoperla* in the Pine-Popple system, plus several others.

Table 4. *Numbers of larvae of Plecoptera collected in benthos samples and drift nets from 15 biotic areas within the Bois Brule River drainage (drift-net catches within parentheses).*

Family	Mainstem Biotic Areas						Tributary Biotic Areas											Benthic
Genus Species	LOW	LED	MEA	MID	BIG	STB	TRA	PNT	ROC	LBR	(LBR)	NEB	BLU	(BLU)	(NOB)	WIL	WFK	Total
PTERONARCYIDAE																		
Pteronarcys dorsata (Say)		76		14														90
TAENIOPTERYGIDAE																		
Strophopteryx fasciata (Burmeister)		1		2								1						4
Taeniopteryx burksi Ricker and Ross							2					38	1			1		42
T. nivalis (Fitch)	49			12						6		2						69
T. parvula Banks		1				4				1								6
NEMOURIDAE																		
Nemoura trispinosa Claassen			18	25				19	1			16						79
Amphinemura linda (Ricker)											(33)			(1)	(41)			
LEUCTRIDAE																		
Leuctra tenella Provancher															(9)			
L. sp.					1													1
Zealeuctra sp.								3	4		(3)							7
CAPNIIDAE																		
Allocapnia pygmaea (Burmeister)												1				3		4
A. sp.												1				3		4
Paracapnia angulata Hanson				1			7		31	20		15	31		(2)	135		240
PERLIDAE																		
Acroneuria lycorias (Newman)	82	57	1	8								14						162
Paragnetina media (Walker)	2	2		18								11	7					40
Perlesta placida (Hagen)				1								1		(8)				2
PERLODIDAE																		
Isogenoides frontalis (Newman)									119	2								121
I. olivaceus (Walker)		6										2						8
Isoperla frisoni Illies												2						2
I. signata (Banks)	1			4			1					29						35
I. slossonae (Banks)							4			1						13		18
I. transmarina (Newman)	40	18	5								(2)	4				2		69

Ephemeroptera (Mayflies)
11 families, 21 genera, 27+ species

The distribution and relative abundance of the 27 identified species are presented in Table 5. Species richness of Ephemeroptera was high throughout most of the Brule River system except for the 2 uppermost mainstem and the colder tributary biotic areas. Nebagamon and Trask creeks contained the most species.

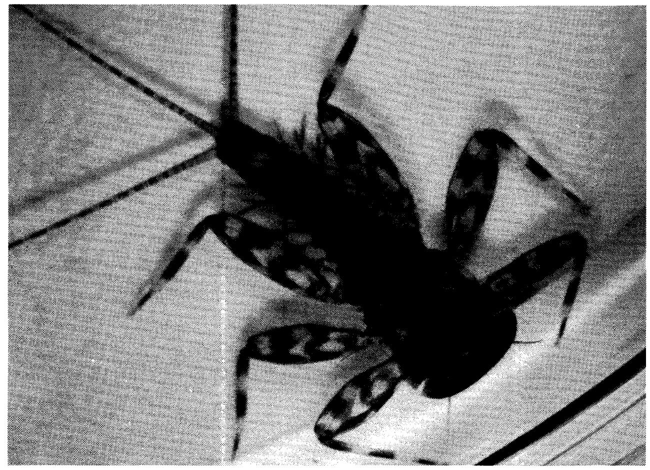
Identification of siphlonurid, isonychiid, leptophlebiid, and tricorythid larvae is uncertain or difficult. Identification of *Siphloplecton basale* is tentative. The genus *Ephemerella* needs further revision. I identified both *Ephemerella invaria* and *E. rotunda* Morgan using the key of Allen and Edmunds (1965), but because the validity of separating these species in Wisconsin using this key is questionable (W.L. Hilsenhoff, Univ. Wis.-Madison Dep. Zoology, pers. comm.), I considered all larvae to be *E. invaria*. Additional species keys provided by Allen and Edmunds (1963*a*, 1963*b*), Bednarik and McCafferty (1979), Bergman and Hilsenhoff (1978), Berner (1978), Burks (1953), Daggy (1941), Flowers and Hilsenhoff (1975), Hilsenhoff (1984*b*), Lewis (1974), McCafferty (1975, 1991), McCafferty and Waltz (1990), Morihara and McCafferty (1979), and Provonsha (1990) were used. W. Hilsenhoff identified *Eurylophella temporalis* and R. Narf confirmed identifications of several species of *Ephemerella*.

Siphlonuridae. Larvae of *Siphlonurus* were collected from among rooted aquatic vegetation in slow water near shore in the LOW and MEA mainstem biotic areas, where they were swimming minnow-like among the plant stems.

Metretopodidae (Cleftfooted Minnow Mayflies). Larvae of *Siphloplecton basale* were collected along with *Siphlonurus* from the same slow-water habitat, and they exhibited similar swimming behavior.

Baetidae (Small Minnow Mayflies). Three genera, *Acentrella*, *Acerpenna*, and *Baetis*, were identified; all were more commonly collected in drift nets from tributary biotic areas than in benthos samples. *Acentrella carolina* was fairly common in drift samples from the BLU biotic area; one specimen was found in the mainstem benthos (LED). *Baetis brunneicolor* (NOB) and *Acerpenna macdunnoughi* (BLU) were collected solely in drift nets from tributaries. *Baetis flavistriga* was widespread in both mainstem and tributary biotic areas, occurring occasionally in benthic samples and abundantly in drift samples. *Baetis tricaudatus* was similarly well distributed, but occurred more often in benthic samples and less often in drift samples. Baetids also were abundant in the Pine-Popple system (Hilsenhoff et al. 1972).

Isonychiidae. Only one larva of *Isonychia* was collected from the MID biotic area. This genus was abundant in the Pine-Popple system (Hilsenhoff et al. 1972).



Heptagenia pulla (×5.0)

Heptageniidae (Flatheaded Mayflies). This family was common in the benthos throughout the Brule River system with most specimens found under rocks in fast water. *Heptagenia pulla* was locally common only in the ROC biotic area. *Nixe lucidipennis* occurred only in drift samples from Blueberry Creek. *Rhithrogena jejuna* occurred occasionally in 2 mainstem (LOW and LED) and in one tributary (NEB) biotic area. *Stenacron interpunctatum* was found only in an upper river spring pond. *Stenonema* was a common and widely distributed genus in the Brule River system with 6 identified species. However, 3 species (*S. exiguum, S. pulchellum*, and *S. terminatum*) each were represented by just one or 2 larvae. *Stenonema femoratum* was collected only from the predominantly lentic habitat along the shore of the BIG biotic area. *Stenonema modestum* occurred occasionally in the benthos of several mainstem and tributary biotic areas. *Stenonema vicarium* was the most common heptageniid, occurring occasionally in mainstem and abundantly in tributary biotic areas. Heptageniids also were common and widely distributed in the Pine-Popple system (Hilsenhoff et al. 1972) including several of the same species found in the Brule River system.

Leptophlebiidae (Pronggills). The 2 identified leptophlebiid genera both were fairly common, especially in tributary biotic areas. Larvae of *Leptophlebia* occurred in 4 tributary biotic areas and one mainstem biotic area. Among the larvae of *Paraleptophlebia* that were found mostly in the BLU and NEB biotic areas, the larger specimens all were identified as *P. mollis*; smaller larvae could not be identified.

Table 5. *Numbers of larvae of Ephemeroptera collected in benthos samples and drift nets from 15 biotic areas within the Bois Brule River drainage (drift-net catches within parentheses).*

Family	Mainstem Biotic Areas						Tributary Biotic Areas											Benthic
Genus Species	LOW	LED	MEA	MID	BIG	STB	TRA	PNT	ROC	LBR	(LBR)	NEB	BLU	(BLU)	(NOB)	WIL	WFK	Total
SIPHLONURIDAE																		
Siphlonurus sp.	5		3															8
METRETOPODIDAE																		
Siphloplecton basale (Walker)	6		2															8
BAETIDAE																		
Acentrella carolina (Banks)		1												(67)				1
Acerpenna macdunnoughi (Ide)														(188)				
Baetis brunneicolor McDunnough							4			8	(754)				(181)			12
B. flavistriga McDunnough		3	5			3					(2,502)			(1,050)	(58)	1	1	13
B. tricaudatus Dodds	15	42	1	23					20		(120)	3		(59)		17		121
B. spp.				16						2	(40)	8	10	(32)	(21)			36
ISONYCHIIDAE																		
Isonychia sp.				1														1
HEPTAGENIIDAE																		
Heptagenia pulla (Clemens)							1		49									50
Nixe lucidipennis (Clemens)														(29)				
Rhithrogena jejuna Eaton	8	8										3						19
Stenacron interpunctatum (Say)						2*												2
Stenonema exiguum Traver				1														1
S. femoratum (Say)					15													15
S. modestum (Banks)	5			6			1					12					2	26
S. pulchellum (Walsh)			2															2
S. terminatum (Walsh)	1																	1
S. vicarium (Walker)	6			6			10			56		36	36			25		175
LEPTOPHLEBIIDAE																		
Leptophlebia spp.	1									18		7	2			2		30
Paraleptophlebia mollis (Eaton)		3										19	20	(13)				42
P. spp.	1			5			4			1					(243)	6		17
EPHEMERELLIDAE																		
Ephemerella aurivillii (Bengtsson)									87	6								93
E. invaria (Walker)	408	106	11	249	8		1					62						845
E. needhami McDunnough		3	2	2														7
E. subvaria McDunnough	9	8	3	43		20	17			47		5	24					176
E. spp.			4	5							(4)						9	18
Eurylophella temporalis (McDunnough)							1									4		5
Serratella deficiens (Morgan)		2		2		1*												5
TRICORYTHIDAE																		
Tricorythodes sp.				26														26
CAENIDAE																		
Caenis youngi Roemhild				2														2
BAETISCIDAE																		
Baetisca laurentina McDunnough			7									1						8
EPHEMERIDAE																		
Ephemera simulans Walker				3														3
Hexagenia limbata (Serville)	35		1	4	10													50

* Blue Spring.

Ephemerellidae (Spiny Crawlers). Three genera were identified, among which *Ephemerella* was most abundant and widely distributed. *Ephemerella aurivillii* was found in 2 tributary biotic areas and was abundant in ROC. *Ephemerella invaria* was the most abundant mayfly in benthos samples throughout the Brule River system, and was one of the most common aquatic insects in mainstem biotic areas. It was also one of the most abundant mayflies in the Pine-Popple system (Hilsenhoff et al. 1972). A few larvae of *E. needhami* were found in 3 mainstem biotic areas. *E. subvaria* was common and well distributed in both mainstem and tributary biotic areas. Very small larvae of *Ephemerella* could not be identified to species. *Eurylophella temporalis* was uncommon in 2 tributary biotic areas (TRA and WIL) and *Serratella deficiens* was uncommon in several mainstem biotic areas, including a spring pond.

Tricorythidae (Little Stout Crawlers). I expected the genus *Tricorythodes* to be common and fairly widespread based on angler reports. However, larvae were collected at only one site within the MID biotic area and only with the multi-plate artificial substrate samplers. They may have been underrepresented in my samples because of sampling bias. Larvae probably were *T. atratus* but could not be named with certainty.

Caenidae (Small Squaregills). Two larvae of *Caenis youngi* were collected at one mainstem site (MID).

Baetiscidae (Armored Mayflies). Larvae of *Baetisca laurentina* were uncommon in slow-water, near-shore areas of a mainstem (MEA) and a tributary (NEB) biotic area.

Ephemeridae (Common Burrowers). The 2 identified genera, *Ephemera* and *Hexagenia*, occurred solely in silt-bed areas within mainstem biotic areas. These aquatic insects are important trout food items in the Brule River during the brief adult stage of their life cycle. Only 3 larvae of *Ephemera simulans* were identified, but observations of adult hatches indicated that this aquatic insect was locally common. *Hexagenia limbata* was common and widespread. These species also were common in the Pine-Popple system (Hilsenhoff et al. 1972).

Odonata (Dragonflies and Damselflies)
6 families, 7 genera, 9+ species

The distribution and relative abundance of 9 identified species from the Brule River system are presented in Table 6. Larvae of Odonata infrequently were collected, most likely because they usually are not abundant in riffle areas. Odonates also were uncommonly collected by Hilsenhoff et al. (1972) in the Pine-Popple system. Keys provided by Needham and Westfall (1955), Walker (1953, 1958), and Walker and Corbet (1975) were used to identify all mature larvae. Only 2 species occurred with any regularity in the samples.

Calopterygidae (Broad-winged Damselflies). Although rarely collected, this family was common, based on observations of adults seen flying along riparian areas. Two larvae of *Calopteryx aequabilis* and 3 larvae of *C. maculata* were collected among near-shore vegetation in slow-water areas of 2 biotic areas.

Cordulegastridae (Biddies). Larvae of *Cordulegaster maculatus*, the most widely distributed odonate, were found in 5 tributary biotic areas.

Gomphidae (Clubtails). *Ophiogomphus carolus* was the most common odonate in the mainstem biotic areas (LOW and MID). Larvae also occurred occasionally in one tributary biotic area (NEB).

Aeshnidae (Darners). Larvae belonging to 2 genera, *Aeshna* and *Boyeria*, were identified. Larvae of *Aeshna canadensis*, *A. tuberculifera*, and *Boyeria vinosa* were collected from a shallow, heavily vegetated area of reduced flow at the mouth of the Brule River (LOW). Several larvae of *B. vinosa* also were collected from one tributary biotic area (BLU).

Corduliidae (Green-eyed Skimmers). Six larvae of *Somatochlora minor* were collected in drift nets from 2 tributary biotic areas (BLU and NOB) indicating that this species may have a greater propensity to drift than the other odonates in the tributaries.

Libellulidae (Common Skimmers). One larva of *Plathemis lydia* was collected from a shallow, heavily vegetated area along a bank of MEA biotic area.

Trichoptera (Caddisflies)
12 families, 30 genera, 35+ species

The distribution and relative abundance of 35 identified species are listed in Table 7. Eighteen species were found at MID, but no other mainstem biotic area held more than 6 species. Numbers of Trichoptera were similar among tributary biotic areas with 5 tributaries containing 9 to 11 species.

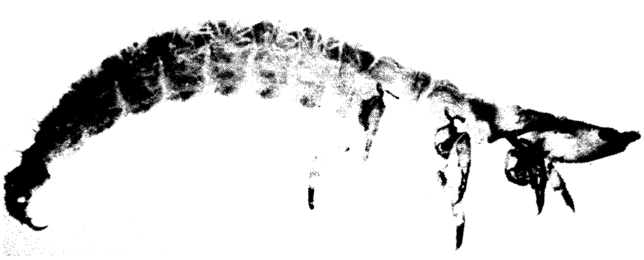
Larvae of Polycentropodidae, Glossosomatidae, Lepidostomatidae, and Phryganeidae could not be identified to species. Most limnephilid larvae were identifiable but problem genera exist; larvae of *Limnephilus* presently cannot be identified. I used keys by Betten (1950), Flint (1960, 1962), Haddock (1977), Hilsenhoff (1985), Ross (1944), Schmude and Hilsenhoff (1986), and Schuster and Etnier (1978). W. Hilsenhoff confirmed identifications of the Brachycentridae. K. Schmude (then with the University of Wisconsin-Madison Department of Zoology; currently at UW-Superior Lake Superior Research Institute) contributed advice concerning identification of the Hydropsychidae and confirmed numerous identifications in that family.

Philopotamidae (Finger-net Caddisflies). Larvae of *Dolophilodes distinctus*, the only species identified, occurred occasionally in small tributary biotic areas.

Polycentropodidae (Trumpet-net and Tube-making Caddisflies). Specimens within this net-spinning family rarely were collected by my samplers, but a few larvae within 4 genera were identified. *Neureclipsis* was found in a fast-water area of the MID biotic area, *Phylocentropus* and *Polycentropus* were found in reduced-flow areas of mainstem biotic areas, and one larva of *Nyctiophylax* was found in a tributary biotic area (NEB).

Hydropsychidae (Common Netspinners). Five genera were identified in this abundant family of netspinners. *Ceratopsyche* was the most abundant genus of Trichoptera in the Brule River system, represented by 7 species. Larvae of *Ceratopsyche slossonae* and *C. sparna* were abundant and widely distributed in both mainstem and tributary biotic areas. *Ceratopsyche vexa* was common in one upper mainstem biotic area (STB). *Ceratopsyche walkeri* and *C. morosa* (morosa form) were fairly common in several mainstem biotic areas. *Ceratopsyche alhedra* occurred occasionally in one mainstem and 5 tributary biotic areas (MID), but often was difficult to separate from *C. sparna* because of head pattern overlap. *Ceratopsyche bronta* was uncommon in the NEB biotic area. Larvae of *Cheumatopsyche* were fairly common and widely distributed throughout the Brule River system. *Diplectrona modesta* was locally common in one tributary biotic area (WIL). Larvae of *Hydropsyche betteni* were uncommon in 3 tributary biotic areas, and just one larva of *H. placoda* was found in a mainstem biotic region (MID). Larvae of *Parapsyche apicalis* were collected from 2 small-tributary biotic areas (TRA and ROC). Most species of *Ceratopsyche* and *Hydropsyche*, as well as the genus *Cheumatopsyche* also were found in the Pine-Popple system (Hilsenhoff et al. 1972), but the genera *Diplectrona* and *Parapsyche* were not.

Rhyacophilidae (Primitive Caddisflies). Most larvae of *Rhyacophila* (*R. brunnea* and *R. vibox*) occurred in small, cold tributary biotic areas. Larvae of *R. fuscula* were collected only from the Hall's Rapids collection site on the mainstem (MID, Site 11).



Rhyacophila brunnea (×6.5)

Glossosomatidae. Only the genus *Glossosoma* was identified, and it occurred in half of the mainstem and most of the tributary biotic areas. I also expected to find larvae of *Protoptila* Banks, but they may have been overlooked because of their small size.

Table 6. *Numbers of larvae of Odonata collected in benthos samples and drift nets from 15 biotic areas within the Bois Brule River drainage (drift-net catches within parentheses).*

Family	Mainstem Biotic Areas						Tributary Biotic Areas											Benthic
Genus Species	LOW	LED	MEA	MID	BIG	STB	TRA	PNT	ROC	LBR	(LBR)	NEB	BLU	(BLU)	(NOB)	WIL	WFK	Total
CALOPTERYGIDAE																		
Calopteryx aequabilis Say	2																	2
C. maculata (Beauvois)	1												2					3
CORDULEGASTRIDAE																		
Cordulegaster maculatus Selys							1	1		1	(1)		5			8		16
GOMPHIDAE																		
Ophiogomphus carolus Needham	19		1	11								7						38
AESHNIDAE																		
Aeshna canadensis Walker	1																	1
A. tuberculifera	1																	1
A. sp.	1																	1
Boyeria vinosa (Say)	1												3					4
CORDULIIDAE																		
Somatochlora minor Calvert														(4)	(2)			
LIBELLULIDAE																		
Plathemis lydia (Drury)			1															1

Table 7. *Numbers of larvae of Trichoptera collected in benthos samples and drift nets from 15 biotic areas within the Bois Brule River drainage (drift-net catches within parentheses).*

Family / Genus Species	Mainstem Biotic Areas						Tributary Biotic Areas											Benthic Total
	LOW	LED	MEA	MID	BIG	STB	TRA	PNT	ROC	LBR	(LBR)	NEB	BLU	(BLU)	(NOB)	WIL	WFK	
PHILOPOTAMIDAE																		
Dolophilodes distinctus (Walker)							1		5				1	(3)		6		13
POLYCENTROPODIDAE																		
Neureclipsis sp.				1														1
Nyctiophylax sp.												1						1
Phylocentropus sp.	1																	1
Polycentropus sp.					4													4
HYDROPSYCHIDAE																		
Ceratopsyche alhedra (Ross)				13			11			1	(2)	3	2					30
C. bronta (Ross)												3						3
C. morosa (Hagen)	8	13		3								3						27
C. slossonae (Banks)	1			32		2	91		1	336	(10)		9			52		524
C. sparna (Ross)	17	34	8	138					3	3	(5)	2	2	(138)				207
C. vexa (Ross)				1		53												54
C. walkeri (Betten and Mosely)		11		50				1										62
Cheumatopsyche spp.	1	2	6	25		5		3		13	(3)	12				1		68
Diplectrona modesta Banks													1			41		42
Hydropsyche betteni Ross										3			7			3		13
H. placoda Ross				1														1
Parapsyche apicalis (Banks)							3		10									13
RHYACOPHILIDAE																		
Rhyacophila brunnea Banks							13		46						(1)	24		83
R. fuscula (Walker)				4								1						5
R. vibox Milne								5								5		10
GLOSSOSOMATIDAE																		
Glossosoma spp.		3	1	12			2		7		(1)		3	(67)	(12)	11		39
HYDROPTILIDAE																		
Agraylea multipunctata Curtis				1														1
PHRYGANEIDAE																		
Ptilostomis sp.						1				1								2
BRACHYCENTRIDAE																		
Brachycentrus americanus (Banks)	7	7	1	91	3		5			63	(24)		5					182
B. lateralis (Say)				7														7
B. numerosus (Say)	2	1		8								1						12
Micrasema kluane Ross and Morse							4						1			2		7
M. rusticum (Hagen)				1														1
LIMNEPHILIDAE																		
Anabolia consocia (Walker)														(1)				
Hesperophylax designatus (Walker)							2	7	3	16								28
Limnephilus spp.			5	1		2						8					2	18
Nemotaulius hostilis (Hagen)										1								1
Platycentropus amicus (Hagen)						3				1							1	5
Pseudostenophylax uniformis (Betten)										2								2
Psychoglypha subborealis (Banks)									3	4	(40)							7
Pycnopsyche guttifer (Walker)	1		6	1			1			1		1	8					19
P. scabripennis (Rambur)						2*												2

(continued on next page)

Table 7. *Continued.*

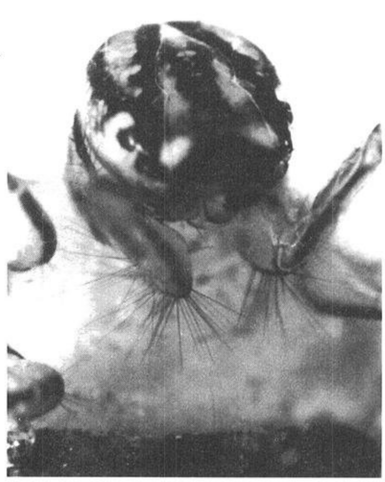
Family Genus Species	Mainstem Biotic Areas						Tributary Biotic Areas											Benthic
	LOW	LED	MEA	MID	BIG	STB	TRA	PNT	ROC	LBR	(LBR)	NEB	BLU	(BLU)	(NOB)	WIL	WFK	Total
UENOIDAE																		
Neophylax concinnus McLachlan					40				4			1						45
N. fuscus Banks				1				1	3									5
N. spp.				7			1			3		3						14
LEPIDOSTOMATIDAE																		
Lepidostoma spp.		1	1		4				1	8	(3)		1	(2)	(6)	23		39
HELICOPSYCHIDAE																		
Helicopsyche borealis (Hagen)		1		1								1						3
LEPTOCERIDAE																		
Mystacides sepulchralis (Walker)				1	3													4
Nectopsyche diarina (Ross)				1														1
Oecetis avara (Banks)													2					2

* Blue Spring.

Hydroptilidae (Micro Caddisflies). This family was represented by only one larva of *Agraylea multipunctata* collected from a mainstem biotic area (MID). More taxa probably were present in the Brule River system, but because of their small size and/or bias in sampling appropriate habitats, I may have overlooked them.

Phryganeidae (Large Caddisflies). Two larvae of *Ptilostomis* were identified in this uncommon family, one each from among vegetation along the banks within the LBR and STB biotic areas.

Brachycentridae (Humpless Case Makers). Larvae of *Brachycentrus americanus* were common throughout the Brule River mainstem and in several tributary biotic areas. Larvae of *Brachycentrus lateralis* collected from a riffle at the DNR Ranger Station canoe landing (MID, Site 10) represent one of the only collections of this rare species in Wisconsin (Hilsenhoff 1985). *Brachycentrus numerosus* occasionally was collected from the mainstem biotic areas and from one tributary biotic area (NEB). Two species of *Micrasema* were identified; *M. kluane* occurred uncommonly in 3 tributary biotic areas and one larva of *M. rusticum* was found in the MID biotic area.



Brachycentrus lateralis (head capsule) (×21.2)

Limnephilidae (Northern Case Makers). This family was rich in species and widely distributed but few larvae were collected at most sites. *Anabolia consocia, Nemotaulius hostilis, Pseudostenophylax uniformis,* and *Pycnopsyche scabripennis* each were represented by just one or 2 larvae from upper river mainstem or tributary biotic areas. Larvae of *Hesperophylax designatus* and *Psychoglypha subborealis* each were found in several tributary biotic areas. Larvae of *Limnephilus* and *Pycnopsyche guttifer* occasionally were found in both mainstem and tributary biotic areas. *Platycentropus amicus* was found among near-shore vegetation at one mainstem (STB) and one tributary (LBR) biotic area. All of these species, with the exception of *Psychoglypha subborealis,* also were found in the Pine-Popple system (Hilsenhoff et al. 1972).

Uenoidae. *Neophylax* was the only genus identified within this family. *N. concinnus* was locally common in the BIG biotic area; outside of that area, *N. concinnus* and *N. fuscus* only occasionally were found in both mainstem and tributary biotic areas.

Lepidostomatidae. Larvae of *Lepidostoma* were distributed widely throughout the mainstem and tributary biotic areas but tended to occur in low numbers.

Helicopsychidae (Snail Case Makers). Three larvae of *Helicopsyche borealis* were collected from one tributary (NEB) and 2 mainstem (LED and MID) biotic areas. This genus probably was more common than these results indicate, but larvae frequently may have been overlooked because of their cryptic, shell-like case.

Leptoceridae (Long-horned Case Makers). Three species of leptocerids within 3 genera were identified, but all were collected infrequently. Larvae of *Mystacides sepulchralis* occurred in slow-water areas of the MID and BIG biotic areas. One larva of *Nectopsyche diarina* was found in the MID biotic area, and 2 larvae of *Oecetis avara* were collected from a tributary biotic area (BLU).

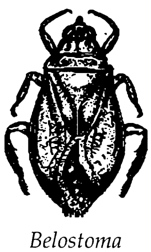
Megaloptera (Fishflies, Dobsonflies, and Alderflies) 2 families, 2 genera, 1+ species

The distribution and relative abundance of the 2 collected genera are provided in Table 8. Only 25 larvae within this order were collected in benthos samples; none were taken in drift-net samples. Larvae of *Nigronia serricornis* only occasionally were found in fast-water areas of both mainstem and tributary biotic areas, and were identified using the key of Neunzig (1966). *Sialis* larvae were not identifiable; only 2 specimens were found in the ROC biotic area.

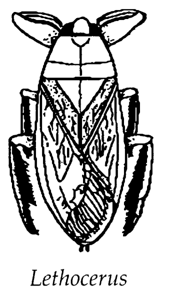
Aquatic and Semi-aquatic Hemiptera (Bugs) 4 families, 6 genera, 12 species

Distribution and relative abundance of the 12 species of aquatic and semi-aquatic Hemiptera (= Heteroptera) that I identified are presented in Table 9. Most Hemiptera prefer lentic habitats or slow-moving stream sections. Consequently, they were collected infrequently by the riffle-oriented sampling approach used in this study. A concerted effort is required to collect semi-aquatic Hemiptera (those living on the surface of the water); because this study focused primarily on trout-food organisms, I did not make that effort. Aquatic and semi-aquatic Hemiptera appear to be consumed infrequently by trout based on their rare mention in reports describing salmonid food habits (e.g., Elliott 1967, Griffith 1974, Johnson 1981, Cada et al. 1986). Hilsenhoff et al. (1972) collected 47 species of aquatic and semi-aquatic Hemiptera in the Pine-Popple system. Regional keys provided by Hilsenhoff (1970, 1984*a*, 1986), and keys by Menke (1963) and Smith and Polhemus (1978) were used to identify adult Hemiptera.

Veliidae (Short-legged Striders). A group of *Rhagovelia obesa* was collected with one sweep of a net in a backwater area of the LOW biotic area. Several individuals of the same species were taken in drift nets from a small tributary biotic area (NOB).



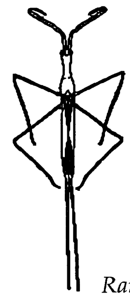
Belostoma flumineum



Lethocerus americanus

Belostomatidae (Giant Water Bugs). Only 5 individuals were collected with the samplers among the 2 identified species, *Belostoma flumineum* and *Lethocerus americanus*. However, both species were common and widespread based on observations made while electrofishing (they reacted to the electrical field) and incidental catches with a salmonid smolt trap (DuBois and Rackouski 1992, trap described in DuBois et al. 1991).

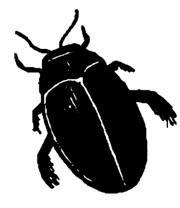
Corixidae (Water Boatmen). Four species each of *Hesperocorixa* and *Sigara* were collected from slow-water areas of the Brule River mainstem and from the LBR tributary biotic area.



Ranatra fusca

Nepidae (Water Scorpions). Only one adult specimen of *Ranatra fusca* was collected by the samplers. However, it too was common, at least in the drift fauna during autumn, based on smolt trap catches (DuBois and Rackouski 1992).

Aquatic Coleoptera (Beetles) 6 families, 16 genera, 15+ species

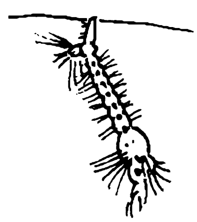


Coleoptera sp.

The distribution and abundance of 15 species identified are listed in Table 10. Adults and larvae of Coleoptera infrequently were encountered by my riffle-oriented sampling approach (except for larvae of *Optioservus*, which were fairly common in most of the mainstem and tributary biotic area) and certainly were more common in the Brule River system than these results indicate. Eight genera (*Gyrinus, Peltodytes, Agabus, Hygrotus, Liodessus, Hydrochus, Dubiraphia,* and *Lixellus*) were collected either solely or predominantly in tributary drift-net samples.

Only adults of Coleoptera were identifiable to species. By family, 3 species of Haliplidae were identified, 6 species of Dytiscidae, 2 species of Hydrophilidae, and 4 species of Elmidae; all identified species were represented by 4 or fewer individuals. Adult Haliplidae were identified using the key by Hilsenhoff and Brigham (1978). Adult Elmidae except for *Dubiraphia* were identified using the key by Brown (1976). W. Hilsenhoff identified adult Dytiscidae, Hydrophilidae, and *Dubiraphia*.

Aquatic Diptera (True Flies and Midges) 11 families, 59 genera, 12+ species



Diptera larva

The distribution and relative abundance of the 12 species and 59 genera identified are listed in Table 11. Diptera were abundant in fast-water mainstem biotic areas (LOW, MID, and LED) and were well distributed throughout the tributary biotic areas where they frequently occurred in drift-net samples.

Species identification of dipteran larvae usually was not possible; in some cases genera could not be named with certainty. I tentatively identified *Atherix variegata* based on distribution information by Webb (1977). *Bittacomorpha* was identified with the key of McAlpine et al. (1981). Larval identification of the Simuliidae was difficult due to head pattern variability and was, therefore, rather uncertain. I used keys by Hilsenhoff (1982), Merritt et al. (1978), and Wood et al. (1963) to make the simuliid determinations, but many were identified only to genus. Ceratopogonids were difficult to identify, and generic determinations were somewhat uncertain. R. Narf identified *Bezzia* and the Chironomidae from Blueberry Creek. M. Rackouski (DNR Bureau of Fisheries Management) identified the remaining Chironomidae (subsequently confirmed by W. Hilsenhoff).

Tipulidae (Crane Flies). Larvae of 7 genera were identified, of which *Hexatoma* and *Tipula* were abundant in both mainstem and tributary biotic areas. Larvae of *Antocha* occasionally were found in mainstem and tributary biotic areas, and larvae of *Dicranota* occasionally were found in 6 tributary biotic areas. *Pilaria* and *Pseudolimnophila* were represented by just one larva each. Larvae of *Prionocera* were uncommon in the ROC biotic area.

Ptychopteridae (Phantom Crane Flies). One larva of *Bittacomorpha* was collected from the LBR biotic area.

Blephariceridae (Net-winged Midges). Twelve larvae of *Blepharicera* were found attached to rocks in fast water of the LOW biotic area. Because special effort was required to collect them, they probably were much more abundant than these results indicate.

Dixidae. Eight larvae of *Dixa* were collected in drift-net samples from the LBR biotic area.

Table 8. *Numbers of larvae of Megaloptera collected in benthos samples from 15 biotic areas within the Bois Brule River drainage.*

Family	Mainstem Biotic Areas						Tributary Biotic Areas											Benthic
Genus Species	LOW	LED	MEA	MID	BIG	STB	TRA	PNT	ROC	LBR	(LBR)	NEB	BLU	(BLU)	(NOB)	WIL	WFK	Total
CORYDALIDAE																		
Nigronia serricornis (Say)	3			9						5		5	1					23
SIALIDAE																		
Sialis sp.									2									2

Table 9. *Numbers of adults of Hemiptera collected in benthos samples and drift nets from 15 biotic areas within the Bois Brule River drainage (drift-net catches within parentheses).*

Family	Mainstem Biotic Areas						Tributary Biotic Areas											Benthic
Genus Species	LOW	LED	MEA	MID	BIG	STB	TRA	PNT	ROC	LBR	(LBR)	NEB	BLU	(BLU)	(NOB)	WIL	WFK	Total
VELIIDAE																		
Rhagovelia obesa Uhler	30														(4)			30
BELOSTOMATIDAE																		
Belostoma flumineum Say			2	1						1								4
Lethocerus americanus (Leidy)	1																	1
CORIXIDAE																		
Hesperocorixa atopodonta (Hungerford)			1							1								2
H. kennicottii (Uhler)			1															1
H. lobata (Hungerford)						1*												1
H. michiganensis (Hungerford)										2								2
H. sp.											(2)							
Sigara compressoidea (Hungerford)			1															1
S. johnstoni Hungerford	1									1								2
S. mathesoni Hungerford						3*												3
S. trilineata (Provancher)	8																	8
S. sp.											(4)							
NEPIDAE																		
Ranatra fusca Palisot de Beauvois			1															1

* McDougal's Spring.

Simuliidae (Black Flies). This was the most commonly represented family of aquatic insects in the tributary drift-net catch. Larvae of *Prosimulium* were not identified to species, and occurred in benthos samples from both mainstem and tributary biotic areas. Six species of *Simulium* were identified, of which 4 (*S. croxtoni, S. excisum, S. rugglesi,* and *S. venustum*) were collected only in drift nets from the BLU or NOB biotic areas. Two larvae of *Simulium verecundum* were identified from benthos samples. Larvae of the *Simulium vittatum* complex were common in one mainstem biotic area (MID) and in LBR. Identifications were difficult in this genus and misidentifications are possible; over half of the larvae collected were not named. Five larvae of *Stegopterna* from the WIL biotic area were not identified to species.

Chironomidae (Midges). Forty-one genera were identified from the Brule River system indicating a somewhat richer chironomid fauna than that described for the Pine-Popple system (26 identified genera, Hilsenhoff et al. 1972). Chironomids were common in benthos samples from 3 mainstem biotic areas (MEA, MID, BIG), and from several tributary biotic areas (NEB, WIL, WFK). They also were common in drift-net samples from BLU. The most common genera (in decreasing order of abundance) were *Conchapelopia, Microtendipes, Pagastia, Diamesa, Polypedilum, Tvetenia, Orthocladius, Cricotopus, Micropsectra, Eukiefferiella, Zavrelimyia,* and *Heterotrissocladius.*

Ceratopogonidae (Biting Midges). Small numbers of *Bezzia* and *Probezzia* were identified from the tributary biotic areas. Ceratopogonids undoubtedly were more abundant than these results indicate; most larvae are very small and easily overlooked.

Tabanidae (Horse and Deer Flies). Two genera, *Chrysops* and *Tabanus*, were uncommon in benthos samples from both mainstem and tributary biotic areas.

Athericidae (Water Snipe Flies). *Atherix variegata* occurred on gravel, cobble, and rubble substrates in fast-water areas of both mainstem and tributary biotic areas, and was one of the most abundant aquatic insects in the lower Brule River mainstem. Although common in benthos samples in the BLU tributary biotic area, *A. variegata* was not taken in drift nets.

Empididae (Dance Flies) and **Syrphidae** (Flower Flies). Three larvae were taken in LBR drift nets but generic keys were not available.

Community Composition

The major aquatic insect orders were well represented in the Brule River system, and 130 species and 155 genera within 60 families were identified. In terms of species richness, Trichoptera was the best-represented order (35 species) followed by Ephemeroptera (27 species) and Plecoptera (19 species). However, Diptera would have contained the most species (59 genera identified) had more of them been identifiable. Ephemeroptera was the most abundant order in terms of numbers of individuals in benthos samples (31% of the total) followed by Trichoptera (28%) and Diptera (18%). These results mirror those of Hilsenhoff et al. (1972) for the Pine-Popple system where Trichoptera and Ephemeroptera also were highest in species richness, and Ephemeroptera most abundant. The best represented families in the Brule River system were Hydropsychidae (11 species) and Heptageniidae (10 species); 41 genera of Chironomidae were identified.

Drift-net samples from the Little Brule River (LBR), Blueberry Creek (BLU), and the North Fork of Blueberry Creek (NOB) contained large numbers of individuals within relatively few taxa. The drift fauna in all 3 tributaries was overwhelmingly dominated by Baetidae and Simuliidae (Tables 5 and 11). However, 20 species (*Amphinemura linda, Leuctra tenella, Acerpenna macdunnoughi, Nixe lucidipennis, Somatochlora minor, Anabolia consocia, Hydroporus dentellus, Hygrotus picatus, Liodessus affinis, Hydrochus squamifer, Dubiraphia minima, Simulium croxtoni, S. excisum, S. rugglesi, S. venustum, Ablabesmyia mallochi, Cricotopus bicinctus, Paracladopelma undine, Polypedilum convictum,* and *P. illinoense*) and 20 genera (*Amphinemura, Acerpenna, Nixe, Somatochlora, Anabolia, Gyrinus, Peltodytes, Hygrotus, Liodessus, Hydrochus, Lixellus, Dixa, Ablabesmyia, Chaetocladius, Natarsia, Nilotanypus, Paracladopelma, Rheopelopia, Synorthocladius,* and *Thienemannimyia*) that were not collected by any other method were collected in the drift nets, underscoring their usefulness for contributing distributional information.

Differences Among Biotic Areas

Considerable variation in total numbers of genera (Table 12), species richness within taxonomic orders, and relative abundances of aquatic insects among biotic areas was evident beyond that attributable to differences in sampling effort alone. Most species occurred in the first 5 to 10 samples taken, allowing general comparisons to be made among biotic areas concerning the more common taxa; additional sampling added mostly occasional, relatively uncommon forms. Differences in species occurrence between mainstem and tributary biotic areas were particularly striking. Among the more abundant species identified, *Acroneuria lycorias, Ephemerella invaria,* and *Ceratopsyche sparna* were found primarily in the Brule River mainstem, whereas *Paracapnia angulata, Stenonema vicarium, Ceratopsyche slossonae, Rhyacophila brunnea,* and *Hesperophylax designatus* were found primarily in tributaries. The tributaries selected for sampling varied considerably in their physical and chemical characteristics (Table 3), and consequently had unique aquatic insect assemblages. Among the tributaries, the small, clear, cold streams (PNT, ROC, and WIL) contained the fewest taxa. Through the Brule River mainstem, there was no clear trend for species richness to change longitudinally within a biotic area; rather, it appeared that biotic areas having more variable gradients, and consequently greater diversity of substrate particle sizes (MID, LOW, and LED), contained more species.

Table 10. *Numbers of Coleoptera (adults except where indicated to be larvae) collected in benthos samples and drift nets from 15 biotic areas within the Bois Brule River drainage (drift-net catches within parentheses).*

Family	Mainstem Biotic Areas						Tributary Biotic Areas											Benthic
Genus Species	LOW	LED	MEA	MID	BIG	STB	TRA	PNT	ROC	LBR	(LBR)	NEB	BLU	(BLU)	(NOB)	WIL	WFK	Total
GYRINIDAE																		
Gyrinus sp. (larvae)											(8)							
HALIPLIDAE																		
Haliplus apostolicus Wallis	1																	1
H. connexus Matheson			1															1
H. immaculicollis Harris			1						1									2
H. sp. (larva)											(3)	1				1		2
Peltodytes sp. (larva)											(1)							
DYTISCIDAE																		
Agabus seriatus (Say)							1	1										2
A. spp.														(4)	(4)			
Colymbetes paykulli Erickson				1														1
Hydroporus dentellus Fall											(1)							
H. solitarius Sharp	1					2*												3
H. sp.											(2)							
Hygrotus picatus (Kirby)															(1)			
Liodessus affinis (Say)											(6)							
HYDROPHILIDAE																		
Berosus sp. (larva)		1																1
Hydrobius sp. (larva)							1											1
Hydrochus squamifer LeConte											(1)							
Tropisternus mixtus (LeConte)										3								3
ELMIDAE																		
Dubiraphia minima Hilsenhoff											(1)							
D. quadrinotata (Say)					1						(1)							1
D. sp.											(5)							
Optioservus fastiditus (LeConte)							3			1				(14)				4
O. trivittatus (Brown)	1																	1
O. spp. (larvae)	35	3	5	4		1	17			52		8	26	(38)	(2)	3		154
Stenelmis sp. (larvae)	2																	2
CURCULIONIDAE																		
Lixellus sp.											(146)							

* McDougal's Spring.

Table 11. *Numbers of larvae of Diptera collected in benthos samples and drift nets from 15 biotic areas within the Bois Brule River drainage (drift-net catches within parentheses).*

Family	Mainstem Biotic Areas						Tributary Biotic Areas											Benthic
Genus Species	LOW	LED	MEA	MID	BIG	STB	TRA	PNT	ROC	LBR	(LBR)	NEB	BLU	(BLU)	(NOB)	WIL	WFK	Total
TIPULIDAE																		
Antocha sp.		3	1	5			1					1						11
Dicranota sp.							5		3	9	(1)		2	(17)		2		21
Hexatoma sp.	12	34	3						27	4		24	1	(1)		5		110
Pilaria sp.				1														1
Prionocera sp.									6									6
Pseudolimnophila sp.										1								1
Tipula sp.	11			3			15	1	7	7		1	10			5		60
PTYCHOPTERIDAE																		
Bittacomorpha sp.										1								1
BLEPHARICERIDAE																		
Blephariceru sp.	12																	12
DIXIDAE																		
Dixa sp.											(8)							
SIMULIIDAE																		
Prosimulium sp.				36				4								1		41
Simulium croxtoni Nicholson and Mickel														(2)				
S. excisum Davies, Peterson and Wood														(264)				
S. rugglesi Nicholson and Mickel														(1,205)				
S. venustum Say														(1,334)	(187)			
S. verecundum Stone and Jamback		1								1								2
S. vittatum Zetterstedt				19						26	(72)							45
S. spp.		9	2	23	1	1		2	1			1		(3,026)				40
Stegopterna sp.																5		5
CHIRONOMIDAE																		
Ablabesmyia mallochi Walley														(1)				
Brillia sp.			2		1									(2)	(3)			3
Brundiniella sp.																	3	3
Chaetocladius sp.														(1)				
Chironomus sp.						2*											2	4
Cladotanytarsus sp.				2								1						3
Conchapelopia sp.			1	11	1							4		(7)	(11)		13	30
Corynoneura sp.				1													2	3
Cricotopus bicinctus (Meigen)														(3)				
C. sp.					4							6		(2)				10
Cryptochironomus sp.				2													4	6
Demicryptochironomus sp.				2														2
Diamesa sp.				5				3		10		3						21
Dicrotendipes sp.					5													5
Endochironomus sp.																	1	1
Epoicocladius sp.				1														1
Eukiefferiella sp.				1										(7)		4		5

(continued on next page)

Table 11. *Continued.*

Family / Genus Species	Mainstem Biotic Areas						Tributary Biotic Areas											Benthic Total
	LOW	LED	MEA	MID	BIG	STB	TRA	PNT	ROC	LBR	(LBR)	NEB	BLU	(BLU)	(NOB)	WIL	WFK	
CHIRONOMIDAE *(continued)*																		
Heterotrissocladius sp.			11															11
Micropsectra sp.			1									1				6	5	13
Microtendipes sp.				23	2							1				2		28
Natarsia sp.															(2)			
Nilotanypus sp.														(1)				
Odontomesa sp.			1															1
Orthocladius sp.				15	1							1						17
Pagastia sp.			7	19						2								28
Paracladopelma undine (Townes)														(1)				
Paralauterborniella sp.				1														1
Parametriocnemus sp.				5								1		(3)				6
Paratanytarsus sp.					2							1						3
Phaenopsectra sp.			1	4	1													6
Polypedilum convictum (Walker)														(12)				
P. illinoense (Malloch)														(2)				
P. sp.			1	3								4						8
Procladius sp.				3													4	7
Psectrocladius sp.			1		1													2
Rheocricotopus sp.												1						1
Rheopelopia sp.															(2)			
Synorthocladius sp.														(1)				
Tanytarsus sp.					2							3				1		6
Thienemanniella sp.					1													1
Thienemannimyia sp.														(1)				
Tribelos sp.				2													1	3
Tvetenia sp.			1	7										(11)				8
Zavrelimyia sp.				1										(7)	(1)	2	1	4
CERATOPOGONIDAE																		
Bezzia sp.														(3)			1	1
Probezzia sp.										1						1		2
TABANIDAE																		
Chrysops sp.		2		1									1					4
Tabanus sp.							2		2	2						2		8
ATHERICIDAE																		
Atherix variegata Walker	348	103		115			10					24	116					716
EMPIDIDAE											(2)							
SYRPHIDAE											(1)							

*McDougal's Spring.

Table 12. *Aquatic insect collection site numbers, sample sizes, number of genera collected, and mean biotic index values in 15 biotic areas within the Bois Brule River drainage including mainstem and tributary averages and totals.*

			Number of Samples		Number of Genera Collected		Mean Biotic Index Values
Biotic Area	Region Code	Site Numbers	Drift	Benthos	Drift	Benthos	(N* in parentheses)
Lower river	LOW	1-4	-	21	-	34	1.43 (9)
Ledges area	LED	5-7	-	10	-	26	1.21 (4)
Meadows area	MEA	8,9	-	8	-	38	—
Midsection transition area	MID	10-13	-	28	-	65	1.47 (8)
Big Lake	BIG	14	-	3	-	22	—
Stone's Bridge area	STB	15-17	-	5	-	17	2.84 (1)
Trask Creek	TRA	18,19	-	2	-	28	2.88 (2)
Pine Tree Tributary	PNT	20	-	1	-	13	—
Rocky Run	ROC	21	-	6	-	24	1.77 (4)
Little Brule River	LBR	22-27	50	8	26	51	3.43 (8)
Nebagamon Creek	NEB	28-31	-	7	-	48	1.66 (3)
Blueberry Creek	BLU	32	56	2	33	52	2.20 (2)
North Fork Blueberry Creek	NOB	33	30	-	19	18	—
Wilson Creek	WIL	34	-	12	-	33	1.78 (3)
West Fork	WFK	35	-	10	-	16	—
Mainstem avg.							1.47 (22)
Mainstem total		17 sites	-	75	-	107	
Tributary avg.							2.50 (22)
Tributary total		18 sites	136	48	58	119	

*N = Number of samples used to calculate Mean Biotic Index Values.

I examined frequency of occurrence by biotic area for species of Plecoptera, Ephemeroptera, Odonata, and Trichoptera (Table 13). Orders having aquatic or semi-aquatic, winged-adult forms (Hemiptera and Coleoptera) were excluded from this analysis as were orders having few identified species (Megaloptera and Diptera). No species was found in more than 9 of the 15 biotic areas. *Paracapnia angulata* was the most frequently found stonefly (8 biotic areas). *Baetis tricaudatus* and *Ephemerella subvaria* (9 biotic areas), followed by *B. flavistriga* (8 biotic areas), were the most frequently occurring mayflies. *Cordulegaster maculatus* was the most widely distributed dragonfly (5 biotic areas). *Ceratopsyche slossonae, C. sparna,* and *Brachycentrus americanus* (8 biotic areas) were the most widely distributed caddisflies. Only 7 of the 89 species (8%) considered in this analysis were present in more than half (8 or more) of the biotic areas. Approximately 70% of all identified species were present in 3 or fewer biotic areas.

Habitat-specific associations of dominant species varied considerably among biotic areas (Table 14). I considered species to be numerically predominant if they made up 10% or more of the total benthos collected in a biotic area. Only 2 species satisfied this requirement for one biotic area (STB), whereas 8 species did at another (BLU). There was a mean of 5 dominant species per biotic area. Two species (*Ephemerella invaria* and *Atherix variegata*) were dominant community components in 6 biotic areas. *Stenonema vicarium* was dominant in 5 of the 8 tributary biotic areas. Overall, I conclude that certain substrates in biotic areas, gravel in particular, produce higher numbers of aquatic insects and deserve management consideration and protection.

Biotic Index Values

Forty-four biotic index values were calculated from samples taken throughout the Brule River system during 1983 and 1984 (Table 12), which gave an average value of 1.98 (range 1.12 to 3.91 on a scale of 1 to 10) indicating excellent water quality throughout the system with no apparent organic pollution (Hilsenhoff 1987). Biotic index averages by biotic area ranged from 1.21 for the Ledges area (LED) of the lower Brule River mainstem to 3.43 for the LBR biotic area. Biotic indexes from tributary biotic areas averaged slightly higher than those from mainstem biotic areas (2.50 vs 1.47), though all means could be categorized as indicating excellent water quality. The relatively high values reported for the LBR biotic area cannot be explained by organic enrichment to the stream from the State Trout Rearing Station because values were equally high above and below the Rearing Station. By

Table 13. *Aquatic insect larvae within Plecoptera, Ephemeroptera, Odonata, and Trichoptera that occurred in at least two biotic areas within the Bois Brule River drainage, arranged according to frequency of occurrence of species.*

Number of biotic areas in which present	PLECOPTERA	EPHEMEROPTERA	ODONATA	TRICHOPTERA
9		*Baetis tricaudatus* *Ephemerella subvaria*		
8	*Paracapnia angulata*	*Baetis flavistriga*		*Ceratopsyche slossonae* *C. sparna* *Brachycentrus americanus*
7		*Stenonema vicarium* *Ephemerella invaria*		*Pycnopsyche guttifer*
6	*Isoperla transmarina*			
5	*Nemoura trispinosa* *Acroneuria lycorias* *Paragnetina media*	*Stenonema modestum*	*Cordulegaster maculatus*	*Ceratopsyche alhedra*
4	*Taeniopteryx burksi* *T. nivalis* *Isoperla signata*	*Hexagenia limbata*	*Ophiogomphus carolus*	*Dolophilodes distinctus* *Ceratopsyche morosa* *Rhyacophila brunnea* *Brachycentrus numerosus* *Hesperophylax designatus*
3	*Strophopteryx fasciata* *Taeniopteryx parvula* *Amphinemura linda* *Perlesta placida* *Isoperla slossonae*	*Baetis brunneicolor* *Rhithrogena jejuna* *Paraleptophlebia mollis* *Ephemerella needhami* *Serratella deficiens*		*Ceratopsyche walkeri* *Hydropsyche betteni* *Micrasema kluane* *Neophylax concinnus* *N. fuscus* *Platycentropus amicus* *Helicopsyche borealis*
2	*Pteronarcys dorsata* *Allocapnia pygmaea* *Isogenoides frontalis* *I. olivaceus*	*Siphloplecton basale* *Acentrella carolina* *Heptagenia pulla* *Ephemerella temporalis* *Baetisca laurentina*	*Calopteryx maculatum* *Boyeria vinosa* *Somatochlora minor*	*Ceratopsyche vexa* *Diplectrona modesta* *Parapsyche apicalis* *Rhyacophila fuscula* *R. vibox* *Psychoglypha subborealis* *Mystacides sepulchralis*

comparison, biotic index values from 55 sites on 40 streams within the Chequamegon National Forest ranged from excellent to poor (Steven and Jacobi 1978, Nelson 1979) and, as a whole, these streams gave higher average values (were of poorer quality) than the averages for the Brule River system. However, the trout streams they sampled fell into the same range.

Effects of TFM on the Aquatic Insect Community

Studies of TFM impacts on aquatic invertebrate communities show a consistent pattern of temporary reductions in abundance of a relatively small number of taxa sensitive to TFM, but no, or minor, long-term effects (articles cited in Introduction; laboratory studies summarized in Nat. Res. Counc. Can. 1985).

During the preliminary study phase of the project, aquatic insect drift in Blueberry Creek was examined before, during, and after TFM treatment in 1986 (DuBois and Plaster 1993). Results from this phase showed catastrophic drifting of *Simulium* in response to the chemical, as well as elevated drift responses of *Glossosoma* and *Baetis*. These results indicate that short-term reductions in abundance of a few sensitive taxa following TFM treatments are likely, at least in Blueberry Creek. However, most aquatic insect taxa in the drift fauna were not affected significantly by the treatment. Other studies of drifting macroinvertebrates before, during, and after TFM treatments have shown a similar pattern of increased drift rates in response to TFM among taxa likely to be seriously impacted by treatment (Dermott and Spence 1984, Kolton et al. 1986, MacMahon et al. 1987).

In addition, a comparison of biotic index values from TFM-treated vs non-treated areas of the Brule River system might be expected to provide information about TFM effects on aquatic insects. Under our circumstances, however, such a comparison would not shed light on the TFM issue because non-treated areas (headwater areas and the upper reaches of tributaries) tended to differ in many ways, both physically and chemically, from TFM-treated areas (most of the mainstem and the lower reaches of tributaries).

Table 14. *Aquatic insect species comprising 10% or more of the total number collected in benthos samples within each biotic area.*

	Mainstem Biotic Areas						Tributary Biotic Areas							
Species	LOW	LED	MEA	MID	BIG	STB	TRA	PNT	ROC	LBR	NEB	BLU	WIL	WFK
PLECOPTERA														
Pteronarcys dorsata		✧												
Taeniopteryx burksi											✧			
Nemoura trispinosa			✧					✧			✧			
Paracapnia angulata									✧			✧	✧	
Acroneuria lycorias	✧	✧												
Isogenoides frontalis									✧					
Isoperla signata											✧			
EPHEMEROPTERA														
Baetis flavistriga														✧
B. tricaudatus		✧							✧				✧	
Heptagenia pulla									✧					
Stenonema femoratum					✧									
S. modestum														✧
S. vicarium							✧			✧	✧	✧	✧	
Paraleptophlebia mollis											✧	✧		
Ephemerella aurivillii									✧					
E. invaria	✧	✧	✧	✧	✧						✧			
E. subvaria						✧	✧			✧		✧		
Baetisca laurentina			✧											
Hexagenia limbata					✧									
TRICHOPTERA														
Ceratopsyche alhedra							✧							
C. slossonae							✧			✧		✧		
C. sparna		✧	✧	✧										
C. vexa						✧								
C. walkeri				✧										
Diplectrona modesta												✧		
Rhyacophila brunnea							✧		✧			✧		
R. vibox								✧						
Brachycentrus americanus				✧						✧				
Hesperophylax designatus								✧						
Neophylax concinnus					✧									
Platycentropus amicus														✧
Pycnopsyche guttifer			✧											
DIPTERA														
Atherix variegata	✧	✧		✧			✧				✧	✧		

Lampricide treatments of the Brule River system undoubtedly subjected some aquatic insect taxa to temporary reductions in abundance following treatments and may have greatly reduced populations of a few very sensitive species. Treatments may have contributed to reduced sizes of some aquatic insect hatches during the year of treatment or the following year. It also is likely that short-term reductions in growth rates and abundances of salmonids were caused by treatments, either through direct mortality from higher-than-desired concentrations of the chemical or from secondary effects through the foodweb (DuBois and Blust, in press). On the other hand, it is unlikely that TFM treatments played a major role in the apparent declines in the Brule River's salmonid stocks in recent years. Fortunately, the 1986 construction of an effective barrier to lamprey movement about 11 km upstream from the mouth of the river eliminated the need for TFM treatment upstream of that point. Although the stretch of river downstream of the lamprey barrier will continue to require treatment at 3-year intervals, this section is not known to contain any rare species of aquatic insects.

SUMMARY

During the period of this study, the aquatic insect community of the Brule River drainage was diverse and apparently healthy, and showed considerable variation among biotic areas. Biotic index values were consistent with expectations for a spring-fed, relatively undisturbed watershed in northern Wisconsin; water quality was excellent. No threatened or endangered species were found, but a population of *Brachycentrus lateralis*, a caddisfly that is rare in Wisconsin, was identified from one riffle area. Community composition appeared to be most strongly correlated with gradient-regulated habitat features, such as substrate composition and flow conditions, with temperature and water chemistry also playing large roles. The diversity of the aquatic insect community is attributable to, and will continue to hinge upon, the river's excellent water quality and the natural and diverse habitat conditions that exist throughout the system.

The major factor responsible for maintaining the Brule River Valley in its relatively unspoiled state has been continuing protection afforded both by public acquisition of land bordering the river and by the commendable preservation efforts of private interests. The entire mainstem is now encompassed within the Brule River State Forest and dwellings steadily are being removed as the state policy of land acquisition within forest boundaries continues. The prognosis is, therefore, good that the excellent water quality and aquatic insect-producing capability of this river system will be maintained in years to come.

Repeated lampricide treatments of most of the Brule River system probably caused short-term reductions in abundance of some aquatic insect taxa, but no major impacts are known to have occurred. Because a lamprey barrier now effectively prevents lamprey movement into most of the Brule River system, lampricide treatments and concerns about toxicity are expected to decrease.

This survey highlighted the difficulty of documenting relatively slight changes in aquatic insect densities or community structure for a river system as large and complex as the Brule River system; inevitably, less-than-complete documentation of aquatic insect species inhabiting the system was provided. Deep-water areas (>1 m) generally were not effectively sampled, particularly when current velocity was high, and such areas probably contained a number of undetected species. Also, the sampling of additional tributaries, non-riffle mainstem areas, and the lentic communities of Lakes Minnesuing and Nebagamon would have revealed many localized and lentic taxa. However, this survey did reveal most of the common lotic species, particularly those inhabiting important riffle areas. Hynes (1960) and Mackay (1969) firmly established that, in order to accurately measure the rate and extent of aquatic insect community changes when streams become disturbed, information on species compositions of similar healthy streams is useful. This survey and report provide a database that is available for comparison if ecological conditions change in the future on this or other large, spring-fed trout streams in Wisconsin.

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

1. The diversity and health of the aquatic insect community of the Brule River system is attributable, at least in part, to strong efforts by both the DNR and private interests to preserve and protect habitat quality. We should continue to maintain a strong posture to preserve the environmental quality of this river, including continued public acquisition of riparian land as it becomes available, and maintenance of adequate buffer strips along riparian areas to protect against erosion from logging practices.

2. No threatened or endangered aquatic insect species were found in the Brule River system, but *Brachycentrus lateralis*, found near the DNR Ranger Station canoe landing, is rare in Wisconsin. Other rare species may exist in hard-to-sample habitats. The Brule River is physically unique and one of the few spring-fed rivers of its size found in the Midwest; it also should be considered unique in terms of the aquatic insect habitat that it provides.

3. Some concern recently was expressed that the amount of sand in the Brule River mainstem appears to be increasing (D. Pratt, Wis. Dep. Nat. Resour. Bur. Fish Manage., pers. comm.). Gravel substrates are very productive aquatic insect habitats; sand substrates usually are not. I recommend initiation of a study to determine if sand sedimentation is increasing in the river and, if so, to identify the sources so that these inputs can be controlled.

4. Knowledge of any negative future changes in the water quality of the Brule River is desirable before these changes become severe. I recommend an abbreviated water quality monitoring program using Hilsenhoff's biotic index. A modest number (6 to 12) of biotic index samples per year should be taken at 3-year, site-rotation intervals from some of the same areas sampled during this study. Although seasonal correction factors are available (Hilsenhoff 1988), sampling should occur during spring before 1 June or between 1 September and 15 October during autumn to ensure the most accurate results.

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Approximate Metric-English Equivalents	
1 ha = 2.48 acres	1 L = 1.06 qt
1 m = 3.28 ft	1 g = 0.035 oz
1 cm = 0.39 inches	1 kg = 2.21 lb
1 km = 0.62 miles	1 metric ton = 1.10 tons
1 m^2 = 1.20 yd^2	

Acknowledgments

Assistance with identifications provided by W. Hilsenhoff, R. Narf, M. Rackouski, and K. Schmude was greatly appreciated. Helpful review comments by J. Ball, W. Hilsenhoff, R. Hunt, B. Les, M. Miller, R. Narf, and K. Schmude improved the manuscript. Able field assistance was supplied by C. Sand, D. Hausman and S. Plaster. I also thank J. Meierotto for providing laboratory space at the Brule Trout Rearing Station and F. Stoll and A. Stoll for assisting with the photography. This research was supported in part by funds provided by the Anadromous Fish Conservation Act (Project AFS-16), the Federal Aid in Sport Fish Restoration Act (Projects F-83-R and F-95-P) and the DNR.

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