Monitoring Aquatic Insect Densities and Habitat Factors on the Gallatin River, Montana – 2024 Data Report

Prepared for:
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Purpose

The purpose of this report is to describe the year-one findings of a newly initiated macroinvertebrate and habitat monitoring project throughout the Gallatin River, Montana. The project was initiated by the Gallatin River Task Force (GRTF) and designed, carried out, and led by The Salmonfly Project (SFP). Monitoring began in August, 2024 and will occur annually hereafter. Here, we summarize necessary background information and describe initial findings, conservation implications, and recommendations to guide monitoring efforts in future years. This report is not intended to be exhaustive, but instead briefly summarizes macroinvertebrate survey results and acts a tool for evaluating and improving the design and execution of the monitoring project during its early phases.

Key takeaways

1. We found that total macroinvertebrate densities were consistently high across the Gallatin River and that this was driven by very high numbers pollution-tolerant true flies (e.g., midges), along with moderately high numbers of more sensitive macro-invertebrates, including mayflies, stoneflies, and caddisflies. While high densities of midges and other true flies are likely caused by nutrient pollution, it appears that densities of other species have remained at healthy levels.

2. We found that, despite recently high nutrient levels and severe algal blooms, densities of focal target species, including giant salmonflies, golden stoneflies, pale morning duns, western green drakes, and spotted sedges, were similar to, if not higher than, other famous fisheries throughout the Montana and the Greater Yellowstone Region. This should be encouraging for local stakeholders and resource managers, as it suggests that severe declines for most species may not yet have occurred.

3. Nevertheless, we found that many sites have concerningly low %EPT (proportion of macro-invertebrates represented by mayflies, stoneflies, and caddisflies) and concerningly high total macroinvertebrate densities, proportions of midges, proportions of non-insects, and proportions of blue-winged olives to total mayflies. These metrics are used widely by ecologists to monitor water quality, and corroborate recent MTDEQ surveys showing low water quality across much of the middle Gallatin River. Metrics suggested surpassingly poor water quality near Yellowstone National Park, suggesting that some tributaries may naturally have high nutrient levels.

4. Overall, our findings suggest that important, sensitive species of mayflies, stoneflies, and caddisflies are still abundant on the Gallatin River, and thus, if nutrient levels can be mitigated, macroinvertebrate communities should return to former, balanced levels. Monitoring should thus continue annually so that trends can be quantified to guide ongoing management plans.

A *Baetis tricaudatus* adult (Blue-Winged Olive) – one of the most abundant aquatic insects in the Big Wood Basin. Photo Credit: Jason Neuswanger, TroutNut.com

INTRODUCTION

Why Monitor Macroinvertebrates

Aquatic insects and other macroinvertebrates are foundational to stream and river ecosystems worldwide. They make up over 70% of aquatic biodiversity and often dominate in-stream animal biomass (Dijkstra et al. 2013). As primary components of aquatic food webs, they support fish—including trout—as well as birds, bats, and terrestrial invertebrates (Allan & Castillo 2007; Merritt et al. 2008; Shipley et al. 2022). By consuming algae, macrophytes, and detritus, they regulate plant production and decomposition. During adult emergences, aquatic insects transfer substantial nutrients to riparian ecosystems, fueling adjacent terrestrial food webs (Walters et al. 2018). Their ecological importance also translates into economic value through their role in supporting recreational fisheries (Macadam & Stockan 2015). Without abundant and diverse aquatic insect communities, freshwater ecosystems—and the trout populations and fishing industries they sustain—would rapidly decline.

Macroinvertebrates are also widely used as bioindicators of water quality and ecosystem integrity (Barbour et al. 1999). Because species differ in their tolerances to environmental stressors and must survive chronic exposure to local conditions, they provide a useful measure of overall stream health. In addition, monitoring macroinvertebrates is relatively fast and inexpensive, it is often preferred over directly measuring habitat conditions (e.g., for temperature, sediment, or pollutants).

Despite their importance, aquatic insects—especially sensitive taxa like mayflies, stoneflies, and caddisflies—are in widespread decline across the U.S. and globally (Sánchez-Bayo et al. 2019). Since the 1990s, aquatic insect abundance in U.S. streams has declined by an estimated 23% (Rumschlag et al. 2023), with disproportionate losses among sensitive taxa (DeWalt et al. 2005; Giersch et al. 2017; Stepanian et al. 2020; Rumschlag et al. 2023; Birrell et al. 2024). These trends are linked to multiple stressors, including flow alteration, warming, nutrient pollution, and pesticides (Sánchez-Bayo et al. 2019; Didham et al. 2020; Wagner et al. 2021) and have been documented by both scientists and anglers (e.g., DeWalt et al. 2005; Sánchez-Bayo et al. 2019; Stepanian et al. 2020; Sautner 2023; Bonavist 2023)

Local conservation efforts are, however, hindered by limited understanding of the specific causes of declines in individual watersheds. Indeed, aquatic insects are rarely included in state or federal conservation plans due to data gaps regarding regional threats (e.g., USDA 2011; Montana FWP 2015). This lack of information limits the ability to manage wild fisheries and the ecological and economic systems they support. Addressing this challenge will require large-scale, coordinated monitoring efforts, like this monitoring program established on the Gallatin River, to document status, trends, and causes of insect declines. Only then can targeted conservation strategies be developed to protect these vital species and the fisheries they sustain.

The Gallatin River

Implementing monitoring programs on economically and ecologically important fisheries should be heavily prioritized, especially on rivers with limited data for their local insect populations, such as the Gallatin River, Montana. The Gallatin is well-known for its wild scenery, abundant trout, and diverse insect hatches, which draw anglers and other users from across Montana and beyond. However, water quality throughout the Gallatin Basin has declined in recent years. In 2018, the basin experienced its first documented severe algal bloom, which affected large stretches of the middle Gallatin River (Yellowstone National Park to Spanish Creek), as well as the South Fork, West Fork, and Taylor Fork tributaries. Similar events occurred in 2020 and 2022, which are attributed to high nutrient levels (i.e., nitrogen and phospohorous) combined with low flows and warm temperatures (Gardner & Buban 2024). As a result, the middle Gallatin River was listed as a Category 5 impaired waterbody under Section 303(d) of the Clean Water Act in 2023 due to excessive algal growth (MTDEQ 2023a). Several tributaries have already been listed as impaired by DEQ for nutrient- and sediment-related pollution, including the Middle Fork West Fork Gallatin (nutrients, sediment, and pathogens), South Fork West Fork Gallatin (nutrients, sediment), and West Fork Gallatin (nutrients, sediment), along with Storm Castle Creek, Cache Creek, and the Taylor Fork for nutrient-related impairments (MTDEQ 2020). In response, DEQ and GRTF have collaboratively initiated an extensive multi-year monitoring program to track nutrients, algae, streamflow, water temperature, an sediment across the River (e.g., Gardner & Buban 2024). The program aims to determine the drivers of bloom severity and will culminate in the development of a Total Maximum Daily Load (TMDL) — a pollution budget that identifies how much nutrient loading the river can receive while still meeting water quality standards (MTDEQ 2023b). The TMDL will include pollutant reduction targets and identify both point and nonpoint source contributors.

In addition to water quality concerns, resource users—particularly anglers—have expressed concern about the potential effects of algal blooms on the local fishery. Montana Fish, Wildlife & Parks (MTFWP) has expanded fish population surveys in the basin and, to date, has found no measurable decline in the size or abundance of trout populations in the Gallatin River or its major tributaries (Hayes 2023). However, many remain concerned about the long-term health of aquatic insects, which form the foundation of the aquatic food web and support the Gallatin's world-renowned hatches and fishing. Pollution-sensitive taxa such as mayflies, stoneflies, and caddisflies are especially vulnerable to changing water quality, and some local users believe the strength and timing of major hatches are shifting. Given the recent decline in water quality, we believe these concerns to be valid. Unfortunately, however, data on aquatic insect populations from the Gallatin River are sparse, and there have been few systematic insect monitoring programs to validate claims or determine where, why, and to what degree to insect populations may be shifting. One exception is the recent macroinvertebrate monitoring efforts by MTDEQ, but these efforts are primarily intended to use macroinvertebrate data as a proxy for water quality. Because MTDEQ employs a semi-quantitative sampling methodology (composited kick net samples) they will be unable to accurately measure the densities of individual species or *changes* in aquatic insect communities over time due to low numbers of samples (typically one).

Initiating Additional Monitoring

Given the limitations of both historical and current macroinvertebrate data from the Gallatin River, we initiated an annual macroinvertebrate and habitat monitoring program at nine sites along the entire middle Gallatin River, from Yellowstone National Park to Spanish Creek. This monitoring program is intended to be synergistic with that of MTDEQ, with surveys occurring at the same time of year (August) and at many of the same sites. Instead of monitoring *all* macroinvertebrates at the species level at each site, we employed a 'target species' approach to reduce costs and increase feasibility of long-term funding – a major barrier for other monitoring programs that accrue large expenses from monitoring all species. In particular, we focused monitoring efforts to track population trends of ecologically and economically important species, along with basic, macroinvertebrate-based water quality metrics, such as the proportion of the community represented by mayflies, stoneflies, and caddisflies (%Ephemeroptera-Plecoptera-Trichoptera [%EPT]). More specifically, the primary goals of the program are to: i) establish more extensive baseline data on target insect species and habitat conditions throughout the Gallatin River, ii) track spatial and temporal trends in both target species, macroinvertebrate-based water quality metrics, and habitat quality, iii) detect likely causes of insect trends, iv) ultimately, inform and guide local conservation decisions to preserve the Gallatin River.

Below, we report results for the first year of macroinvertebrate sampling, performed in August, 2024. Data outputs here, and in future years, will be distributed to local managers and stakeholders to help identify the status and trends of aquatic insects and threats that should be mitigated. Ultimately, these efforts will facilitate more compressive conservation efforts throughout the Gallatin River.

METHODS

Target Species

We selected 23 target taxa of aquatic insects to monitor on the Gallatin River: blackfly (*Simuliidae*), blue-winged olive (*Baetidae*), brown dun (*Ameletus spp.*), crane fly (*Tipulidae*), giant salmonfly (*Pteronarcys californica*), golden stonefly (*Hesperoperla pacifica*), least salmonfly (*Pteronarcella badia*), mahogany dun (*Paraleptophlebia spp.*), march brown (*Rithrogena spp.*), midge (*Chironomidae*), mother's Day caddis (*Brachycentrus spp.*), nocturnal stonefly (*Claassenia sabulosa*), non-insects, pale morning dun (*Ephemerella spp.*), riffle beetle (*Elmidae*), skwala (*Skwala americana*), slate brown duns (*Epeorus spp.*), spotted sedge (*Hydropsychidae*), water snipe (*Atherix spp.*), western green drake (*Drunella doddsi*; *Drunella grandis*), and yellow sallie (*Chloroperlidae*; *Perlodidae*). These species (or genera for *Ephemerella*, *Rhithrogena,* etc. and family for Brachycentridae, Hydropsychidae, etc.; hereafter species) are among the most dominant insect hatches on the Gallatin and are thus of primary importance for both the ecology of the River and its recreational, cultural, and economic value. Target species also have readily-visible diagnostic features, allowing for rapid identification and enumeration. Higher taxonomic resolution for yellow sallies, pale morning duns, march browns, mother's day caddis, spotted sedges, and midges was not feasible because the necessary diagnostic features are not easily visible with the naked eye. Choosing important yet readily identifiable species was a primary goal of the project to ensure a useful, yet low-cost monitoring program. Due to effects of seasonality on nymphal densities, data collection in future years will occur on approximately the same dates (within seven days) as this first year of sampling. All macroinvertebrates that did not fall into target species groups were identified to higher taxonomic levels, usually order, (i.e., mayfly, stonefly, caddisfly, true fly, beetle, moth, or non-insect) to facilitate the calculation of basic metrics of community composition used to track water quality.

Monitoring Sites

We collected aquatic macroinvertebrates and measured fine sediment and substrate embeddedness levels at nine sites on the Gallatin River, Montana between Yellowstone National

Park and Spanish Creek (Fig. 1). This represents the entire length of the middle Gallatin River recently listed as impaired by MTDEQ.

Macroinvertebrate and Habitat Sampling

To align with standards of the MTDEQ, sampling was conducted during summer base-flow conditions from August 26th-September 3rd, 2024. However, other methods differed significantly due to the differing goals of MTDEQ and our monitoring efforts (see *Introduction*). In our surveys, we specifically targeted the same habitat – riffles – for sampling at each site to decrease variance in the macroinvertebrate data. We also did not composite samples (i.e., combine multiple samples at a single site into a single large one) to increase statistical power for detecting changes over time. We also used Hess nets (see below) instead of kick-nets typically used by MTDEQ, given that they more accurately measure macroinvertebrate density (number of individuals per unit area). Given these differences, future comparisons between our data and that of MTDEQ must be done with caution.

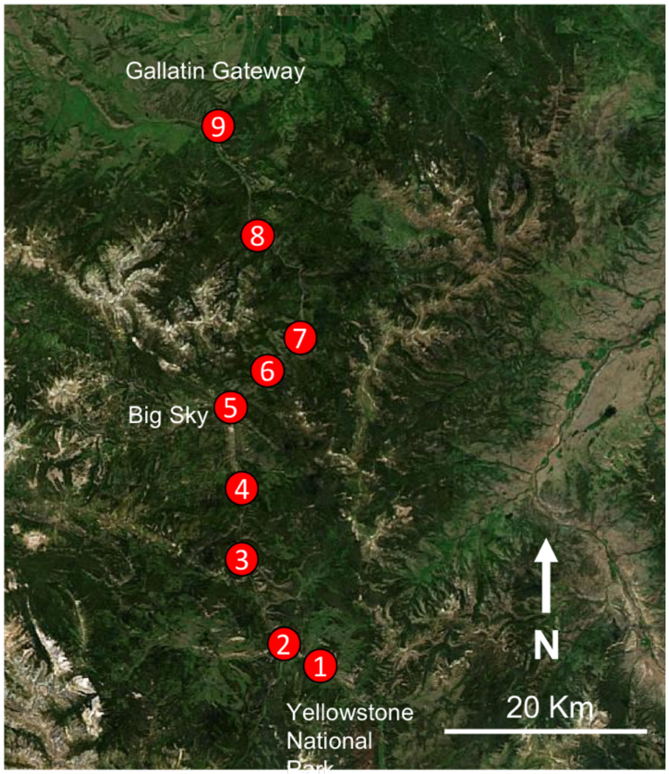

Fig. 1: Map of insect and habitat monitoring sites. GPS locations of monitoring sites are as follows: Site 1 – Yellowstone (45.05436, -111.15598), Site 2 – Above Taylor (45.07173, -111.19648), Site 3 – Gun Range (45.14251, -111.24112), Site 4 – Twin Cabin (45.20163, -111.23872), Site 5 – Conoco (45.26466, -111.25278), Site 6 – Deer Creek (45.29842, -111.20531), Site 7 – Portal (45.32189, -111.17917), Site 8 – Lava Lake (45.40652, -111.22507), Site 9 – Spanish Creek (45.49286, -111.27167)

More specifically, in our surveys, all macroinvertebrate samples were made with a 1 ft^2 (0.093 m^2) Hess sampler (WildCo) with 500 micron mesh. At each site, one sample was taken along each of six evenly spaced transects of a 30m section of riffle (six samples per site). At each transect, a sampling location was chosen by walking a randomly chosen number of paces from shore and driving the Hess sampler into a representative cluster of cobbles until a seal was made between the sampler and stream substrate. If no seal could be made, a sample was taken in a nearby location. Macroinvertebrates were then collected by disturbing the substrate contained within the Hess sampler, thereby washing all individuals into the attached net. This was achieved by first removing the larger substrate (> 10 cm) from the streambed and scrubbing it with a brush. The smaller substrate was then vigorously agitated with a metal gardening claw to a depth of ~7cm for one minute or until all fine sediment had been washed away. Once the substrate was completely disturbed, the contents of the net were brought to shore and washed into a 5-gallon bucket. Organic material was separated from substrate within each sample by repeatedly rinsing the bucket with clean stream water and pouring the buoyant contents (i.e., macroinvertebrates) through a 500 micro sieve. Sample contents were then washed from the sieve into labeled, 1-L polyurethane bottles and stored in 99% isopropyl ethanol. Rocks left in the bucket were inspected to ensure no macroinvertebrates were missed.

Substrate, Temperature, and Flow Surveys

Substrate surveys were performed at each site, following macroinvertebrate surveys. Fine sediment levels were measured with a sampling frame, similar to that of Bunte & Abt (2001). Measurements were made by throwing a 0.5m diameter steel hoop in twelve random locations throughout the riffle and observing the presence of fine sediment (dominant particle < 0.2mm in diameter; sand, silt, or clay) directly below 36 sampling points along two steel bars (i.e., 19 tick marks spaced at even intervals, per bar) welded along the vertical and horizontal axes of the hoop (Kowalski & Richer 2019). Observations were made visually with an underwater viewer (Fieldmaster, Aquaview Underwater Viewer) and by feel. The number of fine-sediment-dominated points were expressed as the percentage of the sampling area containing fine sediment (i.e., number of fine sediment observations / 36 total sampling points). Following the methods of Platts et al. (1982), the embeddedness of substrate by fine sediment was also visually estimated from within the steel hoop each time it was thrown and expressed on an ordinal scale (1: 0-5% embedded, 2: 5-25 embedded, 3: 25-50% embedded, 4: 50-75% embedded, and 5: 75-100% embedded). Fine sediment measurements and embeddedness estimates were then averaged across each site, and these values were used in the analyses, below.

Temperature loggers (HOBO, Pendant) were deployed at five sites and are currently monitoring temperatures at 15-minute intervals. Temperature data, along with flow data retrieved from United States Geological Survey (USGS) gages, will be summarized and incorporated into analyses once at least one year of data has been collected.

Macroinvertebrate Sorting, Taxonomy, and Metric Calculation

In the lab, macroinvertebrates from each sample were subsampled, with each subsample containing at least 300 individuals. The number of each target species were enumerated per sample by dividing by the subsampling proportion (often 0.25), and density was calculated per 1 ft^2. Commonly used macroinvertebrate-based water quality metrics were then calculated for each sample (e.g., %Ephemeroptera-Plecoptera-Trichoptera [EPT], % midges, and % non-insects). These metrics, along with densities of target species were used as response variables in the analyses. Other commonly used metrics, such as species richness or the Hilsenhoff Biotic Index (HBI) could not be calculated because we did not perform taxonomy on all species.

Statistical Analysis

Summarization of macroinvertebrate and habitat data were performed in R (R Core Team, 2023). How macroinvertebrates densities varied by species group, along with other basic analyses were analyzed using ANOVA models with the base-R function, *aov*.

INTERPRETING METRICS AND MULTI-METRIC INDICES

Notes for Interpreting Results

Environmental degradation is generally a function of a wide array of environmental stressors exerting pressure on biotic communities. In addition, because organisms – from individual species to broad species groups (e.g., Orders) – have different sensitivities to combinations of stressors, biotic communities often respond to stress in complex ways. Despite this complexity, a wide array of metrics have been developed over the past several decades to assess water quality and ecosystem integrity from macroinvertebrate community data (Barbour et al. 1999). Interpretations of metrics rely on the fact that some species (or species groups) tend to be more sensitive to environmental degradation than others and that healthy communities generally support higher species diversity (e.g., number of species). For instance, mayflies, stoneflies, and caddisflies (i.e., Ephemeroptera, Plecoptera, and Trichoptera; EPT) tend to be sensitive, while true flies and non-insects tend to be tolerant. Thus, ecosystems represented by many species, and especially by many species of sensitive taxa, are generally considered to be healthier. In reality, however, variation in sensitivity also exists within each major macroinvertebrate group (including within EPT), and it is possible to find unhealthy streams that are nonetheless dominated by EPT (typically mayflies and/or caddisflies), but by only a few tolerant species. Because of this complexity, it is essential to use a broad range of metrics to interpret macroinvertebrate data. A full range of metrics (e.g., species richness, etc.) can only be calculated after identifying and enumerating all macroinvertebrates to species or genus level. This is currently performed throughout the Gallatin River by MTDEQ and was not the primary purpose of this monitoring program. Instead, we calculated a limited number of easily interpretable macroinvertebrate-based metrics used to infer water quality and ecosystem health to supplement data on target species densities (Table 1).

Table 1: Table defining macroinvertebrate-based metrics used to assess water quality, along with expected responses to disturbance, and impairment thresholds. *Impairment thresholds are based on the authors' experience and do not represent legal thresholds in Montana.

Metric	Expected response to disturbance	Subjective threshold*	Metric description
% EPT	Decrease	< 40%	% of individuals represented by mayflies, stoneflies, and caddisflies (i.e., Ephemeroptera, Plecoptera, Trichoptera; EPT)
% Midges	Increase	> 45%	% of individuals represented by midges (i.e., Chironomidae)
% Non-insects	Increase	> 15%	% of individuals represented by non-insects (e.g., snails, skuds, worms)
Density	Increase or decrease	< 500 or > 3000	Number of individuals per unit area; some disturbances (e.g., heavy metals) cause densities to decrease, while others (e.g., nutrient pollution) cause them to increase
% Hydropsychidae/Total Caddisflies	Increase	> 80%	% of all caddisflies represented by spotted sedge (Hydropsychidae)

RESULTS & DISCUSSION

Below, we report on findings from 2024 macroinvertebrate sampling. We summarize the status of macroinvertebrate populations and community composition across the River. We also rank the water quality and ecosystem health at each site, using a simple set of macroinvertebrate-based metrics and discuss the results within the context of recent algal blooms. The results and interpretations provided below are not meant to be exhaustive. Additional analyses will be performed once multiple years of macroinvertebrate and habitat data are accumulated.

Cumulative Macroinvertebrate Densities

In 2024, the Gallatin River supported an average of 2867 macroinvertebrate individuals per ft^2 across all sites. These densities are comparable to other well-known trout streams in the Greater Yellowstone region. For example, in 2024, the Madison River, MT supported an average of 1085.1 indi./ft^2 at five sites along the Upper and Lower River, while the Henry's Fork of the Snake River, ID supported about 3,000 indi./ft^2 across five sites from Flat Rock to Saint Anthony's (Birrell & Frakes unpublished data; Van Kirk 2025). While these numbers may appear encouraging at first, extremely high macroinvertebrate densities (e.g., > 3000 indi./ft^2) often denote *poor* water quality (Maguire 1993). This is because excessive nutrient levels and algal growth stimulate the proliferation of pollution-tolerant species, including midges and non-insects. Indeed, this appears to be occurring on the Gallatin River, as densities of true flies (1565 indi/ft^2) (including midges, blackflies, and others) far outnumbered the densities of more sensitive species groups like mayflies (348 indi/ft^2), stoneflies (103 indi/ft^2), and caddisflies (489 indi/ft^2) (Fig. 2; $P < 0.001$).

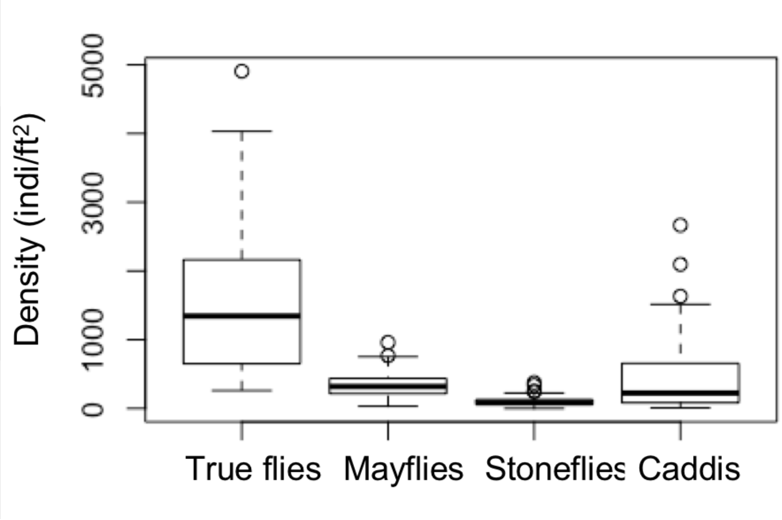

Fig. 2: Boxplot of macroinvertebrate densities for the most abundant insect orders on the Gallatin River. Densities of true flies are significantly higher ($P < 0.001$) than other insect orders.

Without strong historical data, however, it is impossible to determine if poor water quality has caused a decline in mayfly, stonefly, and caddisfly densities, or if their densities have remained the same while true fly densities have increased. The fact that mayflies, stoneflies, and caddisflies still have cumulative mean densities (near 1000 indi/ft^2) should, nevertheless, be encouraging – indicating that sensitive species, which generate fishable hatches and abundant food for trout, are still abundant. Additional data collection will be necessary, however, to accurately quantify trends going forward.

Target Species Densities

Across the Gallatin River, the majority of target species had relatively low densities or were encountered infrequently. Some target species, however, tended to be very abundant at the majority of sites. These often included species that produce well-known hatches targeted by anglers (e.g., blue-winged olives, western march browns, yellow sallies, and spotted sedges), though some are more discrete or do not hatch from the water at all (e.g., riffle beetles) (Table 2). The most abundant macroinvertebrates at each site, however, tended to belong to pollution-tolerant groups, including midges, blackflies, and non-insects (Table 2). Blue-winged olives and spotted sedges were also consistently abundant, and these species are moderately tolerant to organic pollution. Sensitive species, such as Mother's Day caddis, western green drakes, giant salmonflies, and golden stoneflies, had relatively low to moderate densities across sampling locations.

Table 2: Table of mean, minimum, maximum, and standard deviation of densities (indi/ft^2) for all target species found on the Gallatin River, with pollution-tolerance scores ranging from 0 (extremely sensitive) to 10 (extremely tolerant) from Barbour et al. 1999.

Order	Common name	Scientific name	Pollution tolerance score	mean density (indi/ft2)	min density (indi/ft2)	max density (indi/ft2)	st.dev. density (indi/ft2)
True fly	Midge	Chironomidae	6	1031.63	20.00	4842.67	1191.42
True fly	Blackfly	Simuliidae	6	397.25	0.00	3136.00	735.17
Non-insect	Non-insects	NA	—	258.32	0.00	1664.00	274.57
Caddisfly	Other caddisflies	Trichoptera	—	231.47	0.00	1770.67	342.73
Mayfly	Blue-winged olive	Baetidae	4	227.41	7.38	874.67	186.93
Caddisfly	Spotted sedge	Hydropsychidae	4	157.78	0.00	1056.00	233.06
Caddisfly	Mother's Day caddis	Brachycentrus spp.	1	99.53	0.00	1232.00	264.78
True fly	Other true flies	Diptera	—	85.80	0.00	432.00	89.77
Stonefly	Yellow sallie	Chloroperlidae	1	63.06	0.00	336.00	68.03
Mayfly	March brown	Rhithrogena spp.	0	52.68	0.00	172.73	45.94
Beetle	Riffle beetle	Elmidae	4	35.50	0.00	144.00	33.23
Mayfly	Western green drake	Drunella doddsi	0	35.05	0.00	168.00	37.38
True fly	Water snipe	Atherix spp.	2	25.98	0.00	181.33	41.16
True fly	Crane fly	Tipulidae	3	24.18	0.00	368.00	51.13
Mayfly	Western green drake	Drunella grandis	0	17.03	0.00	208.00	40.02
Stonefly	Giant salmonfly	Pteronarcys californica	0	12.54	0.00	60.61	15.79
Mayfly	Pale morning dun	Ephemerella spp.	1	9.81	0.00	64.00	13.10
Stonefly	Other stoneflies	Plecoptera	—	9.57	0.00	64.00	14.81
Stonefly	Yellow sallie	Perlodidae	2	9.06	0.00	112.00	20.83
Stonefly	Golden stonefly	Hesperoperla pacifica	1	6.37	0.00	42.67	9.44
Mayfly	Other mayflies	Ephemeroptera	—	3.05	0.00	32.00	6.30
Mayfly	Slate brown duns	Epeorus spp.	0	2.01	0.00	32.00	5.86
Stonefly	Least salmonfly	Pteronarcella badia	0	1.04	0.00	16.00	3.13
Stonefly	Skwala	Skwala americana	2	0.86	0.00	14.77	2.87
Stonefly	Nocturnal stonefly	Claassenia sabulosa	3	0.72	0.00	12.00	2.51
Mayfly	Brown dun	Ameletus spp.	0	0.16	0.00	8.00	1.12
Mayfly	Mahogany dun	Paraleptophlebia spp.	2	0.08	0.00	4.00	0.56

Given the large number of target species assessed in this monitoring program, highlighting variation in population densities across all sites for each species is outside the scope of this report. This will be prioritized in future years, once multiple seasons of macroinvertebrate and habitat data are collected. However, given both their ecological importance and popularity among anglers, the viability of some target species, including pale morning duns, green drakes, giant salmonflies, golden stoneflies, and spotted sedges, tend to be of great concern among the fly fishing community. We thus highlight site-to-site variation in these species' population densities, below, and compare their abundances to other fisheries in the Montana and the Greater Yellowstone Region.

Across all sites, giant salmonflies had a mean density of 12.5 ind/ft^2, with the highest densities occurring at Portal (site 4) and Twin Cabin (site 7) (mean ~ 30 indi/ft^2) (Fig. 3A). Densities were highly variable from site to site, however, with no salmonflies found at Deer Creek (site 6) and very few found at Yellowstone (site 1) and Above Taylor Fork (site 2). These densities are much higher than other nearby Rivers. For instance, Anderson et al. (2019) found an average of 4.0 giant salmonflies per ft^2 across eight sites on the Upper Madison (Ennis to West Yellowstone, with some reaches supporting a maximum of 11 indi/ft^2. Similarly, average salmonfly densities across seven sites on the Big Hole River in 2023 (Twin Bridges to Wisdom) were 3.2 indi/ft^2 (Birrell & Frakes 2023). High salmonfly densities on the Gallatin River suggest that populations are still healthy and that recent algal blooms have not caused a severe crash in population size. Future monitoring will be necessary confirm this assessment.

Golden stoneflies had a mean density of 6.4 individuals per ft^2 across all sites. Populations were highly variable from site to site and ranged from near zero (Above Taylor [site 2] and Conoco [site 5]) to 14.7 indi/ft^2 at Portal (site 7) (Fig. 3B). These densities are higher than densities on the Madison River (mean = 0.6 indi/ft^2 from Ennis to Varney in 2024) and Big Hole River (mean = 1.2 indi/ft^2 in 2023 from Wisdom to Twin Bridges) (Birrell & Frakes unpublished data; Birrell & Frakes 2023). This suggests that golden stoneflies have not undergone a severe decline in recent years.

Pale morning duns had a mean density of 15.3 individuals per ft^2 across all sites, with the highest densities occurring at Conoco (site 5) (mean = 52.4 indi/ft^2) (Fig. 3C). Populations were relatively similar at most other sites (~10 indi/ft^2). These densities are higher than densities on the Madison River (mean = 13.0 indi/ft^2 from Ennis to Varney in 2024), but much lower than on the Henry's Fork (mean = 727 indi/ft^2 over ten years Flat Rock to Saint Anthony) (Birrell & Frakes unpublished data; Van Kirk 2025). Without additional data, determining whether pale morning duns have declined on the Gallatin in recent years is impossible. However, current densities suggest populations may be healthy.

Western green drakes, including *Drunella grandis*, *Drunella doddsi,* and *Drunella flavilinea*, had a mean density of 52.1 individuals per ft^2 across all sites. Populations were moderately variable from site to site, ranging from 20.0 indi/ft^2 at Conoco (site 5) to 164.0 indi/ft^2 at Portal (site 7) (Fig. 3D). These densities are much higher than densities on the Big Hole River (mean = 3.3 indi/ft^2 from Wisdom to Twin Bridges in 2023) and the Henry's Fork River (mean = 4.8 indi/ft^2 from 2014-2024 from Flat Rock to Saint Anthony) (Birrell & Frakes 2023; Van Kirk 20225). These data suggest that western green drake populations are extremely healthy and that little concern should be warranted about their current viability in the Gallatin River.

Spotted sedges had a mean density of 157.8 individuals per ft^2 across all sites. Populations were highly variable across all sites. They ranged from 26.5 indi/ft^2 (Gun Range [site 3]) to 538.7 indi/ft^2 (Portal [site 7)]) (Fig. 3E). These densities are higher than spotted sedge densities on the Madison River (mean = 32.9 indi/ft^2 from Ennis to Varney in 2024), but lower than those on the Henry's Fork River (mean = 774 indi/ft^2 from 2014-2024 from Flat Rock to Saint Anthony) (Birrell & Frakes unpublished data; Van Kirk 20225). These data suggest that spotted sedge populations are still viable.

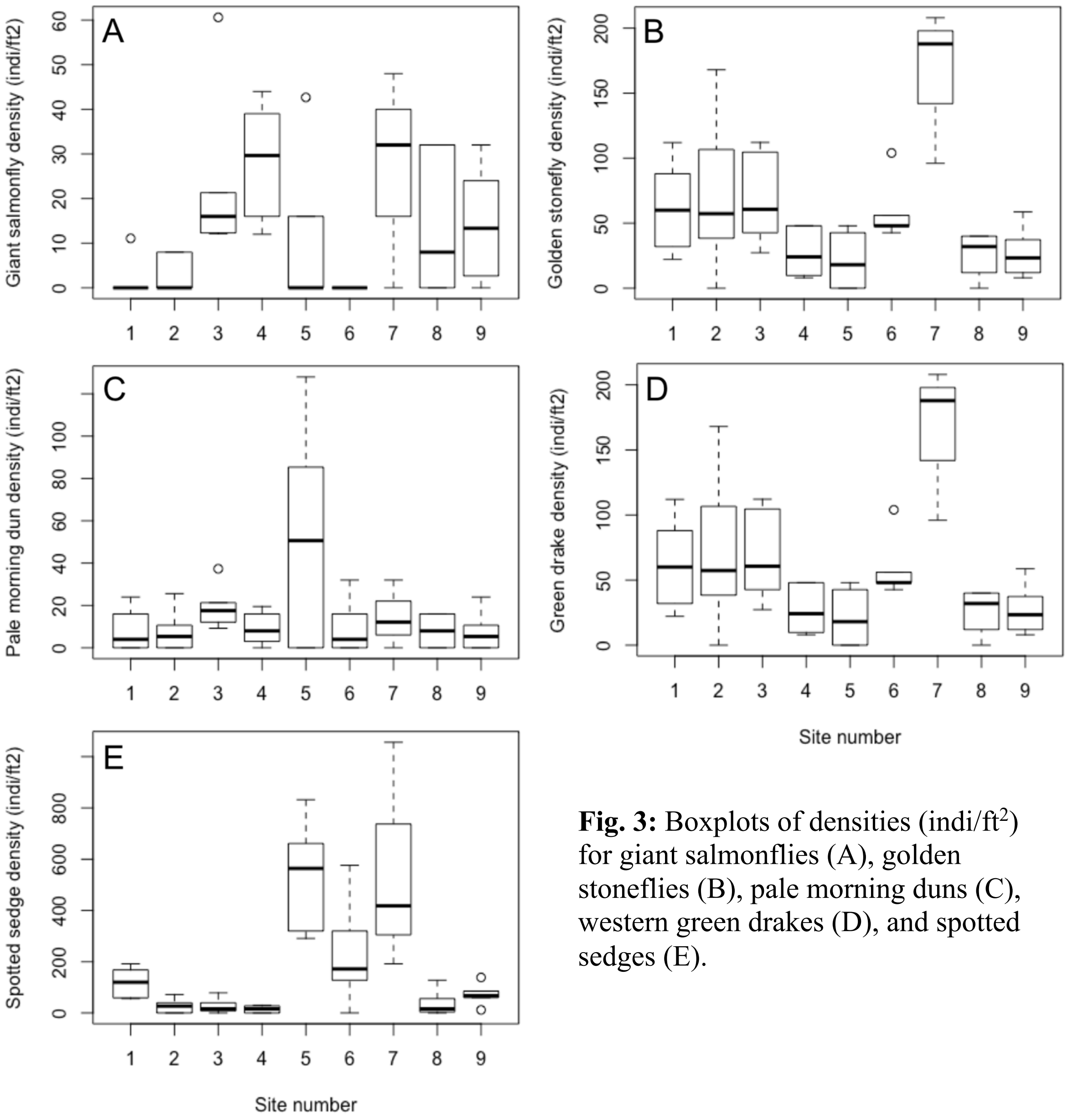

Fig. 3: Boxplots of densities (indi/ft^2) for giant salmonflies (A), golden stoneflies (B), pale morning duns (C), western green drakes (D), and spotted sedges (E).

Although we found high densities of mayflies, stoneflies, and caddisflies, along with several target species, we hypothesize that densities of sensitive taxa will *decrease* in the future if nutrient levels and algal blooms continue to rise. While short-term nutrient loading can cause increases in densities of all species, severe nutrient pollution leads to oxygen depletion and extirpation of all but the most pollution-tolerant taxa (typically true flies and non-insects) (Barbour et al. 1999). Declines will likely also be exacerbated by increases in water temperature and decreases in river flows. Mitigating sources of habitat degradation should thus be of highest priority going forward.

Macroinvertebrate-Based Metrics

Comparisons of six macroinvertebrate-based metrics with water quality impairment thresholds derived by the author raise considerable concern about biointegrity across the Gallatin River

(Table 3). For instance, %EPT – a widely used water quality metric based on the proportion of the community represented by mayflies, stoneflies, and caddisflies – was consistently low across the River, with 5 out of 9 sites below the subjective threshold limit of 40%. Low %EPT appeared to be primarily driven by high numbers of true flies, including midges (*Cumulative macroinvertebrate densities,* above), which surpassed healthy levels at 2 out of 9 sites. Total macroinvertebrate densities, the percentage of the community represented by non-insects, and the proportion of blue-winged olive mayflies to total mayflies also surpassed subjective thresholds at several sites (4, 2, and 2 out of 9 sites, respectively). Overall, these results corroborate MTDEQ data showing excessive levels of nutrient pollution in the Gallatin River.

The total number of metrics that surpass subjective thresholds at each site, show that Yellowstone (site 1) and Spanish Creek (site 9) appear to have the highest ecosystem integrity and that Above Taylor (site 2) and Conoco (site 5) have the poorest ecosystem integrity. Metrics exceeding impairment thresholds were particularly surprising at Above Taylor (site 2), as this site lies above all known tributaries listed as impaired by MTDEQ. In addition, multiple metrics (total density, %EPT, and % midges) were near threshold limits at Yellowstone (site 1). This suggests that headwater streams in Yellowstone National Park may naturally have high nutrient levels, as they are above areas of direct human impact. It is also surprising that thresholds were not exceeded more often below Conoco (i.e., sites 6-9), as these sites lie below the West Fork, which has recently experienced severe algal blooms throughout much of the basin, with multiple reaches listed as impaired for nutrient pollution by MTDEQ. Additional data collection will be necessary to understand causes of such variation in macroinvertebrate-based metrics and whether they are consistent from year to year.

Table 3: Table of six macroinvertebrate-based water quality metrics for each sampling site. Orange highlighted cells represents metrics that are above subjective macroinvertebrate impairment thresholds determined by the authors (see Table 2). Note: All sites remain within boundaries of the middle Gallatin, listed as impaired for excessive algal growth by MTDEQ in 2023.

Site name	Site number	Density (indi/ft2)	%EPT	%Midges	%Non-insects	BWO/Total mayfly	Spot. sedge/Total caddis	TOTAL
Yellowstone	1	2958.56	51.36%	40.90%	2.01%	23.09%	10.36%	0
Above Taylor	2	3370.49	14.73%	61.08%	11.47%	69.78%	15.95%	3
Gunrange	3	1299.97	38.35%	26.72%	19.39%	29.10%	27.12%	2
Twin Cabin	4	1574.92	37.84%	38.04%	11.65%	44.37%	17.61%	1
Conoco	5	5813.82	40.16%	50.21%	6.87%	82.42%	36.18%	3
Deer Creek	6	3253.11	28.74%	17.72%	10.47%	76.84%	52.63%	2
Portal	7	3952.73	45.40%	28.46%	21.08%	70.48%	62.94%	2
Lava Lake	8	2358.67	29.00%	2.39%	3.17%	82.44%	60.41%	2
Spanish Creek	9	1223.22	40.06%	7.07%	8.54%	55.69%	49.68%	0
TOTAL	TOTAL	4	5	2	2	2	0	15

Habitat conditions

Fine sediment levels were consistently low across all sites, with fine sediment representing only 1% of substrates on the Gallatin River, on average. Gun Range (site 3) had the most fine sediment (3.5%) and Lava Lake and Spanish Creek (sites 8 and 9, respectively) had the lowest (0.0%). Excess sediment is thus unlikely to be negatively affecting macroinvertebrates on the

Gallatin. Fine sediment levels were only measured in riffles, where fast flows generally prevent deposition and fine sediment levels are likely much higher in other habitats such as runs and pools. In addition, fine sediment levels vary over time, and results may differ in surveys performed at different times of year.

The monthly average discharge (flow) during August of 2024 was 352.9 CFS, about 56 CFS below the long-term August average discharge (USGS gage station 06043120 above Deer Creek). The average monthly temperature in August 2024 was 14.09 ºC, 0.8 ºC above the long-term August average (USGS gage station 06043120 above Deer Creek). A more in-depth analysis of water temperature and levels of dewatering – along with the effect of these habitat conditions on macroinvertebrates – will be analyzed in future years once multiple years of data are collected.

CONCLUSIONS

The first season of the Gallatin River monitoring program was an overwhelming success, and analysis of year-one data led to several important findings. First, we found that total macroinvertebrate densities were consistently high across the Gallatin River, and that this was driven by very high numbers pollution-tolerant true flies (e.g., midges), along with moderately high numbers of more sensitive macroinvertebrates, including mayflies, stoneflies, and caddisflies. While high densities of midges and other true flies are likely caused by nutrient pollution, it appears that densities of other insects have remained at healthy levels. Second, we found that, despite high nutrient levels and severe algal blooms, densities of focal target species, including giant salmonflies, golden stoneflies, pale morning duns, western green drakes, and spotted sedges, were similar to, if not higher than, other famous fisheries throughout Montana and the Greater Yellowstone Region. This should be encouraging for local stakeholders and resource managers, as it suggests that declines for most species have not yet occurred. Third, we found that many sites have concerningly low %EPT (proportion of macro-invertebrates represented by mayflies, stoneflies, and caddisflies) and concerningly high total macroinvertebrate densities, proportions of midges, proportions of non-insets, and proportions of blue-winged olives to total mayflies. These metrics are used widely by ecologists to monitor water quality, and corroborate recent MTDEQ surveys showing low water quality across much of the middle Gallatin River. While many of these results are certainly concerning, the data are also encouraging because we found no evidence of very low target species densities indicative of recent population crashes. This suggests that if nutrient levels can be mitigated, macroinvertebrate communities of the Gallatin River should return to former, balanced levels. Monitoring should thus continue annually so that trends can be quantified to guide ongoing management plans.

DATA ACCESSIBILITY

For raw macroinvertebrate sampling data and other data inquires, including R-scripts used in analyses, contact The Salmonfly Project at conservation@salmonflyproject.org.

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