Baseline Macroinvertebrate Monitoring 2015-2018 for the Upper Missouri River: Building a Long-term Data Set

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All photos in the report were taken by MBS, unless otherwise noted

Executive Summary

UMOWA began the Missouri River Baseline Monitoring program in 2015, and has continued this effort into 2018. In 2015, we established seven long-term, baseline monitoring stations for sampling benthic macroinvertebrates and water chemistry within the Blue Ribbon section of the Missouri River between Wolf Creek and Cascade and two sites upstream of Canyon Ferry Lake. Aside from one long-term NWE (PPL) monitoring site below Holter Dam, and 5 sites sampled in 2005 by MDEQ, very few macroinvertebrate samples have been collected below the Wolf Creek Bridge (MDEQ 2007). Therefore, the project goals of UMOWA's program are: 1) to conduct standardized and quantitative macroinvertebrate surveys to serve as the baseline standards for future monitoring efforts within this Missouri River section 2) to establish seasonal macroinvertebrate population estimates and community characteristics to assess aquatic biointegrity and 3) to understand the insect dynamics in relation to increasing aquatic macrophyte beds, algae and recent sediment-flushing lows (2018).

Record high spring flows have played a particularly important role in 2018 by flushing silts from gravels, reshaping riffles and reducing macroinvertebrate densities at many of the main stem Missouri River sites; thus, the relative composition of many benthic macroinvertebrate assemblages has been restructured. In July and October of 2018, we collected 45 quantitative, replicated macroinvertebrate samples, habitat data and water chemistry (WQ) samples seasonally at 8 (included Mid-Cannon) and 7 sites, respectively. Total nitrogen and phosphorus levels for the June and October 2018 samples were well above MDEQ's numeric nutrient standard across most sites, except downstream of Little Prickly Pear and the Dearborn River (see UMOWA 2018 WQ Report).

Other than the indirect effects of increased weed bed extents, we can find no direct correlation with the Missouri River's excessive nutrients (TN & TP) and macroinvertebrate population characteristics. Spring run-off events from Little Prickly Pear Creek and the Dearborn River continue to have significant effects on the densities and diversity of insect communities in the Missouri River below those tributaries, especially by adding mayfly (E), stonefly (P) and caddisfly (T) taxa (total EPT taxa). In 2016, at the Missouri River upstream of Little Prickly Pear Creek, we observed the highest densities of macroinvertebrates (>20,000 per m^2) and New Zealand mudsnails (>300 per m^2) since the study began; these densities were significantly "knocked-back" by high flows in June 2017. But surprisingly, even with the high flows of 2018, average annual densities further increased at this site. High densities and standing crops of *Baetis* (BWOs), *Tricorythodes* (Tricos), Chironomidae (midges), and *Ephemerella* (PMDs) in the spring samples within the Wolf Creek to Craig section "hatch-out" by the summer sampling period leading to lowered summer densities of these taxa, and a dominance of non-insect taxa (scuds, sowbugs, worms and snails).

EPT taxa (mostly mayflies) gradually build up to their summer high densities, hatch out and then are small nymphs though the fall sampling period, but are likely hampered by aquatic vegetation growth; therefore, non-insect taxa still dominate the fall benthos at most sites from Wolf Creek to upstream of the Dearborn River. It does initially appear that the 2018 flushing flows have alleviated this somewhat at Craig and LPPC sites. Percentages of sowbugs (*Caecidotea*), scuds (*Gammarus, Hyalella* and *Crangonyx*) and other non-insect taxa in the samples were highest during this fall period when EPT taxa contributions were lowest. Of the 20 species of caddisflies that were collected across all sites, the net spinning caddis, *Cheumatopsyche* and the long-horned caddis, *Oecetis* were usually the most prevalent. Caddisflies were more common during the spring and summer sampling periods at some sites, but as a percentage of total EPT were usually much lower than mayflies. While stonefly taxa are not common within the Wolf Creek to Dearborn reach, 8 taxa were reported below the tributaries, especially in the spring samples. Stonefly diversity and EPT

taxa richness in general increases with increasing distance from Holter Dam. Highest total taxa and EPT richness were reported at sites least affected by the dam, particularly the Missouri River near Hardy Bridge and at Cascade which are 28 and 37 miles downstream from Holter dam, respectively. The Cascade site also contained a unique benthic fauna reporting four mayfly species that were collected nowhere else in the study.

We sampled aquatic weed-beds with Hess samples (n=3) at two sites (MO_LPPC_US and MO_HARDY) during the summer and fall sampling periods in 2016 to better understand insect communities using this abundant macro-habitat. Average macroinvertebrate densities across the weed bed samples (n=12) was ~8,300 per m^2; this is more abundant than the surrounding bottom substrate at Hardy Bridge (~6,500 per m^2), but not as high as the Little Prickly Pear upstream benthic densities of ~20,000 per m^2. While aquatic weed beds are dominated by scuds, sowbugs, worms, snails and damselflies, there are 4 Baetidae mayfly species that are preferentially found in this habitat at low numbers: *Callibaetis, Acerpenna pygmaea, Plauditus punctiventris* and *Pseudocloeon*. These species add to the overall EPT diversity of the reach. Weed beds also provide the preferred habitat for damselflies (*Enallagma* and *Ishnura*) in this river section, and they averaged ~500 individuals per m^2 of weedbed. Crayfish (*Orconectes virilis*) biomass and densities were highest at sites where benthic substrate contained cobbles larger than ~6 inch diameter (Mid-Cannon, Hardy Bridge and Cascade). The riffle beetle, *Optioservus quadrimaculatus* contributed significant numbers (avg. ~1,000 individuals per m^2) to the macroinvertebrate communities of the Missouri River sites between Wolf Creek and Craig; these are not represented in any of the metrics analyzed, because they are non-EPT insects.

Overall, macroinvertebrate communities collected in 2018 resemble those reported in 2015-2017 with similar taxa composition; there are some continued increases in total and EPT taxa richness at the Missouri River below Little Prickly Pear, D/S of the Dearborn, Hardy Creek and Cascade. We recorded significant reductions in Chironomidae (midges) and the % of non-insect taxa in the summer samples, especially at sites from Wolf Creek to upstream of the Dearborn River. Increases in the percentage of non-insect taxa in the fall samples, largely from Turbellarian flatworms, worms and sowbugs, comprising the benthic samples was substantial in the Missouri River from Craig and upstream of the Dearborn River sites. This community shift from summer to fall reflects an increase in sediment build-up in many gravel areas of the stream channel, compounded with large contributions of aquatic vegetation trapping sediments. HBI tolerance scores indicated significant organic pollution at four of the seven (>57%) monitoring sites, and this metric has also been used as a surrogate for sediment impairment.

New Zealand mudsnails had low densities at multiple sites in the Missouri River from Wolf Creek to Cascade in 2015, but had begun to substantially increase their populations upstream of Craig, especially upstream and downstream of the Little Prickly Pear Creek. High densities of the NZMS in 2016 at the MO_LPPC_US site were reduced by 66% after the flushing flows of June 2017 and by 60% at Craig in 2018. We postulate that NZMS population increases, overall non-insect macroinvertebrate density increases, significant caddisfly decreases and the expansion of rooted weed-beds in the Wolf Creek to Dearborn section is potentially correlated with lower spring flushing flows from Holter Dam since 2011. Future monitoring events will be focused on determining macroinvertebrate community responses (i.e., caddisflies, NZMS, non-insect taxa) to the above average 2017 spring flows, and the larger flushing flows of 2018.

1.0 Introduction

UMOWA contracted Montana Biological Survey in 2018 to continue the Missouri River Baseline Monitoring program started in 2015. This study was designed to evaluate baseline status and monitoring of benthic macroinvertebrates, in the Blue Ribbon section of the Missouri River between Wolf Creek and Cascade. Until 2015 very few macroinvertebrate samples have been collected below the Wolf Creek Bridge, but there were four sites below Holter Dam and two sites above Canyon Ferry that MT Department of Environmental Quality (MDEQ) sampled qualitatively in the mid 2000's that are available to use as comparisons to this study (MDEQ 2007, Table 1). Benthic macroinvertebrates have been monitored at one site about 0.8 miles below Holter Dam annually by PPL (now Northwestern Energy) since 1995 (McGuire 2016). This is a highly regulated stream reach with dampened seasonal and short-term flow fluctuations, modified temperature regime, minimal flushing of sediment loads, and tremendous inputs of plankton and nutrients from upstream reservoirs. These conditions promote the extensive growth of aquatic plants (primarily water buttercup) and high benthic macroinvertebrate standing crops with limited community diversity (McGuire 2016). August density estimates at this Holter site typically range from 10 to 20 thousand benthic macroinvertebrates per square meter. Recent density estimates (2015 and 2016) were near the high end of this range (McGuire 2016). Our 2015-2017 results corroborate these high invertebrate densities between Wolf Creek and Craig averaging ~15,000 organisms per m^2 across all seasons (avg. 23,000 per m^2 in the fall) (Stagliano 2018). Mayflies, stoneflies and caddisflies (i.e. Ephemeroptera, Plecoptera and Trichoptera {EPT taxa}) are of particular interest to fly fisherman, and are typical focal points of benthic invertebrate analysis because these orders also contain some of the more sediment and "pollution" sensitive species of insects (Barbour et al 1999, Bukantis 1996). Anecdotal data and personal experiences have noted reduced caddis hatches and the disappearance of the fall BWO hatches. **Project goals are**: 1) to conduct standardized and quantitative macroinvertebrate surveys to serve as the baseline standard against future monitoring efforts, 2) to assess aquatic biointegrity with key community indicators and comparing these against previously collected qualitative samples by MDEQ (2007), 3) to understand the insect dynamics in relation to increasing aquatic macrophyte beds and minimal sediment flushing lows during below average water years.

2.0 Methods

2.1 Habitat and Physical Water Sampling

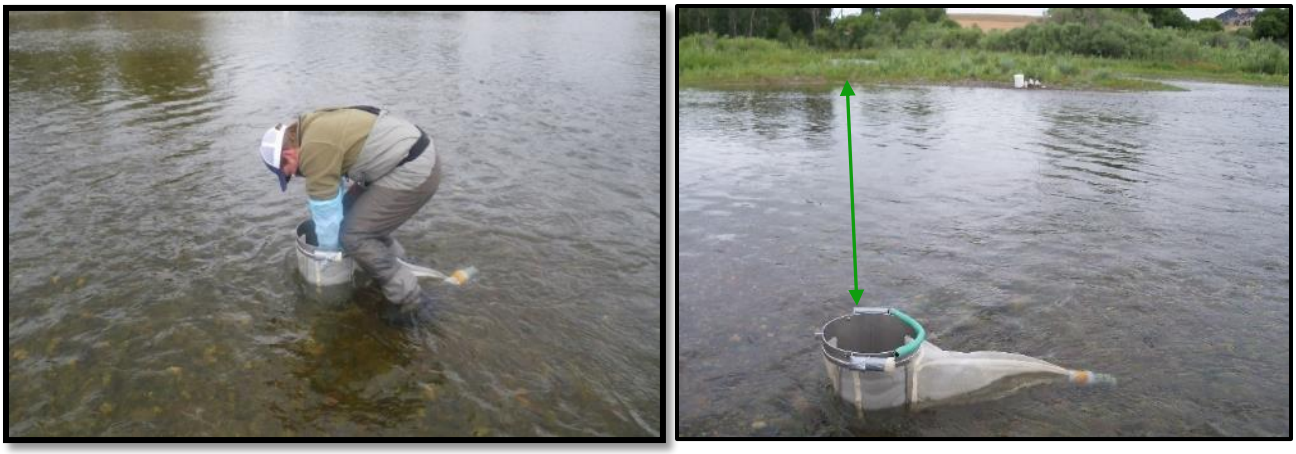
Temperature and basic physical water parameters (Total Dissolved Solids, pH, and Conductivity) were recorded at each site prior to macroinvertebrate sampling using an Oakton 10 water quality

multi-meter, calibrated for the lower conductivity range (Appendix D). A suite of water samples was also collected according to MDEQ protocols (MDEQ 2012b) and processed at the Energy Laboratories in Helena (See UMOWA Water Quality Report). A 50 m survey tape was staked from the green-line on the stream bank to record sampling distances where samples were taken in the stream channel. Stream channel depths at each bug sample point (n=3) were recorded at the time of sampling (**Appendix D**).

2.2 Macroinvertebrate Sampling

Three replicate Hess (33 cm diameter) samples were taken at each site to quantitatively collect macroinvertebrates within a designated riffle at measured distances from the bank (**Photo 1 Appendix D**). Three Hess samples typically capture 90% of the total taxa present in a riffle (Vinson and Hawkins 1996). Each Hess sample constitutes a benthic area of 0.1 m^2. At each sampling point, the Hess sampler was pushed into the stream bottom to form an effective seal and all cobbles (>64 mm) within the sampling frame were scrubbed clean of organisms and removed; then the entire area within the sampler frame was raked (disturbed) for approximately one minute until all organic matter and macroinvertebrates were washed into the collection net of the Hess sampler (**Photo 1)**. Macroinvertebrates, organic and inorganic matter were composited into a 40 liter bucket. By swirling the bucket with several water washes, organic material was elutriated from the inorganic (cobbles/gravels) portion onto a 500µm sieve, so that only macroinvertebrates and organic matter were transferred into 1 liter labeled sampling jars filled with 95% ethanol. The inorganic portion in the bottom of the bucket was thoroughly examined for caddisfly cases before being discarded back into the stream. Additional Hess samples (n=3) were taken at 2 sites in established weed beds in 2016 without disturbing the bottom sediments to fully

Photo 1. Hess sampling procedure in a Missouri River riffle near Little Prickly Pear Creek (MO_LPPC_US). Distance to the greenline was measured.



understand the macro-habitat dynamics of the aquatic vegetation insect communities in this reach of the Missouri River.

2.3 Taxonomic Analysis

Samples were processed and analyzed at the Montana Biological Survey laboratory in Helena. Macroinvertebrates were picked from the samples, subsampled to 500 individuals, if needed, and identified to the lowest taxonomic level possible (genus/species) with a dissecting microscope (10-40x) following Montana Department of Environmental Quality protocols (MDEQ 2012). Numerous metrics were calculated from the data after it was entered into EDAS (Jessup 2006), including EPT taxa, %EPT, %Non-insect, %Chironomidae, %Crustacean-Mollusk and Hilsenhoff Biotic Index (HBI). The combined mayfly, caddisfly and stonefly species (EPT taxa) and the percentage of these in the sample (% EPT) are always informative metrics, as EPT taxa contain some of the more intolerant aquatic insects, usually requiring clean substrates. These are also the insects that most fly-fisherman are concerned about matching the hatch. Thus, EPT metrics typically decrease with increasing sediment in the benthic substrates (Barbour et al. 1999); although, Tricos (*Tricorythodes* and *Caenis*) are silt tolerant and can increase in numbers with increasing siltation. One informative stand-alone metric is the Hilsenhoff Biotic Index (HBI) which measures the tolerance of a macroinvertebrate community to organic enrichment (Hilsenhoff 1987) or sediment (MDEQ 2012). Tolerance values are based on a 0-10 scale, where zero-ranked taxa are most sensitive and 10-ranked taxa are most tolerant to pollutants. Values of 0.0-3.0 indicate no apparent organic pollution (excellent), 3.0-4.0 possible slight organic pollution (very good), 4.0-5.0 some pollution, 5.0-6.0 fairly significant pollution, 6.0-7.0 significant pollution (fairly poor), 7.0-8.0 very significant organic pollution 8.0-10 severe organic pollution.

2.4 Sample Sites

We sampled macroinvertebrates and water chemistry at seven established monitoring sites between Wolf Creek and Cascade (**Table 1**). During the pre-runoff, spring monitoring period, we have been trying to collect the Hess samples during late-April at flows of approximately 4,300 cfs, as in 2015 and 2016. Stream flows on the Missouri River during the 2018 spring sample period were increased to ~5,500 cfs on April 17th at the Wolf Creek Bridge and ~6,000 cfs at the Cascade site; these continued to ramp up into May, therefore, a spring 2018 sample was not collected at any site (**Figure 1**). We sampled macroinvertebrates for the summer monitoring period on July 20 and 21st when flows were ~4,500cfs at Wolf Creek bridge and ~5,200cfs at Cascade and for the fall monitoring period on Sept 27th and Oct 1st (**Figure 1, Appendix D**); these were within days of the sampling time-frame in 2015-2017.

Table 1. UMOWA 2018 Sampling Study Reaches and ones that overlapped with MDEQ (2007).

Station ID	Agency	Waterbody Site Name	Latitude	Longitude
MO_LPPC_US	UMOWA	MISSOURI RIVER U/S LITTLE PRICKLY PEAR	47.02281	-112.01527
MO_LPPC_DS	DEQ/UMOWA	MISSOURI RIVER D/S LITTLE PRICKLY PEAR	47.02345	-112.01523
M12MISSR02	DEQ	MISSOURI RIVER @ CRAIG	47.06722	-111.96388
MO_CRAIG	UMOWA	MISSOURI RIVER U/S CRAIG	47.05415	-111.96701
MO_DEAR_US	UMOWA	MISSOURI RIVER U/S DEARBORN	47.12791	-111.91092
M12MISSR03 MO_DEAR_DS	DEQ/UMOWA	MISSOURI RIVER D/S DEARBORN	47.12336	-111.92396
MO_HARDYBR M12MISSR04	DEQ/UMOWA	MISSOURI RIVER U/S OF SHEEP CREEK (HARDY BRIDGE)	47.16781	-111.83366
MO_CASCADE	UMOWA	MISSOURI RIVER AT CASCADE FAS	47.28062	-111.69113

Map 1. Study locations on the Missouri River from Holter Dam to Cascade, flow direction is to the northeast from the bottom center of the map to the top right.

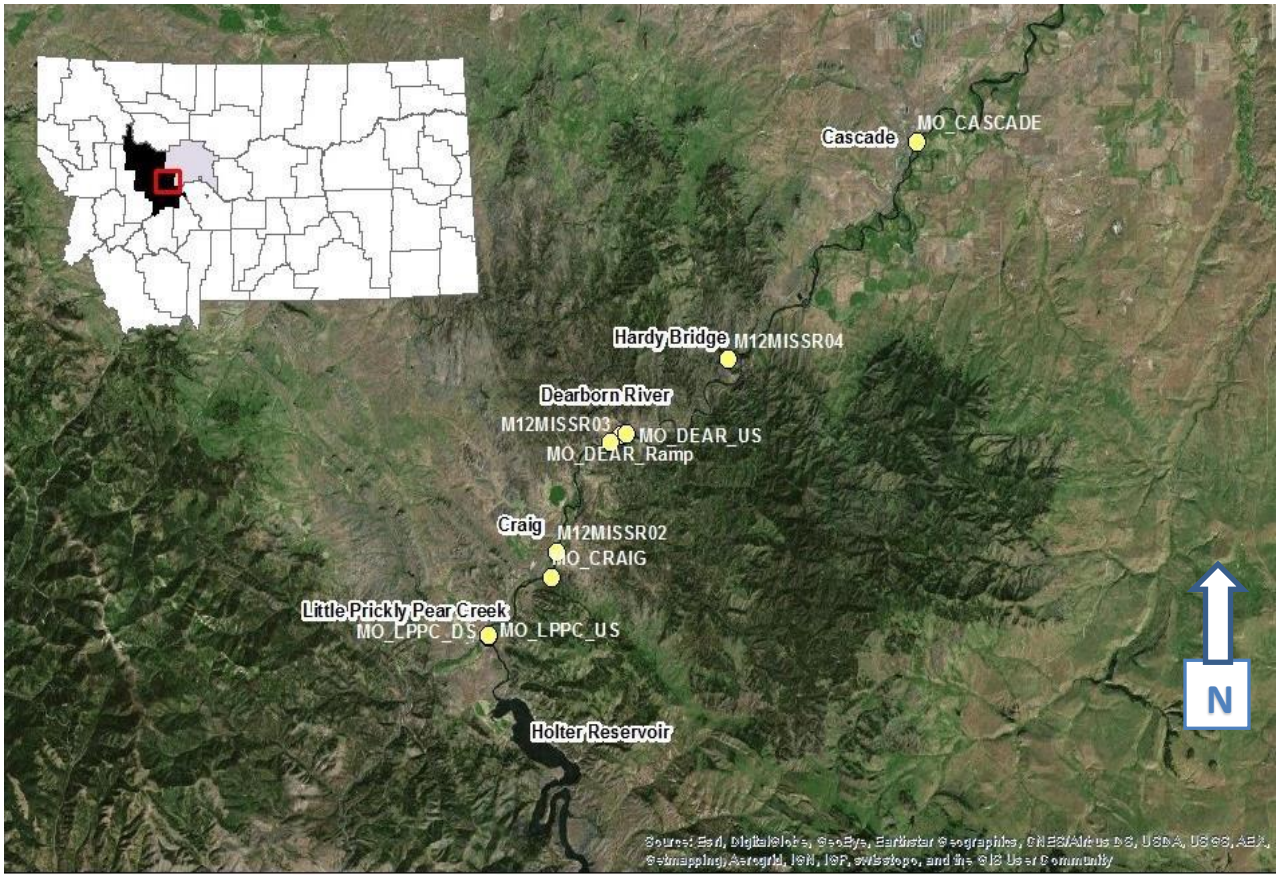
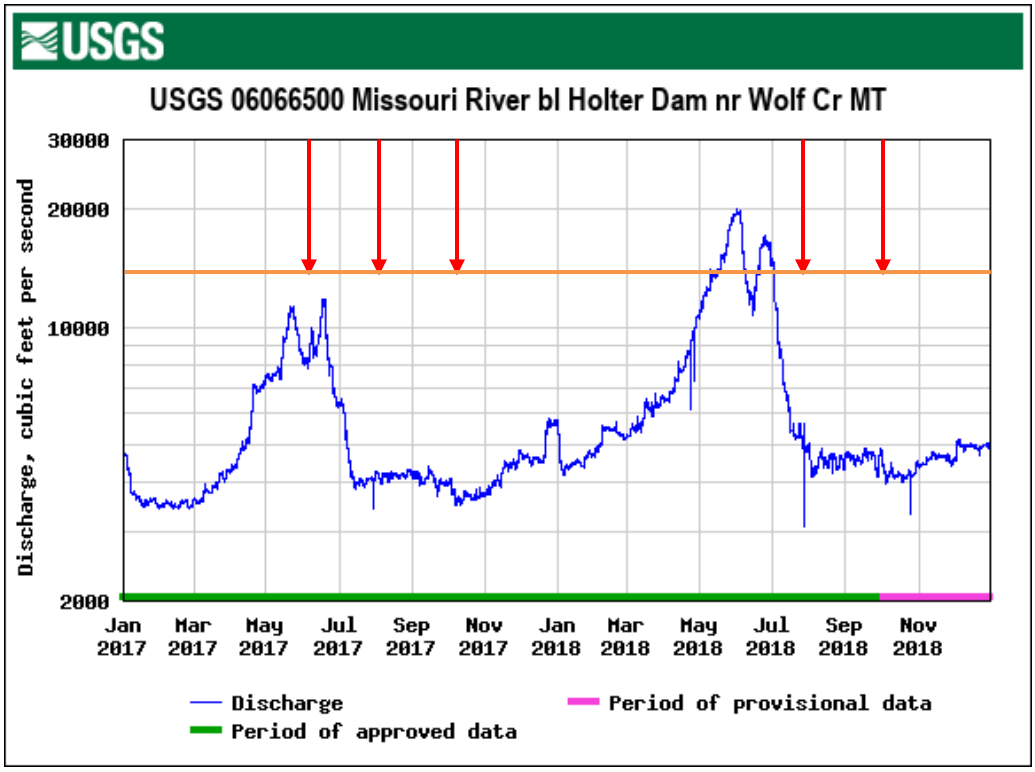
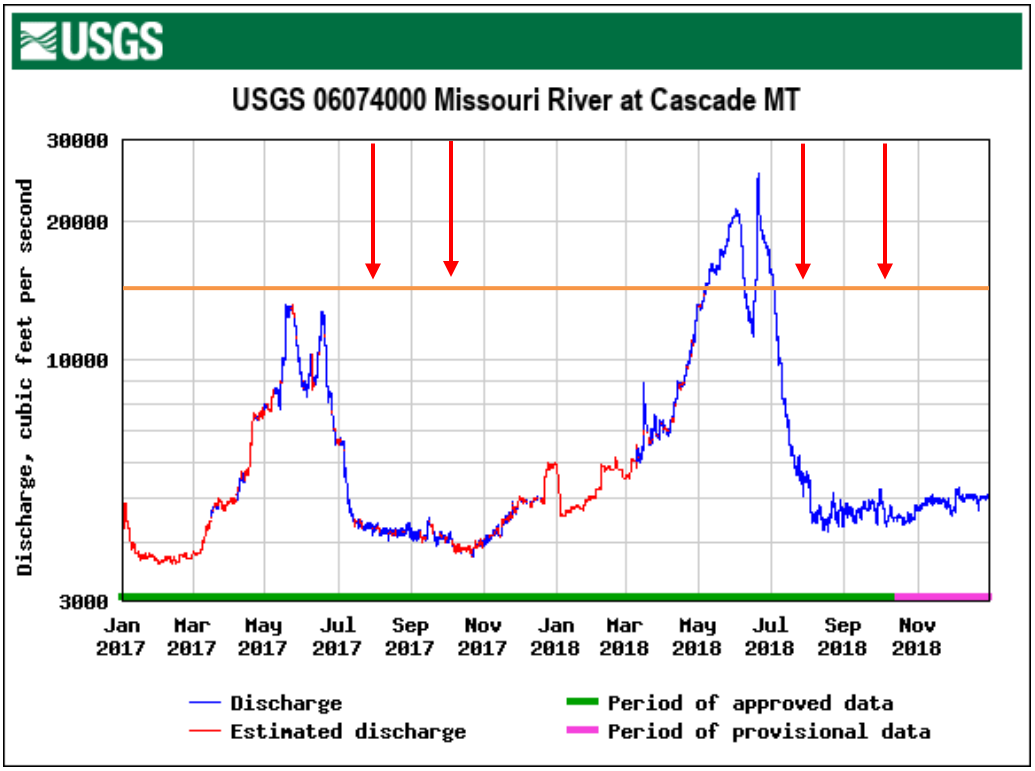


Figure 1. USGS Station 06066500: Missouri River below Holter Dam (top) and USGS Station 06074000 at Cascade (bottom) streamflow graph for the 2017-2018 sampling period**.** Red arrows are the seasonal sampling period dates. Orange line is the estimated flow (15,000 cfs) to have a sediment flushing effect (R2 Resources 1994).





3.0 Results

Overall, 116 cumulative macroinvertebrate taxa were reported from the study between 2015 and 2018; 2016 sampling added 24 taxa to the cumulative Missouri River taxa list from 2015. Many of these new taxa (10 species) were reported from weed bed sampling or observed at Missouri River sites below tributaries. We gained additional occurrences of 3 baetid mayfly taxa (*Callibaetis, Acerpenna pygmaea* and *Pseudocloeon*) by sampling the aquatic weed beds in 2016 (**Table 2**). Since 2015, the Missouri River U/S and D/S of LPPC (MO_LPPC_US) gained 7 EPT taxa each. No new taxa were added in 2018 from the 45 seasonal macroinvertebrate assessment samples collected between Wolf Creek Bridge and Cascade but many rare taxa were reported in higher numbers at sites below tributaries (especially salmonflies, *Pteronarcys californica* and yellow sallies, *Sweltsa* D/S of the Dearborn) (**Appendix C**).

Densities of benthic macroinvertebrates varied significantly spatially and seasonally with the overall trend of higher densities from Wolf Creek to upstream of the Dearborn River and decreasing down to Cascade, except in 2017 where large increases in densities were observed at Hardy Creek and Cascade (**Figure 2a**). These densities were driven by large increases in % midges and % non-insects in the samples (**Figure 2b**). The Missouri River above Little Prickly Pear Creek (MO_LPPC_US) reported the highest benthic invertebrate densities of all sites, averaging ~24,000 individuals per m^2 and attained a very large standing crop, especially in the spring (~26,000 per m^2) (**Figure 2a**). Macroinvertebrate densities reported at the Craig site this fall (~30,000 per m^2) were the highest ever reported during this study (**Figure 2a**). The Missouri River upstream of the Dearborn reported significantly higher invertebrate densities in 2016, than in 2015 (**Figure 3**); while the Craig monitoring station reported significantly lower numbers than in 2015 (**Figure 3**). Relatively lower numbers of benthic invertebrates were reported from the Missouri River below Little Prickly Pear Creek (MO_LPPC_DS) and the Dearborn River (MO_DEAR_DS), as well as Hardy Creek, especially in the spring (**Figure 2a**). Low densities did not necessarily equate to lower taxa richness, as the Hardy Bridge and Cascade sites reported the lowest “non-tributary affected” populations 2016, but also had the highest taxa richness (**Figure 2a**).

Study-wide average macroinvertebrate taxa richness per site was 30.1 taxa in the spring, 29.6 in the summer and 33 taxa in the fall with no significant difference between seasons (T-test, $p>0.05$) (**Appendix B**); this is a slight increase from 2016. The most taxa rich macroinvertebrate community was again collected at the Missouri River FAS site near Cascade; these averaged 36.2 total taxa over the three seasons with a high of 45 taxa in the fall of 2017 (**Appendix B**).

The combined mayfly, caddisfly and stonefly (EPT) taxa richness for the entire sampled section totaled 50 taxa and averaged 22.3 species per site (**Table 2**), the highest cumulative EPT richness (28 spp.) was reported at Missouri River FAS site near Cascade. The next highest EPT taxa richness were reported at the Missouri River sites downstream from the Dearborn (27 spp.) and D/S of Little Prickly Pear Creek (26 spp.) (**Table 2**). Mayfly and caddisfly taxa were more diverse and abundant than stonefly taxa at all sites (**Table 2**). There were 23 species of mayflies recorded throughout the study section with the dominant three, BWO's (*Baetis tricaudatus*), Tricos (*Tricorythodes explicatus*) and Pale Morning Duns (*Ephemerella excrucians*), often exchanging dominance at any one site depending on the season and silt or weed-bed coverage in the sampling area (**Table 2**). Of the 21 species of caddisflies that were collected across all sites, the net spinning caddis, *Cheumatopsyche,* and the long-horned caddis, *Oecetis* was usually the most prevalent (**Table 2**). Populations of other net-spinning caddis (*Hydropsyche occidentalis, H. morosa group*), micro-caddis *(Hydroptila*) and snail-cased caddis (*Helicopsyche borealis*) were also common, but not as abundant (**Table 2**). A couple of caddisfly taxa, including *Glossosoma* and *Ceraclea* appeared for the first time in summer of 2017 at the Missouri River Flushing Flow Study plot upstream from Little Prickly Pear Creek. High percentages of caddisflies comprising the % EPT were only documented at sites below tributaries (MO_LPPC_DS, MO_DEAR_DS) and at the Cascade site in the spring (**Figure 2d**). The large October caddis, *Dicosmoecus gilvipes,* occurred throughout the study reach, but was more common below the Dearborn River downstream to Cascade (**Table 2**). Caddisflies were more common during the spring and summer sampling periods at some sites than in the fall, but as a percentage of total EPT were usually much lower than mayflies (**Figure 2d**).

Stonefly (Plecoptera) taxa (8 species) were collected sporadically across the study reaches (**Table 2**). *Sweltsa*/*Suwallia* (Yellow Sallies), *Isoperla* (Green-winged Stoneflies), *Hesperoperla pacifica* and *Claassenia sabulosa* (Golden Stones) begin to appear in the mainstem Missouri River at Mid-Cannon and Hardy Bridge and near tributary sites (especially up and downstream of the Dearborn River and Little Prickly Pear Creek) (**Table 2**). Even a couple of salmonfly (*Pteronarcys californica*) and *Skwala* individuals were reported in the samples of the Missouri River downstream of Little Prickly Pear Creek and the Dearborn River, likely washed in from the spring-flows (**Table 2**). Stonefly taxa are sporadic and increase in numbers and diversity the further distance downstream from Holter Dam; they have never been reported at PPL's site 0.8 miles below Holter Dam in the 21 years of monitoring (McGuire 2016).

The riffle beetle, *Optioservus quadrimaculatus* contributed significant numbers (avg. ~1,000 individuals per m^2) to the macroinvertebrate communities (~10%) of the Missouri River sites between Wolf Creek and Craig (**Appendix C**); adults and larvae are always present since the adults are aquatic and remain on the bottom substrate. These are not usually represented in any of the macroinvertebrate metrics analyzed, since they are non-EPT insects.
Lowest insect densities, as sparse as 700 individuals per m^2, were reported at the Missouri River sites below tributary streams (e.g. below Little Prickly Pear Creek in 2015 and D/S of the Dearborn River 2016) in the spring and summer, but these numbers increased rapidly by the fall sampling period to mirror population densities in adjacent Missouri River sites (**Figure 2a**).

As observed in 2015 and 2016, non-insect percentages in 2017 and 2018 increased through the seasons with highest abundances in the fall, as mayflies and caddisflies hatch out and leave the benthic substrates to be dominated by scuds, sowbugs, worms and snails; this is especially noticeable at the Missouri River at Craig, upstream of Little Prickly Pear Creek and u/s of the Dearborn River (**Figure 2c, Figure 5**). On an annual basis across all sites, 2017 did not report significantly more % non-insect comprising the samples than in 2015 and a few sites in 2018 reported a significant decrease in % non-insects compared to other years (**Figure 3**). Weed beds were largely dominated by non-insects during all seasons (Stagliano 2016).

Lowest insect densities, as sparse as 700 individuals per m^2, were reported at the Missouri River sites below tributary streams (e.g. below Little Prickly Pear Creek in 2015 and D/S of the Dearborn River 2016) in the spring and summer, but these numbers increased rapidly by the fall sampling period to mirror population densities in adjacent Missouri River sites (**Figure 2a**).

In the summer of 2018, % EPT was significantly higher across most sites than in previous years, but, as was observed in previous years, this metric significantly declined in the fall samples as non-insect populations increased in the substrates (**Figure 2b & 3b, 5**).

Table 2. The combined mayfly, stonefly and caddisfly (EPT) taxa occurrences and dominance for the entire study reach sampled. x=rare, X=common, XX=abundant, XXX=dominant at site.

Order	Species	MO_LPPC_US	MO_LPPC_US weed bed	MO_LPPC_DS	MO_Craig	MO_Dear_US	MO_Dear_DS	MO_MidCann	MO_Hardy	MO_Hardy weed bed	MO_Cascade
Mayflies	**Ephemeroptera (Mayflies)**										
Ameletidae	*Ameletus*						x	x	x		
Baetidae	*Acerpenna pygmaea*		x							x	x
Baetidae	*Acentrella insignificans*				x	x	x		x		
Baetidae	*Baetis intercalaris*										X
Baetidae	*Baetis flavistriga*				x						
Baetidae	***Baetis tricaudatus* (BWO)**	XX		X	XX	XX	x	XX	XX		X
Baetidae	*Callibaetis*		x							X	
Baetidae	*Centroptilum bifurcatum*						x				
Baetidae	*Diphetor hageni*					x	x				x
Baetidae	*Plauditus punctiventris*		x			x	x	x	x	x	X
Baetidae	*Pseudocloeon sp.*		x						x	x	x
Leptophlebiidae	*Paraleptophlebia sp.*					x	X	x	x		
Leptophlebiidae	*Choroterpes albiannulata*										XX
Leptohyphidae	***Tricorythodes explicatus* (Tricos**	XX		X	XXX	XXX	X	X	XX		XX
Ephemerellidae	*Attenella margarita*	x		x		x	x		x		x
Ephemerellidae	***Ephemerella excrucians* (PMD)**	XX		x	XX	XX	XX	XXX	XX		X
Ephemerellidae	*Drunella coloradensis*			x							
Ephemeridae	*Ephemera simulans*						x				x
Heptageniidae	*Epeorus albertae*			x		x	x				
Heptageniidae	*Epeorus longimanus*					x		x			
Heptageniidae	*Heptagenia*								x		x
Heptageniidae	*Macaffertium terminatum*					x	x		x		x
Heptageniidae	*Ecdyonurus simpliciodes*						x		x		X
Heptageniidae	*Rhithrogena sp.*	x		x	x		X	x			
Stoneflies	**Plecoptera (Stoneflies)**										
Perlodidae	*Isoperla fulva*	x		x		x		X	x		
Perlodidae	*Skwala*			X			x	x	x		
Chloroperlidae	*Paraperla*						x				
Chloroperlidae	*Suwallia*			x		x					
Chloroperlidae	*Sweltsa*			x			x	x			
Pteronarcidae	*Pteronarcys californica*			x			x	x			
Perlidae	*Hesperoperla pacifica*			x		x	x	X	x		x
Perlidae	*Claassenia sabulosa*			x			x	X			
Caddisflies	**Trichoptera (Caddisflies)**										
Brachycentridae	*Amiocentrus aspilus*					x		x			
Brachycentridae	*Brachycentrus occidentalis*	x		X		x		x	x		
Hydropsychidae	***Cheumatopsyche* (Tan Caddis)**	X		X	XX	x		XX	XX		x
Hydropsychidae	***Hydropsyche occidentalis***	x		x	X			XX	XX		x
Hydropsychidae	*Hydropsyche morosa gr.*	X		x	x	x		X	XX		x
Hydroptilidae	*Hydroptila*	XX	x	XX	X	X		x	X	x	x
Hydroptilidae	*Ochrotrichia*										x
Lepidostomatidae	*Lepidostoma*	x		x			x				
Leptoceridae	*Ceraclea*	x		x	x	x		x			
Leptoceridae	*Nectopsyche*										x
Leptoceridae	***Oecetis avara* (Long-horn Caddis**	X		X	XX	x	x	X			X
Glossosomatidae	*Anagapetus*			x							
Glossosomatidae	*Glossosoma*	x		X			X	x			
Glossosomatidae	*Culoptila*			x							
Uneonidae	*Neophylax splendans*	x		x							
Limnephilidae	*Dicosmoecus gilvipes*	x			x	x	x	x	X		x
Limnephilidae	*Limnephilus*						x		x		x
Limnephilidae	*Onocomoecus unicolor*						x		x		x
Limnephilidae	*Pycnopsyche*										x
Helicopsychidae	*Helicopsyche borealis*					x		X	x		X
Polycentropidae	*Polycentropus*								x		x
	Total EPT per site	17	5	26	13	23	27	25	25	5	28

Figure 2a. Macroinvertebrate seasonal metrics for 2018 sample sites. Blue arrows are major tributaries entering the Missouri River. Sites arranged in upstream to downstream orientation. Error bars are ±SE.

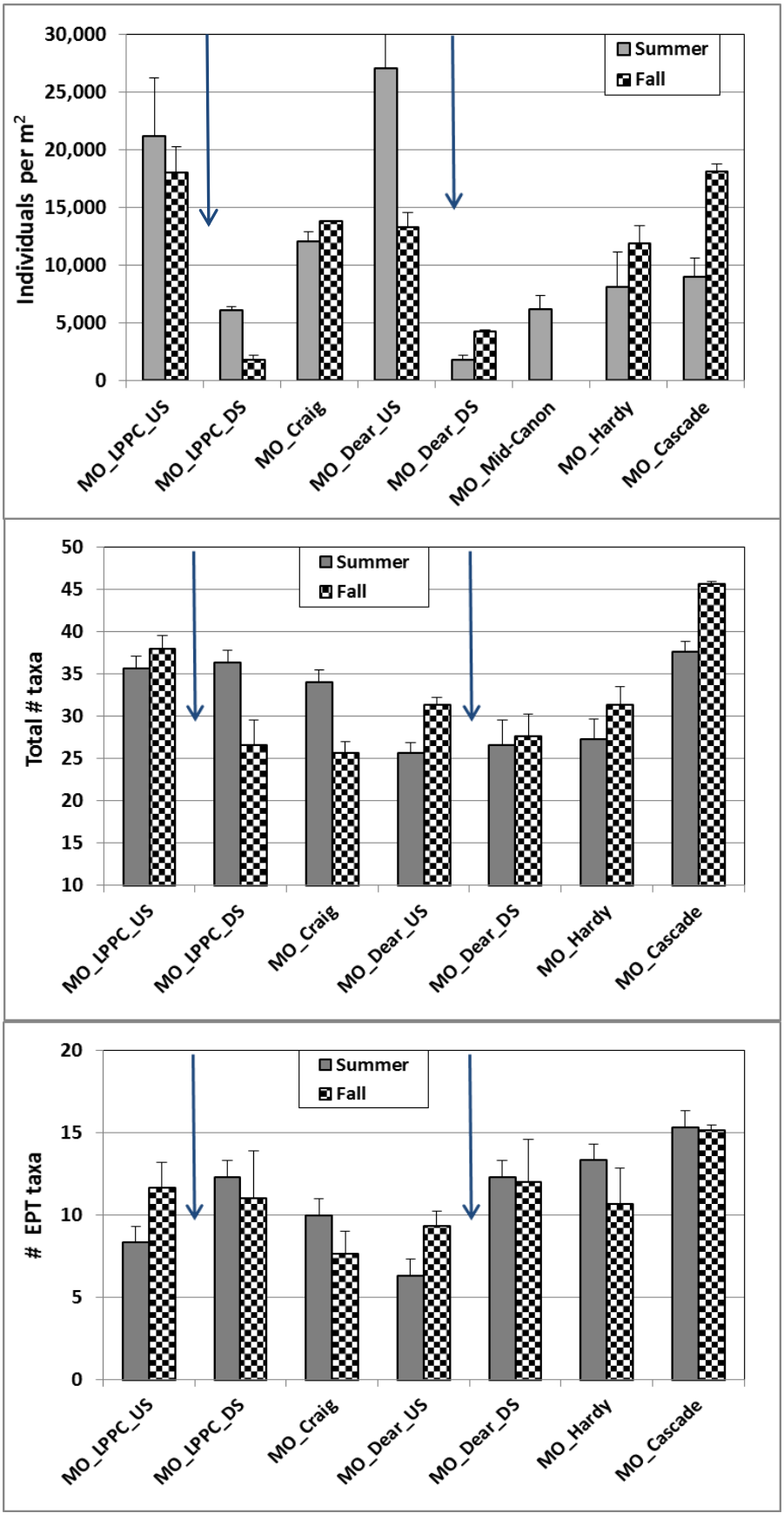


Figure 2b. Macroinvertebrate seasonal metrics for 2018 sample sites. Error bars are SE. Arrows are tributaries entering the Missouri River. Sites arranged in upstream (l) to downstream orientation.

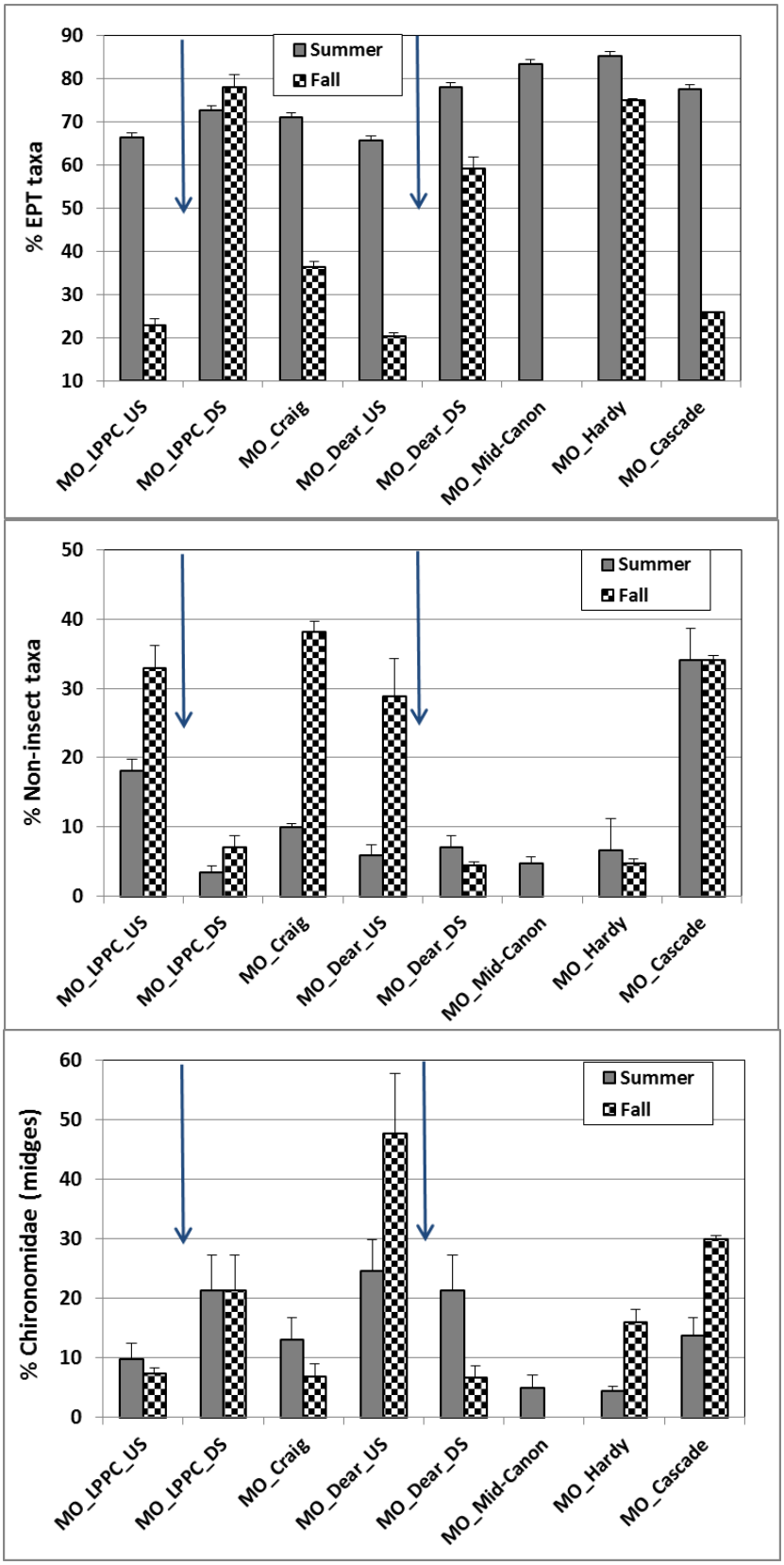
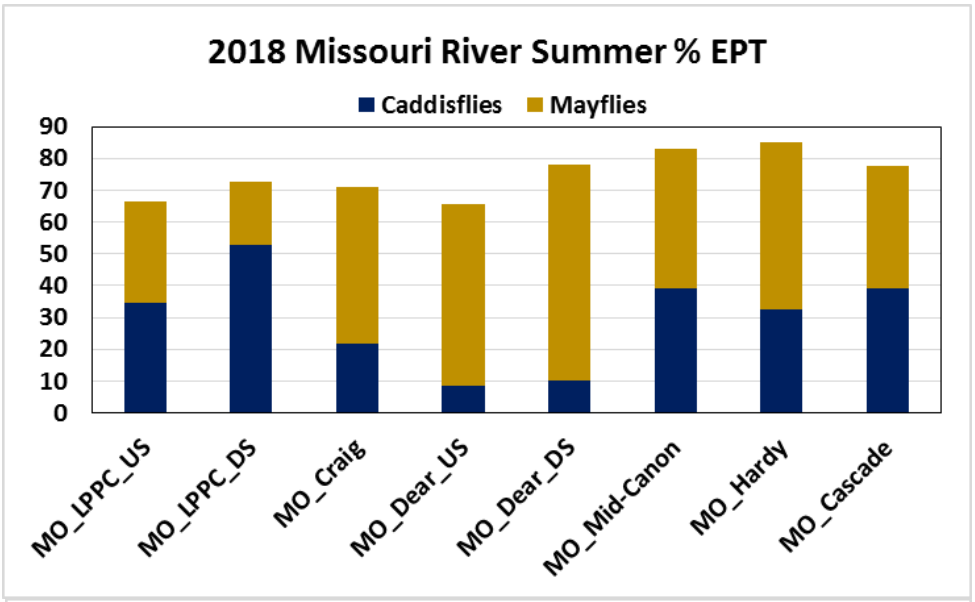


Figure 2c. Macroinvertebrate seasonal metrics for 2018 sample sites. Error bars are SE. Blue arrows are tributaries entering the Missouri River. Sites arranged upstream (l) to downstream (r).



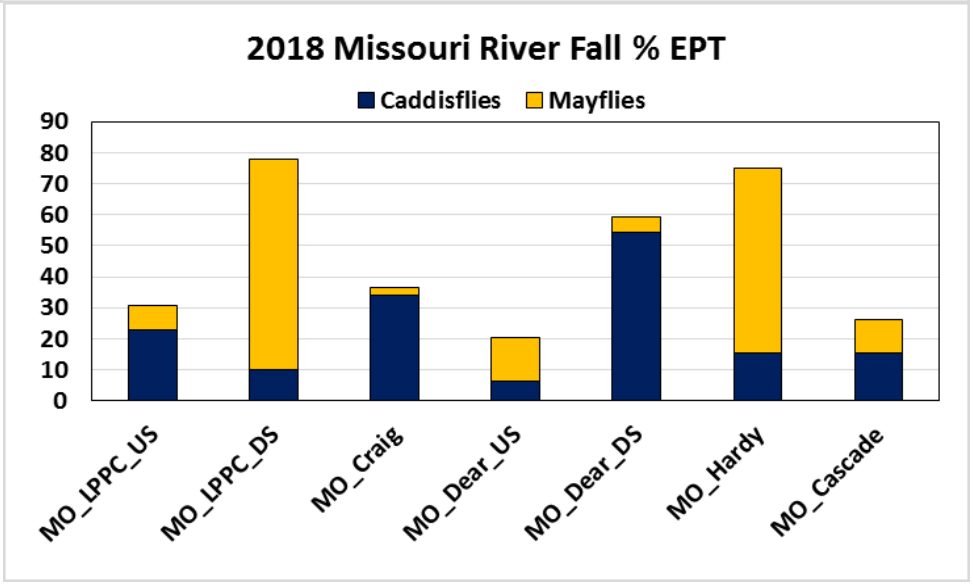


Figure 2d. Macroinvertebrate HBI metrics for 2018 sample sites. Error bars are SE. Blue arrows are tributaries entering the Missouri River. 4.0-5.0 =moderately impaired; >5.0 significant impairment.

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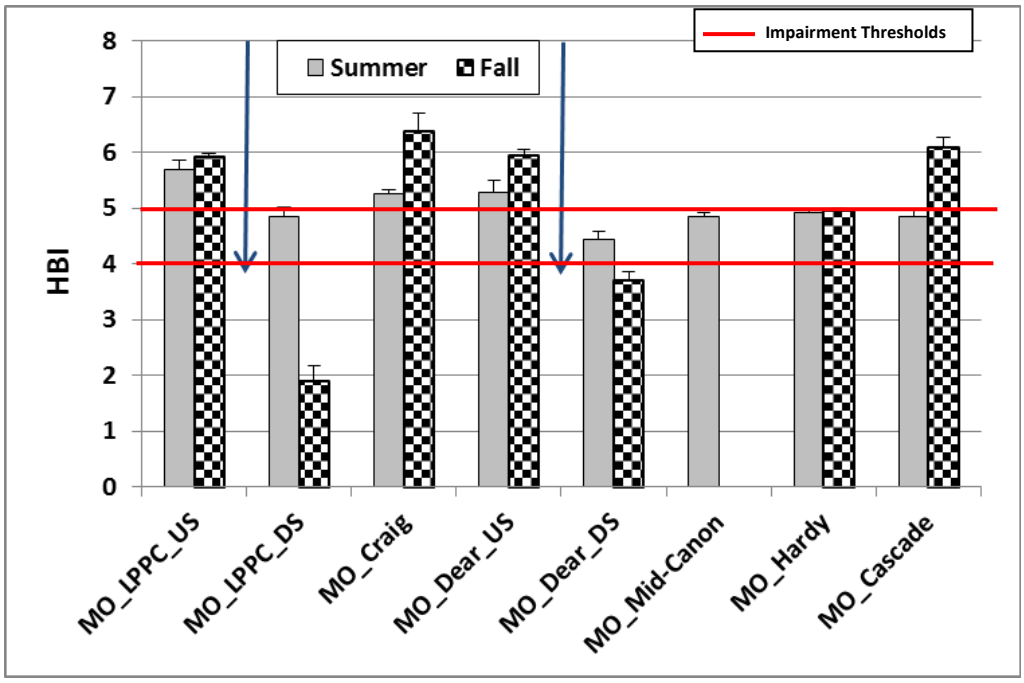


HBI Scores in 2018 indicated that the macroinvertebrate communities at all Missouri River sites, except MO_LPPC_DS and MO_Dear_DS (fall) are experiencing some nutrient/organic enrichment, and four of the eight (50%) monitoring sites are exhibiting moderate organic pollution (scores 5.0-6.0) (**Figure 2d**). Significant organic enrichment (HBI >6.0) was detected in the macroinvertebrate communities during the fall 2018 at Craig and Cascade (**Figure 2d**). Missouri River sites below tributaries showed improvements in the tolerance-level of benthic communities, especially in the fall samples for MO_LPPC_DS and fall for MO_DEAR_DS (**Figure 2d**).

In comparing macroinvertebrate communities sampled at all sites between 2015 and 2018, we can see some highly significant trends in increasing benthic population densities and decreases of % Midges in a sample, (T-test, p=0.006) and (T-test, p=0.00026), respectively (**Figure 3**). The number of total taxa and EPT taxa recorded across all sites has been trending upwards since 2015, but this was not significant (T-test, p=0.07) and (T-test, p=0.26), respectively. Significant increases in benthic densities were detected at particular sites, especially MO_LPPC_US and MO_DEAR_US ($p<0.05$) between 2015 and 2018 (**Figure 3a**). Total taxa richness has increased significantly between 2015 and 2016 (T-test, p=0.04), but not in 2018. The annual average % Chironomidae (Midges) in the benthic community across all sites has significantly decreased between 2015 and 2016 (T-test p=0.004), then again in 2018 (p=0.0003) (**Figure 3a**).

We documented a significant increase in the caddisfly abundance (% caddisflies) in the 2018 samples between the summer and fall sampling periods (p=0.004) (**Figure 2c, Appendix B**); unfortunately, this is due to increases in micro-caddis (*Hydroptila*) which can thrive in mats of algae. On an annual basis, % caddisflies in the samples has significantly decreased between 2015 and 2018 at MO_LPPC_US (T-test, p=0.01) and at MO_DEAR_US (T-test, p=0.05) (**Figure 2c).** Mayfly abundance in the samples has fluctuated, but has not changed significantly on an annual basis between 2015 and 2018 (**Figure 4**). This year's increase in taxa richness seems to have negated the previously reported losses seen between 2005 and 2015 (Stagliano 2015), but these taxa were largely non-insects (snail and worm taxa).

Figure 3. Macroinvertebrate metric annual averages between 2015 and 2018. Error bars are SE. Blue arrows are tributaries entering the Missouri River.

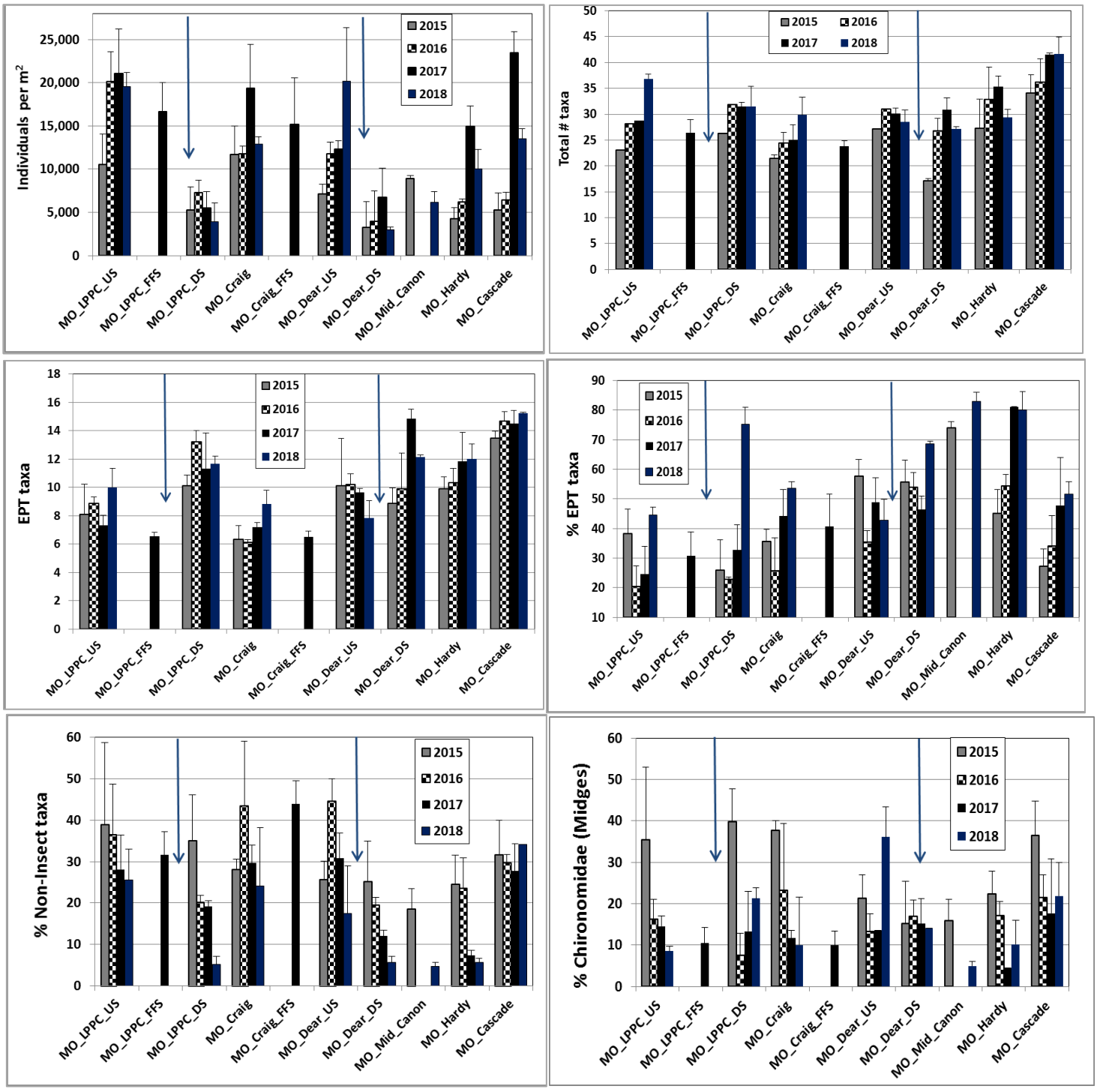
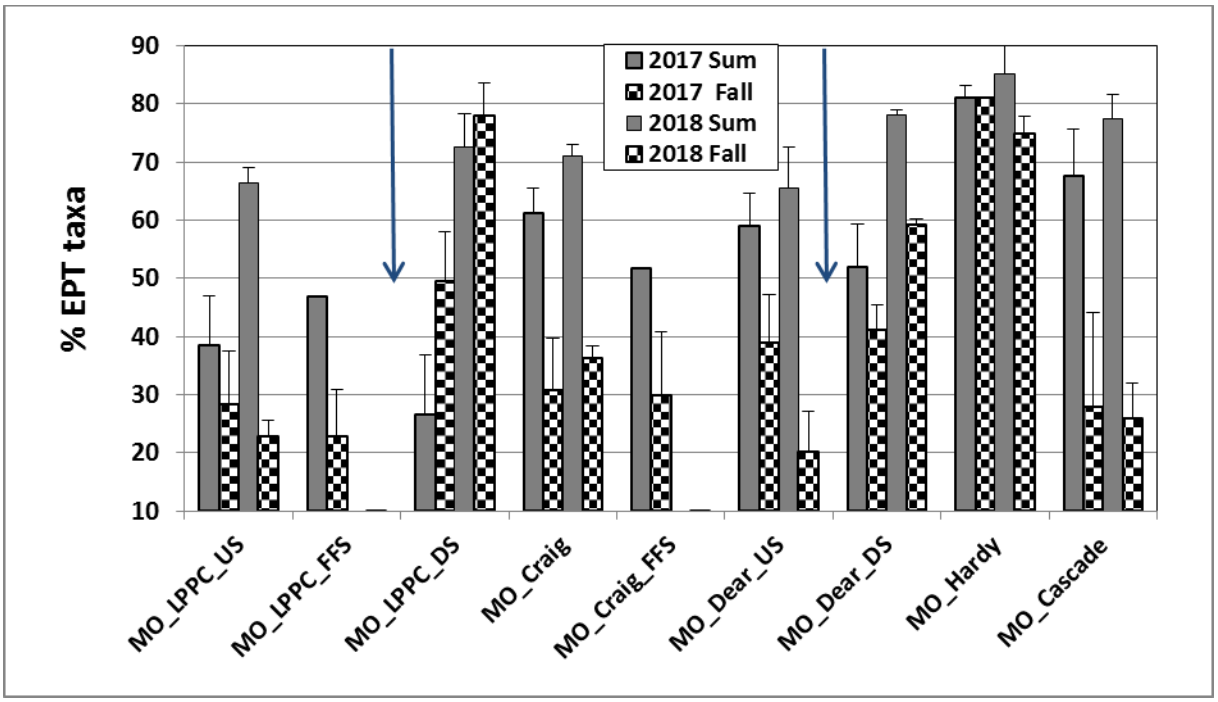


Figure 4. Macroinvertebrate metric % EPT averages between 2017 and 2018. Error bars are SE. Blue arrows are tributaries entering the Missouri River



3.1 Wolf Creek Bridge to Craig Missouri River section

The macroinvertebrate communities at the Missouri River above Little Prickly Pear Creek (MO_LPPC_US) reported the highest benthic invertebrate densities of all sites, averaging ~20,000 individuals per meter^2 and attained a very large standing crop, especially in the spring (~26,000 per m^2) (**Figure 2a and 3**). This is significantly higher than the spring of 2015 and thus, summer 2016 densities remained significantly higher despite the seasonal decreases through the year (**Figure 3**). High peak run-off flows of 2018 did little to decrease the average annual macroinvertebrate densities which are hovering around ~20,000 individuals per meter^2, but appear to have increased total taxa, EPT present at this site and %EPT present in the smaples (**Figure 3**).

Dominant insect taxa at the Craig site in 2018, in order of abundance, were Tricos (*Tricorythodes explicatus*), tan caddisflies (Cheumatopysche, Hydropsyche), midges (Chironomidae; *Cricotopus)*, BWO's (*Baetis tricaudatus*), aquatic worms and; while dominant taxa at the MO_LLPC_US site included, Tricos (*Tricorythodes explicatus*), midges (Chironomidae; *Cricotopus)*, BWO's (*Baetis tricaudatus*), and the micro-caddisflies (*Hydroptila*) (**Appendix B, Table 2**).

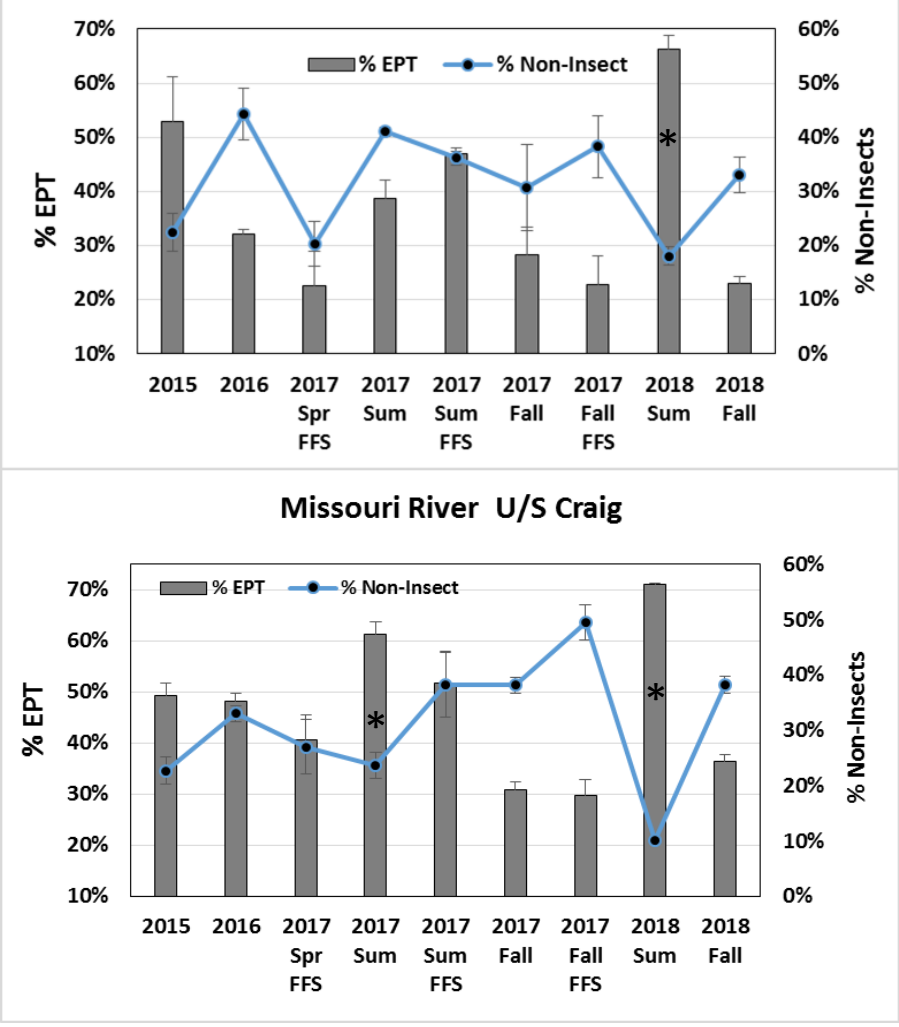
High percentages of EPT taxa at the MO_LPPC_US and MO_Craig sites in the spring and summer transitioned to a dominance of non-insect taxa in the fall during all years, this was particularly significant in 2018 (**Figure 3b**). The dominant non-insect taxa were sowbugs (*Caecidotea*), Turbellarian flatworms, roundworms Nematoda and pouch snails (*Physella acuta*).

In the Wolf Creek Bridge to Craig Missouri River section, the EPT community was primarily composed of three or four mayflies and five or six caddisflies with typically no stoneflies, except for below Prickly Pear Creek (**Table 2**). McGuire (2014) reported that the densities of these two insect orders have showed declines at the PPL monitoring site 0.8 miles below the dam. Only three species of mayflies are common near the dam. *Tricorythodes* is the most abundant mayfly in the August samples, although *Baetis tricaudatus* can also attain high densities. A few *Ephemerella* (PMDs) were usually collected at this site during the 1990's, but they are seldom present in more recent collections (last found during 2011) (McGuire 2014). On average, during the 2016 Missouri River sampling, we collected substantially more invertebrate taxa than were reported in 2015 (Stagliano 2015) between Little Prickly Pear Creek and Craig sites (paired T-test, p=0.02) (**Figure 4**). MDEQ (2007) reported low numbers of the mayfly taxa, *Callibaetis* which we did not collect in the substrate at either site during any season. *Callibaetis* is a mayfly highly tolerant of silt, and the high flows of 2011 may have flushed the bottom sediments enough to

make them less favorable for this species or MDEQ may have sampled a silt pocket favored by this species. We did collect this species in the weed bed samples of MO_LPPC_US during the fall at a density of ~70 per m^2 (**Appendix C**).

June 2018 high flows did little to reduce the summer macroinvertebrate densities at the MO_Craig Site compared to summer of 2016 numbers, but the FFS plot had significantly fewer bugs than the adjacent channel ($p<0.05$) and this pattern continued into the fall samples (**Figure 4)**. Samples from both the MO_LPPC_US and the Craig sites had significant jumps in the % EPT post-June flows, and this was especially pronounced in the MO_LPPC_FFS plot (T-test, p=0.003), and the normally sampled Craig channel (T-test, p=0.005) (**Figure 5**). The MO_LPPC_FFS plot also had an accompanying decrease in the % Non-insects in the samples compared to summer 2016, whereas the adjacent channel did not (**Figure 5**). The MO_Craig site also had a significant decrease in the % Non-insects (p=0.03) in the samples compared to summer 2016, whereas the FFS plot did not (p=0.43) and actually had an increase in aquatic worms (**Figure 5**).

Figure 5. Macroinvertebrate seasonal % EPT and %Non-Insect metrics for 2015-2018 u/s of Little Prickly Pear Creek (top) and Craig (bottom) sample sites. Error bars are SE. *= Significant differences (p<0.05).



3.2 Missouri River upstream and downstream of the Dearborn River (MO_DEAR_US, MO_DEAR_DS)

Sampling in 2018 showed that the benthic macroinvertebrate densities in the Missouri River upstream of the Dearborn River exhibited significant increases in abundance compared to 2015-2017, and this was due to contributions of non-insect taxa, especially Turbellarian flatworms and Oligochaete worms (**Figure 3, Appendix C**). The Missouri River benthic macroinvertebrates downstream of the Dearborn River exhibited significant reductions in abundance due to the spring run-off events, but then rebounded to levels of upstream Missouri River populations by the fall sampling period (**Figure 2a**). As the numbers of insects recolonizing the MO_DEAR_DS site increased, so did the diversity of taxa until by the fall sampling period total taxa richness equaled the upstream site and EPT richness was greater than that of the upstream site (**Figure 2a**).

3.3 Missouri River near Hardy Creek Bridge (MO_HARDYBR)

The macroinvertebrate community collected at this cobble/boulder riffle of the Missouri River near Hardy Bridge was more similar to a spring creek community, likely due to the abundant aquatic weed beds (**Photo 2, Appendix A**). Due to the larger substrate in this riffle, crayfish (*Orconectes virilis*) and mottled sculpin (*Cottus bondi*) were collected in the samples and averaged 1.0 and 0.5 individuals per m^2, respectively. Dominant benthic taxa at this site in 2018 were, in order of abundance, micro-caddis (*Hydroptila*), BWOs (*Baetis tricaudatus*), Tricos (*Tricorythodes explicatus)* and the net-spinning caddis (Cheumatopsyche). This is much improved from the 2016 dominant taxa: sowbugs (*Caecidotea*), BWOs *(Baetis tricaudatus),* midges (*Microtendipes*) and flatworms (Turbellaria*).* MDEQ's fall 2005 sample reported the dominant benthic taxa, in order of abundance, BWOs *(Baetis tricaudatus),* blackflies (*Simulium),* scuds (*Hyalella),* Tricos (T*ricorythodes) and* sowbugs (*Caecidotea*). The 2015-2018 samples had much lower numbers of blackflies than had been reported in 2005 (MDEQ 2007).

Cumulative total EPT for this site was the 3rd highest at 27 species, if we include the weed bed mayfly taxa (**Table 2**). But EPT species other than BWO's, micro-caddis and Tricos were low in abundance. Benthic abundance was in the mid-range for this section in the (~6,500 individuals per m^2), but this number dropped by the fall sampling period to ~5,000 per m^2 (**Figure 3**). Overall, macroinvertebrate densities increased significantly in 2018 (**Figure 3**) largely due to increases in micro-caddisflies in increasing weed beds and algae in the riffle sampled.

Photo 2. Extensive weed beds sampled at Hardy Bridge during the summer and fall 2016 sampling period.

3.4 Missouri River near Cascade (MO_Cascade)

The macroinvertebrate communities collected at the Missouri River FAS site near Cascade were the most diverse (averaging 38.5 total taxa) and also reported one of the highest average EPT taxa richness (avg. EPT taxa per sample = 14.5 species) (**Figure 2b**). Cumulative total EPT for all seasons across the years was the highest reported at 28 species (**Table 2, Figure 4**). Macroinvertebrate densities increased significantly in 2018 (**Figure 3**) largely due to increases in algae in the riffle sampled (**cover photo**). The benthic community tolerance values (HBI) indicates significant organic pollution occurring at this site, but high HBI scores can also be indicative of high sediment in the substrate. Several mayfly taxa occurring here were specific to only here or at the York's Island site above Canyon Ferry Lake, including, *Ecdyonurus simpliciodes*, *Choroterpes albiannulata*, and a *Pseudocloeon sp.* (**Appendix B**). Low densities (avg. 13 per m^2) of the New Zealand mudsnail (*Potamopyrgus antipodarum*) were collected here during the 2016 samples which is a slight increase from 2015. During 2017 and 2018, NZMS have increased their populations to an annual average of 45 per m^2 (Figure 7).

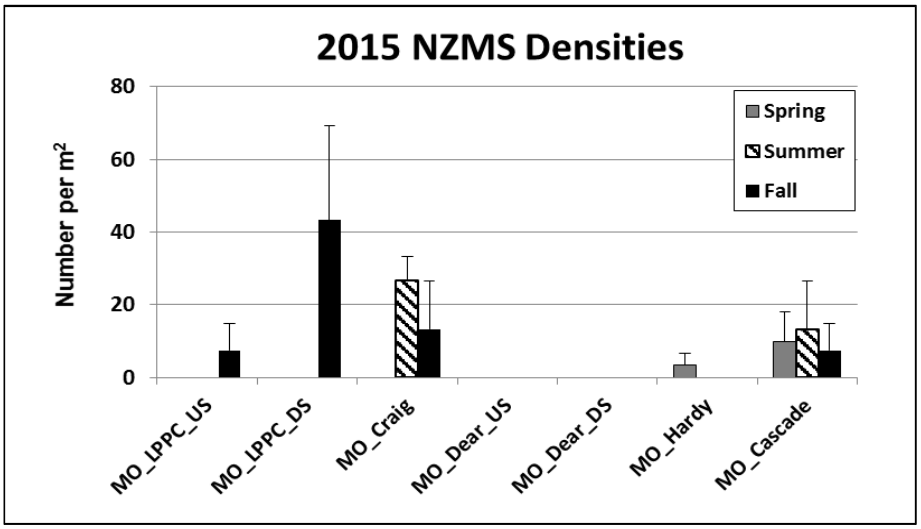
3.5 Missouri River Focal Invasive Species

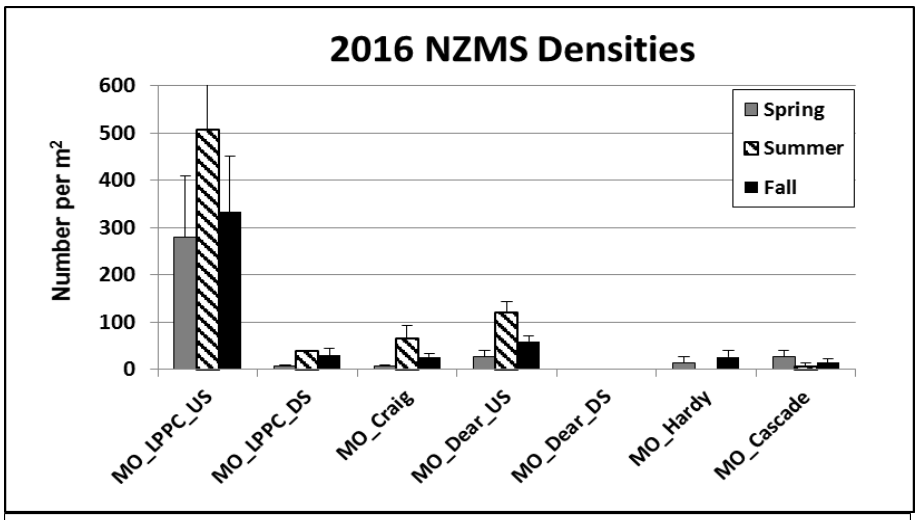
New Zealand mudsnails (*Potamopyrgus antipodarum*) (NZMS) were a perceived significant invasive species threat to the Missouri River in the early 2000's, but have been collected at very low densities at the PPL Holter Dam long-term monitoring site since 2012 (McGuire 2016). During our 2015 sampling, we reported low densities of NZMS at 5 of the 7 sites with the highest density of ~40 ind. per $meter^2$ reported at the Missouri River downstream of Little Prickly Pear Creek (MO_LPPC_DS) (**Figure 6**). NZMS occurrence at two of these sites was only reported in the fall sample, while at 2 sites, Craig and Cascade, NZMS were reported during multiple seasons (**Figure 6**).

During the 2016 sampling period, we collected NZMS at 6 of the 7 monitoring sites with the highest average density of ~373 ind. per m^2 at the Missouri River upstream of Little Prickly Pear Creek (**Figure 6**). We estimated annual NZMS densities at this site to be 7.5 ind. per m^2 in 2015. NZMS occurrence at all six of these sites was reported during multiple seasons (**Figure 6**). This significant increase in NZMS site occupancy and seasonal densities observed across most sites may be directly correlated to low flows (**Figure 1b**). This can especially be observed at the Missouri River upstream of Little Prickly Creek (MO_LPPC_US) (**Figure 7**) where annual NZMS numbers have increased, as overall densities of macroinvertebrates exploded (**Figure 2a**).

During the 2018 sampling period, we collected NZMS at 5 of the 7 monitoring sites with the highest average density of ~290 ind. per m^2 at the Missouri River upstream of Little Prickly Pear Creek (**Figure 6**). The Missouri River at Craig saw large increases in densities between fall 2016 and spring 2018, but these decreased by the summer. Large NZMS density declines were observed between pre-run off and the summer sampling periods in 2018 at both the Missouri River sites at LLP Creek and at Craig (Figure 5) likely due to the higher spring run-off. This can be largely explained by the high flows of June 2018 (~11,600 cfs) which likely displaced NZMS out of the substrate. It appears that the population of NZMS in the reach upstream from the Dearborn River observed in 2016 has decreased to undetectable levels in 2018, since we didn't report this species in the summer or fall samples (**Figure 6**).

Figure 6. NZMS seasonal benthic densities in 2015 (top), 2016 (middle) and 2017 (bottom) from the Wolf Creek to Cascade monitoring section. Note y-axis scale differences.





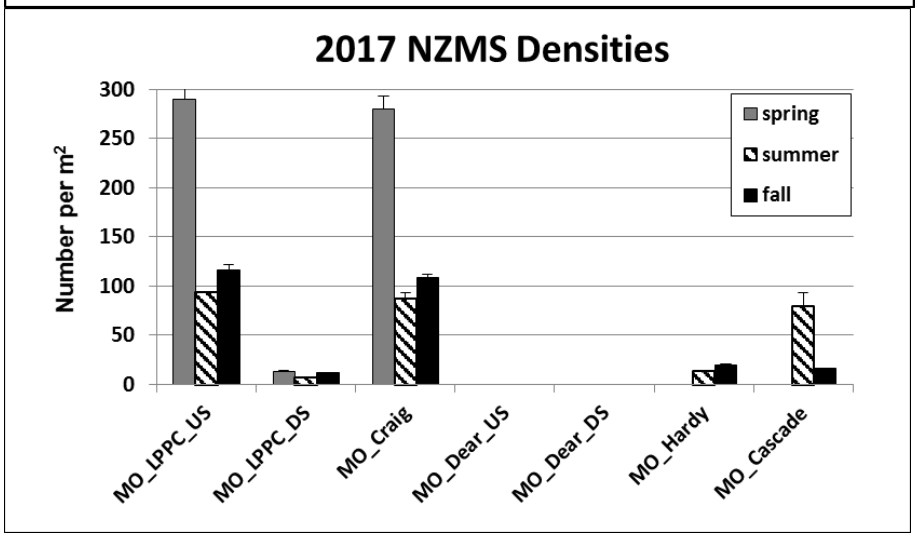
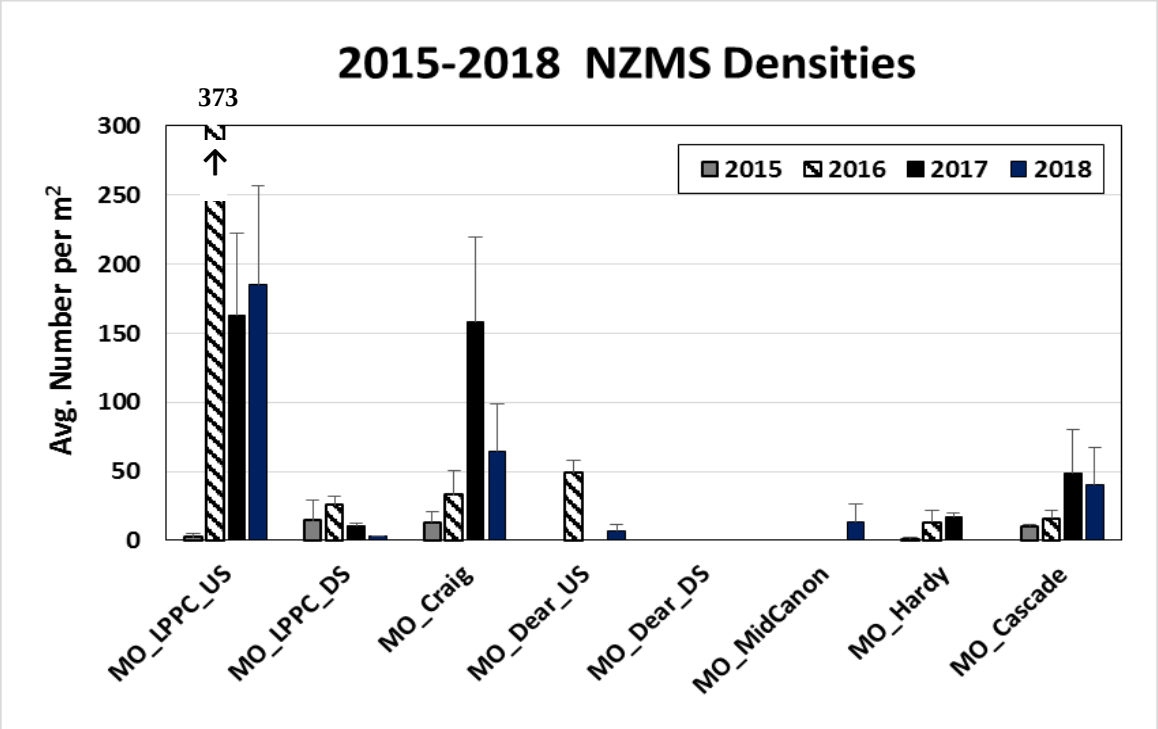


Figure 7. NZMS benthic annual average densities between 2015 and 2018 from the Wolf Creek to Cascade monitoring section with adjusted y-axis scale.



We do report a potential new species of a non-native Planorbidae snail, *Menetus dilatatus*, from the Missouri River U/S of LPPC and at the Craig sites reported in 2016, 2017 and 2018, respectively. According to the NatureServe Explorer Species website, this snail is considered native in the eastern states, but there have been records reported in California, presumably introduced as well (NatureServe 2017). It has never been reported at the Holter NWE (PPL) long-term site until 2016, and was not observed in the 2005 MDEQ samples.

4.0 Conclusions

This 2018 dataset has added another year to the most comprehensive study evaluating the macroinvertebrate communities in the Missouri River from Wolf Creek to Cascade, and provides a significant baseline dataset for future monitoring efforts. Very important spatial and temporal information concerning the macroinvertebrate communities has been generated, including peaks and troughs of benthic insect densities and diversity across multiple sites, and the important role tributary streams have on the Missouri River insect communities.

Record high spring flows (~20,000 cfs peak discharge at the Missouri River near Holter Dam) have played a particularly important role in 2018 by flushing silts from gravels, reshaping riffles and reducing invertebrate densities at many of the main stem Missouri River sites; thus, the relative composition of many benthic macroinvertebrate assemblages have been restructured with higher caddisfly and mayfly densities observed during the summer sampling period. But, as in previous years, increased % EPT (Caddisflies and Mayflies) in 2018 summer samples has yielded to % non-insect dominance in the fall samples.

Tolerance scores of the benthic communities using the HBI indicate significant organic enrichment across the sites, especially at sites closer to Wolf Creek Bridge and downstream at Cascade. Increased benthic coverage of rooted aquatic vegetation through the summer and fall remains an issue despite the flushing flows and favors increases of non-insect taxa, such as sowbugs (*Caecidotea*), scuds (*Gammarus and Hyalella)*, aquatic earthworms (Lumbricidae, Tubificidae) and pouch snails (*Physella acuta*). Aquatic vegetation growth across clean gravel riffles can dampen the recruitment ability of caddisflies and mayflies, hence lower densities are reported across the fall seasons across all years.

1. UMOWA's macroinvertebrate study has allowed us to begin to document patterns of changing aquatic communities and set the stage for future hypothesis testing. From analyzing the past 4 years of data, it seems pretty conclusive, that on an annual basis, caddisflies have significantly declined at the Missouri River reach from Little Prickly Pear Creek to the Dearborn River, but may be on an upward trend in 2019.

2. The sites closest to Holter Dam (MO_LPPC_US and MO_CRAIG) showed the most significant benthic response to the 2018 flows at ~20,000 cfs; reductions in both the macroinvertebrate and NZMS densities. Downstream sites' algae and aquatic plant beds showed some appreciable changes due to the 2018 flows (Appendix A, Photos 15 &17).

3. The Missouri River downstream from the Dearborn River demonstrated the largest improvements in biointegrity of the macroinvertebrate community with substantial increases in the number of EPT taxa and the % EPT taxa in the samples. Macroinvertebrate communities with the highest total taxa richness, EPT richness and % EPT were reported at sites least affected by the dam, particularly the Missouri River at Hardy Bridge and at Cascade site, 28 and 37 miles away from Holter dam. These sites begin to take on the more natural character of the river and acquire the original compliment of macroinvertebrates. Boulder/cobble dominated substrate sections of the river, especially downstream of the Dearborn River provide refuge for juvenile salmonids, mottled sculpin and moderate densities of the northern crayfish, *Orconectes virilis*.

4. New Zealand mudsnails have persisted in low densities at multiple sites in the Missouri River from Wolf Creek to Cascade and had begun to increase their populations upstream upstream of Little Prickly Pear Creek (avg. 373 per m^2), but higher flows of 2017 and 2018 seems to have dampened the increase.

5. We postulate that NZMS population increases, overall non-insect macroinvertebrate density increases, caddisfly decreases and the expansion of rooted weed-beds in the Wolf Creek to Craig section is directly correlated with lower spring flushing flows from Holter Dam. Initial results of the high flushing flows in 2018 showed a decrease in rooted vegetation at both upper sites, lowered NZMS populations at Craig and continued maintenance of lower NZMS populations at the Little Prickly Pear Site.

6. We believe that natural flows of >15,000 cfs seen during this last run-off period may have been extremely helpful in reversing some of the negative effects documented to be occurring on the benthic communities since the last flow of this magnitude in 2011. Due to compiling four years of baseline data (3 of which were below flushing flow levels), we are in a superb position to further evaluate macroinvertebrate responses to this “true” flushing flow event.

5.0 Literature Cited

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Appendix A. Site Photographs

Photo 1. Missouri River at Little Prickly Pear Creek Site U/S (MO_LPPC_US) summer 2016.

Photo 2. Missouri River U/S of Craig looking upstream pre-runoff spring 2017.

Photo 3. Missouri River at MO_Craig looking upstream in summer 2018.

Photo 4. Missouri River MO_LPPC_US Fall 2018 looking upstream

Photo 5. Missouri River non-FFS substrate upstream from Craig (MO_Craig) July 2017.

Photo 6. . Missouri River upstream from Craig (MO_Craig) summer 2016

Photo 7. Missouri River shoreline upstream of Craig (MO_Craig) summer 2016.

Photo 8. Missouri River shoreline upstream of Craig (MO_Craig) summer 2017.

Photo 9. Missouri River upstream of the Dearborn River. (MO_DEAR_US) June 2015.

Photo 10. Missouri River upstream of the Dearborn River. (MO_DEAR_US) May 2016.

Photo 11. Missouri River upstream of the Dearborn River (MO_DEAR_US) July 20, 2018.

Photo 12. Missouri River upstream of the Dearborn River (MO_DEAR_DS) July 17, 2017.

Photo 13. Missouri River downstream of the Hardy Bridge (MO_HARDY) summer 2016.

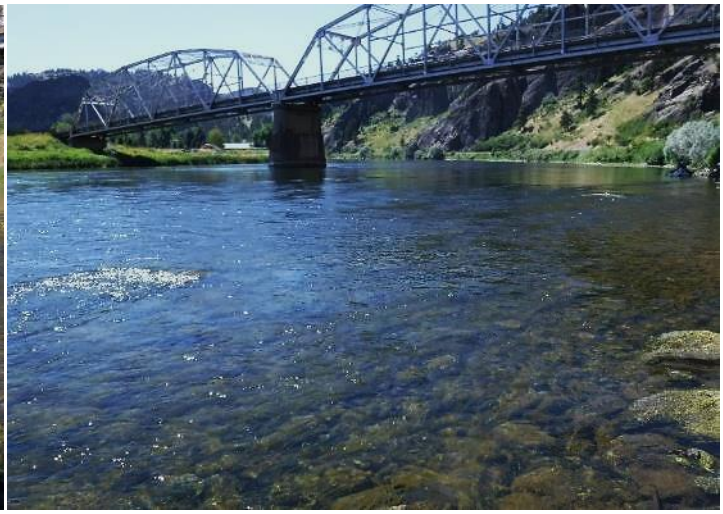

Photo 14. Missouri River downstream of the Hardy Bridge (MO_HARDY) summer 2017.

Photo 15. Missouri River looking upstream to the Hardy Bridge, summer 2018.

Photo 16. Missouri River looking downstream of the Hardy Bridge site, summer 2017.

Photo 17. Missouri River looking upstream of the Cascade FAS site (MO_Cascade), summer 2018.

Photo 18. Missouri River looking upstream of the Cascade FAS site (MO_Cascade) summer 2017.

Appendix B. Macroinvertebrate seasonal summary metric tables.

Appendix B. Macroinvertebrate seasonal metrics Summer 2018 at all sites. Standard Error are SE. Significant differences (p<0.05).

Site	Metric	Hess #1	Hess #2	Hess #3	Average	Standard Error
MO_LPPC_US	#/m2	16,303	15,868	31,336	**21,169**	5085.1
MO_LPPC_US	# taxa	38	36	33	35.7	1.5
MO_LPPC_US	# EPT	9	11	5	8.3	1.8
MO_LPPC_US	% EPT	64%	72%	63%	66%	3%
MO_LPPC_US	% Non-Insect	15%	19%	21%	18%	2%
MO_LPPC_US	% Chironomidae	9%	5%	15%	10%	3%
MO_LPPC_US	%Mayfly	31%	42%	22%	32%	6%
MO_LPPC_US	%Caddisfly	33%	29%	41%	35%	3%
MO_LPPC_DS	#/m2	5,600	6,340	6,400	6,113	257.3
MO_LPPC_DS	# taxa	34	36	39	36.3	1.5
MO_LPPC_DS	# EPT	13	11	13	12.3	0.7
MO_LPPC_DS	% EPT	74%	62%	82%	73%	6%
MO_LPPC_DS	% Non-Insect	5%	1%	4%	3%	1%
MO_LPPC_DS	% Chironomidae	16%	27%	11%	21%	6%
MO_LPPC_DS	%Mayfly	20%	13%	25%	20%	4%
MO_LPPC_DS	%Caddisfly	54%	49%	56%	53%	2%
MO_Craig	#/m2	13,024	12,738	10,448	12,070	815.1
MO_Craig	# taxa	32.0	33.0	37.0	34.0	1.5
MO_Craig	#EPT taxa	9.0	10.0	11.0	10.0	0.6
MO_Craig	% EPT	70%	75%	68%	71%	2%
MO_Craig	% Non-Insect Taxa	10%	9%	10%	10%	0%
MO_Craig	% Chironomidae	**16%**	6%	18%	**13%**	4%
MO_Craig	%Mayfly	55%	49%	44%	49%	3%
MO_Craig	%Caddisfly	15%	26%	24%	22%	3%
MO_Dear_US	#/m2	10,890	22,120	48,150	27,053	11035.3
MO_Dear_US	# taxa	25	28	24	25.7	1.2
MO_Dear_US	#EPT taxa	6	7	6	6.3	0.3
MO_Dear_US	% EPT	61%	56%	79%	66%	7%
MO_Dear_US	% Non-Insect Taxa	5%	9%	4%	6%	1%
MO_Dear_US	% Chironomidae	31%	29%	14%	25%	5%
MO_Dear_US	%Mayfly	59%	46%	66%	57%	6%
MO_Dear_US	%Caddisfly	2%	10%	13%	8%	3%
MO_Dear_DS	#/m2	2,580	1,040	1,620	1,760	447.4
MO_Dear_DS	# taxa	32	22	25	26.7	2.9
MO_Dear_DS	EPT	17	10	10	12.3	2.3
MO_Dear_DS	% EPT	79%	**76%**	**81%**	**78%**	1%
MO_Dear_DS	% Non-Insect Taxa	8%	4%	7%	7%	2%
MO_Dear_DS	% Chironomidae	3%	6%	4%	21%	6%
MO_Dear_DS	%Mayfly	62%	63%	80%	68%	5%
MO_Dear_DS	%Caddisfly	17%	13%	1%	10%	5%
MO_Hardy	#/m2	10,860	2,030	11,420	8,103	3041.0
MO_Hardy	# taxa	**32**	24	26	27.3	2.4
MO_Hardy	#EPT taxa	**18**	12	10	13.3	2.4
MO_Hardy	% EPT	91%	73%	92%	85%	6%
MO_Hardy	% Non-Insect Taxa	2%	16%	2%	7%	5%
MO_Hardy	% Chironomidae	3%	6%	4%	4%	1%
MO_Hardy	%Mayfly	66%	50%	43%	53%	7%
MO_Hardy	%Caddisfly	25%	23%	49%	32%	8%
MO_Cascade	#/m2	6,072	11,600	9,253	8,975	1601.8
MO_Cascade	# taxa	40	**37**	**36**	**37.7**	1.2
MO_Cascade	#EPT taxa	17	**14**	15	15.3	0.9
MO_Cascade	% EPT	70%	79%	83%	77%	4%
MO_Cascade	% Non-Insect Taxa	35%	42%	26%	34%	4%
MO_Cascade	% Chironomidae	1%	1%	1%	14%	3%
MO_Cascade	%Mayfly	41%	30%	44%	38%	4%
MO_Cascade	%Caddisfly	28%	49%	40%	39%	6%

Appendix B. (cont.) Macroinvertebrate seasonal metrics Fall 2018 at all sites. Standard Error are SE. *= Significant differences (p<0.05).

Site	Metric	Hess #1	Hess #2	Hess #3	Average	Standard Error
MO_LPPC_US	#/m2	22,600	**16,000**	**15,394**	**17,998**	2307.7
MO_LPPC_US	# taxa	35	39	40	38.0	1.5
MO_LPPC_US	# EPT	10	13	12	11.7	0.9
MO_LPPC_US	% EPT	31%	30%	31%	31%	1%
MO_LPPC_US	% Non-Insect	33%	38%	27%	33%	3%
MO_LPPC_US	% Chironomidae	5%	8%	8%	7%	1%
MO_LPPC_US	%Mayfly	8%	8%	7%	8%	0%
MO_LPPC_US	%Caddisfly	23%	22%	24%	23%	1%
MO_LPPC_DS	#/m2	2,580	2,380	2,340	1,760	447.4
MO_LPPC_DS	# taxa	32	30	36	26.7	2.9
MO_LPPC_DS	# EPT	10	10	13	11.0	1.0
MO_LPPC_DS	% EPT	79%	83%	74%	78%	1%
MO_LPPC_DS	% Non-Insect	8%	4%	13%	7%	2%
MO_LPPC_DS	% Chironomidae	3%	4%	5%	21%	6%
MO_LPPC_DS	%Mayfly	62%	47%	44%	68%	5%
MO_LPPC_DS	%Caddisfly	17%	36%	30%	10%	5%
MO_Craig	#/m2	13,714	13,664	13,947	13,775	87.1
MO_Craig	# taxa	23.0	27.0	27.0	25.7	1.3
MO_Craig	#EPT taxa	6.0	8.0	9.0	7.7	0.9
MO_Craig	% EPT	45%	14%	50%	36%	11%
MO_Craig	% Non-Insect Tax	41%	81%	27%	49%	16%
MO_Craig	% Chironomidae	9%	3%	9%	7%	2%
MO_Craig	%Mayfly	5%	0%	2%	2%	1%
MO_Craig	%Caddisfly	40%	13%	48%	34%	10%
MO_Dear_US	#/m2	11,040	15,600	13,120	13,253	1318.0
MO_Dear_US	# taxa	30	31	33	31.3	0.9
MO_Dear_US	#EPT taxa	12	13	10	11.7	0.9
MO_Dear_US	% EPT	18%	29%	13%	20%	5%
MO_Dear_US	% Non-Insect Tax	23%	40%	24%	29%	5%
MO_Dear_US	% Chironomidae	56%	27%	59%	48%	10%
MO_Dear_US	%Mayfly	12%	20%	9%	14%	3%
MO_Dear_US	%Caddisfly	6%	9%	4%	6%	2%
MO_Dear_DS	#/m2	4120	4120	4505	4248.3	128.3
MO_Dear_DS	# taxa	23	28	32	27.7	2.6
MO_Dear_DS	EPT	10	12	14	**12.0**	1.2
MO_Dear_DS	% EPT	58%	**59%**	**60%**	**59%**	0%
MO_Dear_DS	% Non-Insect Tax	5%	3%	4%	4%	1%
MO_Dear_DS	% Chironomidae	3%	10%	7%	7%	2%
MO_Dear_DS	%Mayfly	2%	7%	5%	5%	1%
MO_Dear_DS	%Caddisfly	**56%**	52%	55%	54%	1%
MO_Hardy	#/m2	9,741	14,949	10,970	11,887	1571.5
MO_Hardy	# taxa	27	34	**33**	**31.3**	2.2
MO_Hardy	#EPT taxa	10	10	12	10.7	0.7
MO_Hardy	% EPT	73%	73%	79%	75%	2%
MO_Hardy	% Non-Insect Tax	4%	4%	6%	5%	1%
MO_Hardy	% Chironomidae	19%	18%	11%	18%	2%
MO_Hardy	%Mayfly	65%	55%	58%	59%	3%
MO_Hardy	%Caddisfly	7%	19%	21%	16%	4%
MO_Cascade	#/m2	17,240	17,560	19,451	18,084	689.9
MO_Cascade	# taxa	45	46	46	**45.7**	0.3
MO_Cascade	#EPT taxa	17	14	15	15.3	0.9
MO_Cascade	% EPT	30%	24%	24%	26%	2%
MO_Cascade	% Non-Insect Tax	34%	33%	35%	34%	1%
MO_Cascade	% Chironomidae	29%	31%	30%	30%	1%
MO_Cascade	%Mayfly	14%	11%	7%	11%	2%
MO_Cascade	%Caddisfly	16%	13%	17%	15%	1%

Appendix C. Macroinvertebate taxa list and abundance.

APPENDIX C. Macroinvertebrate 2018 summer taxa lists and raw data across all sites.

MO_LPPC_US01	Summer 2018	Subsample	0.33	0.38	0.21		
Order	OTUname2	FinalID	Hess 1	Hess 2	Hess 3	Avg.	SE
Coleoptera	Optioservus	Optioservus quadrimaculatus	9	0	0	3.0	3.03
Coleoptera	Zaitzevia	Zaitzevia	0	0	0	0.0	0.00
Coleoptera	Haliplus	Haliplus	6	0	0	2.0	2.02
Diptera	Ceratopogonidae	Probezzia	0	0	0	0.0	0.00
Diptera	Diamesinae	Potthastia	6	0	5	0.0	1.84
Diptera	Chironominae	Microtendipes	30	16	205	83.7	60.68
Diptera	Chironominae	Cryptochironomus	6	5	10	7.0	1.29
Diptera	Chironominae	Dicrotendipes	18	27	71	38.8	16.52
Diptera	Chironominae	Phaenopsectra	6	0	0	2.0	2.02
Diptera	Chironominae	Polypedilum	3	3	0	1.9	0.96
Diptera	Chironominae	Pseudochironomus	3	0	0	1.0	1.01
Diptera	Diamesinae	Diamesa	0	0	0	0.0	0.00
Diptera	Orthocladiinae	Orthocladius	0	11	14	8.3	4.29
Diptera	Orthocladiinae	Cricotopus	58	11	124	64.0	32.82
Diptera	Orthocladiinae	Eukiefferella	3	0	5	2.6	1.39
Diptera	Orthocladiinae	Tvetenia	6	3	10	6.1	1.98
Diptera	Orthocladiinae	Parametriocnemus	12	8	14	11.5	1.86
Diptera	Orthocladiinae	Synorthocladius	0	0	5	1.6	1.59
Diptera	Orthocladiinae	Parakieffierella	3	3	5	3.5	0.65
Diptera	Simuliidae	Simulium	27	8	5	13.3	7.03
Diptera	Tabanidae	Chrysops	0	0	0	0.0	0.00
Diptera	Tanypodinae	Thienemannimyia gr.	3	0	0	1.0	1.01
Diptera	Tipulidae	Tipula	0	0	0	0.0	0.00
Diptera	Tipulidae	Limnophila	0	0	14	4.8	4.81
Ephemeroptera	Baetis	Baetis tricaudatus	182	272	38	164.0	68.11
Ephemeroptera	Ephemerellidae	Attenella margarita	0	3	0	0.9	0.89
Ephemeroptera	Ephemerella	Ephemerella excrucians	0	3	0	0.9	0.89
Ephemeroptera	Rhithrogena	Rhithrogena	3	0	0	1.0	1.01
Ephemeroptera	Tricorythodes	Tricorythodes explicatus	327	395	643	454.9	95.96
Non-Insect taxa	Hirudina	Erpobdella punctata	0	0	0	0.0	0.00
Non-Insect taxa	Glossiphoniidae	Glossiphonia complanata	0	0	0	0.0	0.00
Non-Insect taxa	Orconectes virilis	Orconectes virilis	0	0	5	1.6	1.59
Non-Insect taxa	Caecidotea	Caecidotea	33	75	67	58.2	12.66
Non-Insect taxa	Hyalella	Hyalella	6	3	5	4.5	0.99
Non-Insect taxa	Gammarus	Gammarus	3	16	10	9.5	3.74
Non-Insect taxa	Acarina	Acarina (Sperchon)	24	13	52	30.0	11.63
Non-Insect taxa	Oligochaeta	Lumbriculidae	0	8	0	2.7	2.67
Non-Insect taxa	Oligochaeta	Lumbricina	3	5	14	7.5	3.43
Non-Insect taxa	Physa_Physella	Physella acuta	30	37	129	65.4	31.65
Non-Insect taxa	Stagnicola	Stagnicola	12	8	0	6.7	3.56
Non-Insect taxa	Pisidiidae	Pisidium	9	11	57	25.6	15.76
Non-Insect taxa	Potamopyrgus	Potamopyrgus antipodarum	9	5	29	14.3	7.20
Non-Insect taxa	Gyraulus	Gyraulus	0	0	24	7.9	7.94
Non-Insect taxa	Menetus	Menetus dilatatus	6	3	62	23.5	19.21
Non-Insect taxa	Valvata	Valvata	0	11	10	6.7	3.38
Non-Insect taxa	Oligochaeta	Tubificidae	70	51	162	94.1	34.35
Non-Insect taxa	Turbellaria	Turbellaria	36	56	19	37.1	10.67
Non-Insect taxa	Nematoda	Nematoda	136	53	33	74.3	31.54
Lepidoptera	Petrophila	Petrophila	0	0	0	0.0	0.00
Plecoptera	Perlodidae	Isoperla	0	0	0	0.0	0.00
Trichoptera	Ceraclea	Ceraclea	0	0	0	0.0	0.00
Trichoptera	Brachycentrus	Brachycentrus occidentalis	6	8	0	4.7	2.41
Trichoptera	Cheumatopsyche	Cheumatopsyche	45	43	19	35.7	8.38
Trichoptera	Glossosomatidae	Culoptila	0	0	0	0.0	0.00
Trichoptera	Limnephilidae	Dicosmoecus gilvipes	0	3	0	0.9	0.89
Trichoptera	Hydropsyche_Cer	Hydropsyche morosa gr.	12	11	0	7.6	3.82
Trichoptera	Hydropsyche_Cer	Hydropsyche occidentalis	3	3	0	1.9	0.96
Trichoptera	Helicopsyche	Helicopsyche borealis	0	0	0	0.0	0.00
Trichoptera	Hydroptila	Hydroptila	470	397	1257	708.1	275.34
Trichoptera	Lepidostoma	Lepidostoma	0	0	0	0.0	0.00
Trichoptera	Uneonidae	Neophylax splendans	0	0	0	0.0	0.00
Trichoptera	Oecetis	Oecetis avara	3	3	14	6.7	3.81
			1630.303	1587	3134	2116.9	508.51

APPENDIX C. Macroinvertebrate 2018 summer taxa lists and raw data across all sites.

MO_LPPC_DS01	Summer 2018	MO_LPPC_DS	1	1	1		
Order	**OTUname2**	**FinalID**	**Hess 1**	**Hess 2**	**Hess 3**	**Average**	**SE**
Coleoptera	Optioservus	Optioservus quadrimaculatus	2	2	5	3.0	1.00
Coleoptera	Zaitzevia	Zaitzevia	2	3	2	2.3	0.33
Diptera	Ceratopogonidae	Probezzia	0	1	0	0.3	0.33
Diptera	Empididae	Hemerodromia	0	0	0	0.0	0.00
Diptera	Tipulidae	Hexatoma	1	3	2	2.0	0.58
Diptera	Simulium	Simulium	22	44	10	25.3	9.96
Diptera	Tipulidae	Tipula	0	1	2	1.0	0.58
Diptera	Muscidae	Limnophora	1	1	0	0.7	0.33
Diptera	Chironominae	Microtendipes	0	1	1	0.7	0.33
Diptera	Chironominae	Rheotanytarsus	3	1	0	1.3	0.88
Diptera	Chironominae	Tanytarsus	0	0	0	0.0	0.00
Diptera	Chironominae	Polypedilum	4	3	2	3.0	0.58
Diptera	Chironominae	Glyptotendipes	6	2	11	6.3	2.60
Diptera	Diamesinae	Diamesa	0	1	0	0.3	0.33
Diptera	Orthocladiinae	Tvetenia	0	3	1	1.3	0.88
Diptera	Orthocladiinae	Cricotopus	75	99	50	74.7	14.15
Diptera	Orthocladiinae	Eukiefferella	2	34	1	12.3	10.84
Diptera	Orthocladiinae	Parakiefferella	0	2	1	1.0	0.58
Diptera	Orthocladiinae	Parametriocnemus	1	17	0	6.0	5.51
Diptera	Orthocladiinae	Cardiocladius	0	10	2	4.0	3.06
Diptera	Orthocladiinae	Synorthocladius	1	1	2	1.3	0.33
Diptera	Tanypodinae	Thienemannimyia gr.	0	0	0	0.0	0.00
Ephemeroptera	Baetidae	Baetis tricaudatus	39	50	47	45.3	3.28
Ephemeroptera	Ephemerellidae	Ephemerella excrucians	5	4	6	5.0	0.58
Ephemeroptera	Ephemerellidae	Attenella margarita	1	0	2	1.0	0.58
Ephemeroptera	Ephemerellidae	Drunella grandis	1	0	1	0.7	0.33
Ephemeroptera	Epeorus albertae	Epeorus albertae	0	0	0	0.0	0.00
Ephemeroptera	Ecdynonurus	Ecdynonurus	0	0	0	0.0	0.00
Ephemeroptera	Nixe	Nixe	0	0	0	0.0	0.00
Ephemeroptera	Rhithrogena	Rhithrogena	0	0	0	0.0	0.00
Ephemeroptera	Paraleptophlebia	Paraleptophlebia bicornuta	0	0	0	0.0	0.00
Ephemeroptera	Tricorythodes	Tricorythodes explicatus	67	30	107	68.0	22.23
Non-Insect taxa	Acarina	Acarina (Hygrobates)	0	0	1	0.3	0.33
Non-Insect taxa	Oligochaeta	Lumbriculidae	5	1	1	2.3	1.33
Non-Insect taxa	Oligochaeta	Lumbricidae	0	0	1	0.3	0.33
Non-Insect taxa	Physa_Physella	Physella acuta	4	0	3	2.3	1.20
Non-Insect taxa	Pisidiidae	Pisidium	0	0	0	0.0	0.00
Non-Insect taxa	Menetus	Menetus dilatatus	1	1	1	1.0	0.00
Non-Insect taxa	Gyraulus	Gyraulus	1	0	1	0.7	0.33
Non-Insect taxa	Potamopyrgus	Potamopyrgus antipodarum	0	0	1	0.3	0.33
Non-Insect taxa	Valvata	Valvata	1	0	2	1.0	0.58
Non-Insect taxa	Gammarus	Hyalella	2	2	1	1.7	0.33
Non-Insect taxa	Caecidotea	Caecidotea	4	3	6	4.3	0.88
Non-Insect taxa	Oligochaeta	Tubificidae	5	1	2	2.7	1.20
Non-Insect taxa	Turbellaria	Turbellaria	4	1	5	3.3	1.20
Plecoptera	Skwala	Skwala	1	0	1	0.7	0.33
Plecoptera	Perlidae	Claassenia sabulosa	0	1.0	0	0.3	0.33
Plecoptera	Pteronarcys	Pteronarcys californica	0	0	0	0.0	0.00
Trichoptera	Brachycentrus	Brachycentrus occidentalis	3	4	5	4.0	0.58
Trichoptera	Cheumatopsyche	Cheumatopsyche	8	11	5	8.0	1.73
Trichoptera	Hydropsyche_Ceratops	Hydropsyche occidentalis	2	2	1	1.7	0.33
Trichoptera	Hydropsyche_Ceratops	Hydropsyche morosa gr.	0	2	0	0.7	0.67
Trichoptera	Hydroptila	Hydroptila	262	216	290	256.0	21.57
Trichoptera	Glossosomatidae	Glossosoma	19	75	55	49.7	16.38
Trichoptera	Lepidostoma	Lepidostoma	3	0	1	1.3	0.88
Trichoptera	Oecetis	Oecetis avara	2	1	2	1.7	0.33
Trichoptera	Limnephilidae	Limnephilus	0	0	0	0.0	0.00
		Totals	**560**	**634**	**640**	**611.3**	**25.73**

APPENDIX C. Macroinvertebrate 2018 summer taxa lists and raw data across all sites.

MO_Craig_US01	Summer 2018	Subsample	0.42	0.42	0.58		
Order	**OTUname2**	**Final ID**	**Hess 1**	**Hess 2**	**Hess 3**	**Avg.**	**SE**
Coleoptera	Optioservus	Optioservus quadrimaculatus	14	29	28	23.5	4.61
Diptera	Orthocladiinae	Cricotopus trifascia	90	29	107	75.3	23.85
Diptera	Orthocladiinae	Tvetenia	2	2	14	6.2	3.80
Diptera	Orthocladiinae	Eukiefferella	0	0	2	0.6	0.57
Diptera	Orthocladiinae	Parametriocnemus	4.8	5	3	4.3	0.44
Diptera	Orthocladiinae	Synorthocladius	0	0	5	1.7	1.72
Diptera	Orthocladiinae	Corynoneura	0	0	2	0.6	0.57
Diptera	Orthocladiinae	Parakieffierella	0	0	2	0.6	0.57
Diptera	Chironominae	Dicrotendipes	0	5	0	1.6	1.59
Diptera	Chironominae	Microtendipes	10	14	10	11.4	1.47
Diptera	Chironominae	Pseudochironomus	2	0	0	0.8	0.79
Diptera	Chironominae	Tanytarsus	95	19	34	49.6	23.26
Diptera	Tanypodinae	Thienemannimyia gr.	2	0	5	2.5	1.49
Diptera	Simulium	Simulium	24	95	10	43.1	26.34
Ephemeroptera	Acentrella	Acentrella	2	0	2	1.4	0.71
Ephemeroptera	Ephemerellidae	Attenella margarita	5	5	3	4.3	0.44
Ephemeroptera	Baetis	Baetis tricaudatus	83	119	119	107.1	11.89
Ephemeroptera	Baetis	Baetis flavistriga	12	14	9	11.6	1.64
Ephemeroptera	Ephemerella	Ephemerella excrucians	29	33	12	24.7	6.44
Ephemeroptera	Tricorythodes	Tricorythodes explicatus	590	460	322	457.5	77.39
Non-Insect taxa	Caecidotea	Caecidotea	14	19	5	12.8	4.07
Non-Insect taxa	Hirudina	Erpobdella punctata	2	0	0	0.8	0.79
Non-Insect taxa	Acarina	Acarina (Sperchon)	0	10	5	4.9	2.75
Non-Insect taxa	Hyalella	Hyalella	10	7	3	6.7	1.77
Non-Insect taxa	Gammarus	Gammarus	12	2	3	5.9	3.01
Non-Insect taxa	Oligochaeta	Lumbricina	7	2	5	4.9	1.38
Non-Insect taxa	Menetus	Menetus dilatatus	10	2	2	4.5	2.50
Non-Insect taxa	Nematoda	Nematoda	7	26	5	12.8	6.70
Non-Insect taxa	Physa_Physella	Physella acuta	17	5	5	8.9	3.90
Non-Insect taxa	Pisidiidae	Pisidium	10	21	12	14.3	3.62
Non-Insect taxa	Pisidiidae	Sphaerium	7	0	0	2.4	2.38
Non-Insect taxa	Gyraulus	Gyraulus	0	5	0	1.6	1.59
Non-Insect taxa	Fossaria	Fossaria	0	2	0	0.8	0.79
Non-Insect taxa	Valvata	Valvata	0	2	0	0.8	0.79
Non-Insect taxa	Potamopyrgus	Potamopyrgus antipodarum	0	5	2	2.2	1.39
Non-Insect taxa	Oligochaeta	Tubificidae	36	7	34	25.8	9.33
Non-Insect taxa	Oligochaeta	Lumbriculidae	0	0	0	0.0	0.00
Non-Insect taxa	Turbellaria	Turbellaria	5	0	26	10.2	7.95
Trichoptera	Cheumatopsyche	Cheumatopsyche	69	138	112	106.4	20.13
Trichoptera	Hydropsyche_Ceratops	Hydropsyche morosa gr.	5	10	3	5.9	1.85
Trichoptera	Hydropsyche_Ceratops	Hydropsyche occidentalis	45	133	45	74.5	29.43
Trichoptera	Hydroptila	Hydroptila	79	21	74	58.0	18.35
Trichoptera	Helicopsyche	Helicopsyche borealis	0	0	2	0.6	0.57
Trichoptera	Leptoceridae	Ceraclea	0	5	2	2.2	1.39
Trichoptera	Leptoceridae	Nectopsyche	0	0	0	0.0	0.00
Trichoptera	Leptoceridae	Oecetis avara	2	21	9	10.8	5.61
		Totals per sample	**1302**	**1274**	**1045**	**1207**	**82**

APPENDIX C. Macroinvertebrate 2018 summer taxa lists and raw data across all sites.

MO_Dearborn_DS	Summer 2018							
Order	**OTUname2**	**FinalID**	**Hess 1**	**Hess 2**	**Hess 3**	**Average**	**SE**	**TolVal**
Coleoptera	Optioservus	Optioservus quadrimaculatus	7	1	3	3.7	1.76	5
Coleoptera	Zaitzevia	Zaitzevia	2	3	1	2.0	0.58	5
Diptera	Tipulidae	Hexatoma	1	3	0	1.3	0.88	5
Diptera	Cryptolabis	Cryptolabis	0	3	1	1.3	0.88	5
Diptera	Simulium	Simulium	7	2	4	4.3	1.45	5
Diptera	Chironominae	Rheotanytarsus	3	1	0	1.3	0.88	6
Diptera	Orthocladiinae	Cricotopus	1	1	1	1.0	0.00	7
Diptera	Orthocladiinae	Eukiefferella	1	1	1	1.0	0.00	7
Diptera	Orthocladiinae	Parametriocnemus	1	0	1	0.7	0.33	7
Diptera	Orthocladiinae	Cardiocladius	0	2	1	1.0	0.58	5
Diptera	Orthocladiinae	Synorthocladius	1	1	2	1.3	0.33	7
Diptera	Tanypodinae	Thienemannimyia gr.	0	0	0	0.0	0.00	7
Ephemeroptera	Acentrella	Acentrella	10	3	4	5.7	2.19	4
Ephemeroptera	Baetidae	Baetis tricaudatus	69	22	14	35.0	17.16	5
Ephemeroptera	Centroptilum	Centroptilum bifurcatum	3	0	3	2.0	1.00	5
Ephemeroptera	Baetidae	Baetis flavistriga	3	0	0	1.0	1.00	5
Ephemeroptera	Baetidae	Diphetor hageni	5	0	0	1.7	1.67	5
Ephemeroptera	Ephemerella	Ephemerella excrucians	46	38	73	52.3	10.59	1
Ephemeroptera	Ephemeridae	Attenella margarita	1	1	0	0.7	0.33	3
Ephemeroptera	Epeorus albertae	Epeorus albertae	1	0	1	0.7	0.33	2
Ephemeroptera	Ecdynonurus	Ecdynonurus	5	4	9	6.0	1.53	0
Ephemeroptera	Nixe	Nixe	0	0	1	0.3	0.33	0
Ephemeroptera	Paraleptophlebia	Paraleptophlebia bicornuta	0	0	4	1.3	1.33	0
Ephemeroptera	Tricorythodes	Tricorythodes explicatus	28	1	24	17.7	8.41	4
Non-Insect taxa	Oligochaeta	Lumbriculidae	5	0	1	2.0	1.53	4
Non-Insect taxa	Oligochaeta	Lumbricidae	0	0	1	0.3	0.33	4
Non-Insect taxa	Physa_Physella	Physella acuta	4	0	2	2.0	1.15	8
Non-Insect taxa	Oligochaeta	Tubificidae	5	4	7	5.3	0.88	10
Non-Insect taxa	Turbellaria	Turbellaria	4	0	1	1.7	1.20	4
Plecoptera	Chloroperlidae	Sweltsa	0	1	1	0.7	0.33	1
Plecoptera	Skwala	Skwala	1	0	1	0.7	0.33	1
Plecoptera	Pteronarcys	Pteronarcys californica	3	4	0	2.3	1.20	1
Trichoptera	Limnephilidae	Dicosmoecus gilvipes	2	0	0	0.7	0.67	1
Trichoptera	Brachycentrus	Brachycentrus occidentalis	1	0	0	0.3	0.33	1
Trichoptera	Cheumatopsyche	Cheumatopsyche	18	6	0	8.0	5.29	5
Trichoptera	Hydropsyche_Ceratops	Hydropsyche occidentalis	7	1	0	2.7	2.19	4
Trichoptera	Hydropsyche_Ceratops	Hydropsyche morosa gr.	10	1	0	3.7	3.18	5
Trichoptera	Oecetis	Oecetis avara	1	0	0	0.3	0.33	8
		Totals	**256**	**104**	**162**	**174.0**	**44.29**	

APPENDIX C. Macroinvertebrate 2018 summer taxa lists and raw data across all sites.

MO_Dear_US01	Summer 2018	Subsample	8/12	1/2	4/12		
Order	**OTUname2**	**FinalID**	**Hess 1**	**Hess 2**	**Hess 3**	**Avg.**	**SE**
Coleoptera	Optioservus	Optioservus quadrimaculatus	5	72	18	31.5	20.62
Coleoptera	Stenelmis	Stenelmis	5	4	0	2.8	1.42
Diptera	Orthocladiinae	Cricotopus	20	104	261	128.4	70.56
Diptera	Orthocladiinae	Cardiocladius	0	0	72	24.0	24.00
Diptera	Orthocladiinae	Corynonura	0	4	0	1.3	1.33
Diptera	Diamesinae	Diamesa	0	0	0	0.0	0.00
Diptera	Chironominae	Microtendipes	38	28	27	31.1	3.59
Diptera	Chironominae	Dicrotendipes	203	400	180	260.8	69.89
Diptera	Chironominae	Glyptotendipes	65	68	72	68.4	1.96
Diptera	Chironominae	Phaenopsectra	9	12	36	19.0	8.54
Diptera	Chironominae	Cryptochironomus	5	16	18	12.8	4.21
Diptera	Chironominae	Tanytarsus	0	16	0	5.3	5.33
Diptera	Simuliidae	Simulium	2	0	0	0.8	0.75
Diptera	Ceratopogonidae	Bezzia	5	0	0	1.5	1.50
Diptera	Tipulidae	Hexatoma	0	0	9	3.0	3.00
Diptera	Tanypodinae	Thienemannimyia gr.	11	48	117	58.8	31.00
Ephemeroptera	Baetis	Baetis tricaudatus	2	8	36	15.4	10.42
Ephemeroptera	Ephemerella	Ephemerella excrucians	43	76	252	123.6	64.92
Ephemeroptera	Tricorythodes	Tricorythodes explicatus	599	932	2871	1467.2	708.49
Ephemeroptera	Ephemerella	Attenella margarita	0	0	27	9.0	9.00
Ephemeroptera	Paraleptophlebia	Choroterpes	2	0	0	0.8	0.75
Odonata	Argia	Argia	0	4	0	1.3	1.33
Non-Insect taxa	Caecidotea	Caecidotea	11	72	72	51.8	20.25
Non-Insect taxa	Gammarus	Gammarus	0	16	9	8.3	4.63
Non-Insect taxa	Hirudina	Erpobdella punctata	2	4	9	5.1	2.02
Non-Insect taxa	Hyalella	Hyalella	2	12	9	7.8	2.88
Non-Insect taxa	Oligochaeta	Lumbricina	2	0	0	0.8	0.75
Non-Insect taxa	Oligochaeta	Tubificidae	20	4	9	11.1	4.81
Non-Insect taxa	Physa_Physella	Physella acuta	2	8	9	6.4	2.10
Non-Insect taxa	Potamopyrgus	Potamopyrgus antipodarum	0	4	0	1.3	1.33
Non-Insect taxa	Turbellaria	Turbellaria	16	64	54	44.6	14.70
Non-Insect taxa	Orconectes virilis	Orconectes virilis	3	8	9	6.7	1.86
Trichoptera	Cheumatopsyche	Cheumatopsyche	5	16	54	24.8	14.96
Trichoptera	Hydroptilidae	Hydroptila	14	204	585	267.5	168.01
Trichoptera	Hydropsyche_Cerato	Hydropsyche morosa gr.	0	4	0	1.3	1.33
Trichoptera	Hydropsyche_Cerato	Hydropsyche occidentalis	0	4	0	1.3	1.33
		Totals	**1090**	**2212**	**4815**	**2705.6**	**1103.34**

APPENDIX C. Macroinvertebrate 2018 summer taxa lists and raw data across all sites.

MO_Mid-Canon	Summer 2018		1	0.5	1		
Order	OTUname2	FinalID	Hess 1	Hess 2	Hess 3	Average	SE
Coleoptera	Optioservus	Optioservus quadrimaculatus	16	14	26	18.7	3.71
Coleoptera	Zaitzevia	Zaitzevia	2	0	2	1.3	0.67
Diptera	Ceratopogonidae	Probezzia	2	2	0	1.3	0.67
Diptera	Cryptolabis	Cryptolabis	2	0	2	1.3	0.67
Diptera	Simulium	Simulium	2	12	4	6.0	3.06
Diptera	Chironominae	Microtendipes	0	4	6	3.3	1.76
Diptera	Chironominae	Rheotanytarsus	0	0	12	4.0	4.00
Diptera	Orthocladiinae	Tvetenia	0	2	8	3.3	2.40
Diptera	Orthocladiinae	Eukiefferella	0	4	4	2.7	1.33
Diptera	Orthocladiinae	Cricotopus	6	10	26	14.0	6.11
Diptera	Orthocladiinae	Cardiocladius	2	4	14	6.7	3.71
Diptera	Tanypodinae	Thienemannimyia gr.	0	0	6	2.0	2.00
Ephemeroptera	Acentrella	Acentrella	8	6	20	11.3	4.37
Ephemeroptera	Baetis	Baetis tricaudatus	98	160	136	131.3	18.05
Ephemeroptera	Centroptilum	Centroptilum bifurcatum	6	0	6	4.0	2.00
Ephemeroptera	Baetidae	Baetis flavistriga	6	0	0	2.0	2.00
Ephemeroptera	Baetidae	Diphetor hageni	10	0	0	3.3	3.33
Ephemeroptera	Baetidae	Plauditus punctiventris	0	0	0	0.0	0.00
Ephemeroptera	Ephemera simulans	Ephemera simulans	0	0	0	0.0	0.00
Ephemeroptera	Ephemerella	Ephemerella excrucians	72	84	86	80.7	4.37
Ephemeroptera	Ephemeridae	Attenella margarita	0	0	6	2.0	2.00
Ephemeroptera	Epeorus albertae	Epeorus albertae	0	0	2	0.7	0.67
Ephemeroptera	Rhithrogena	Rhithrogena	0	2	0	0.7	0.67
Ephemeroptera	Paraleptophlebia	Paraleptophlebia bicornuta	0	0	0	0.0	0.00
Ephemeroptera	Paraleptophlebia	Choroterpes	0	0	4	1.3	1.33
Ephemeroptera	Tricorythodes	Tricorythodes explicatus	24	24	64	37.3	13.33
Non-Insect taxa	Acarina	Acarina	0	0	4	1.3	1.33
Non-Insect taxa	Oligochaeta	Lumbriculidae	2	2	2	2.0	0.00
Non-Insect taxa	Physa_Physella	Physella acuta	0	2	4	2.0	1.15
Non-Insect taxa	Pisidiidae	Pisidium	2	2	2	2.0	0.00
Non-Insect taxa	Gammarus	Gammarus	6	2	6	4.7	1.33
Non-Insect taxa	Gammarus	Hyalella	2	2	0	1.3	0.67
Non-Insect taxa	Oligochaeta	Tubificidae	0	0	4	1.3	1.33
Non-Insect taxa	Turbellaria	Turbellaria	10	6	30	15.3	7.42
Non-Insect taxa	Potamopyrgus	Potamopyrgus antipodarum	4	0	0	1.3	1.33
Non-Insect taxa	Menetus	Menetus dilatatus	2	2	0	1.3	0.67
Plecoptera	Claasennia sabulosa	Claasennia sabulosa	0	0	0	0.0	0.00
Plecoptera	Chloroperlidae	Sweltsa	2	0	0	0.7	0.67
Plecoptera	Skwala	Skwala	2	0	0	0.7	0.67
Plecoptera	Pteronarcys	Pteronarcys californica	0	0	0	0.0	0.00
Trichoptera	Brachycentridae	Amiocentrus aspilus	6	2	2	3.3	1.33
Trichoptera	Brachycentrus	Brachycentrus occidentalis	6	2	2	3.3	1.33
Trichoptera	Cheumatopsyche	Cheumatopsyche	38	136	230	134.7	55.43
Trichoptera	Hydropsyche_Cerato	Hydropsyche occidentalis	14	2	0	5.3	4.37
Trichoptera	Hydropsyche_Cerato	Hydropsyche morosa gr.	54	74	118	82.0	18.90
Trichoptera	Hydroptila	Orchotrichia	0	2	2	1.3	0.67
Trichoptera	Hydroptila	Hydroptila	16	8	4	9.3	3.53
Trichoptera	Ceraclea	Ceraclea	2	4	2	2.7	0.67
Trichoptera	Oecetis	Oecetis avara	8	2	0	3.3	2.40
		Totals	**432**	**578**	**846**	**618.7**	**121.23**

APPENDIX C. Macroinvertebrate 2018 summer taxa lists and raw data across all sites.

			1/2FS	1/2FS	1/2FS		
MO_Hardy_DS01	Summer2018		1/2ss	1/1sub	1/6 sub		
Order	OTUname2	FinalID	Hess 1	Hess 2	Hess 3	Avg.	SE
Coleoptera	Optioservus	Optioservus quadrimaculatus	32	16	16	21.3	5.33
Diptera	Simuliidae	Simulium	8	2	12	7.3	2.91
Diptera	Orthocladiinae	Cricotopus	40	2	12	18.0	11.37
Diptera	Orthocladiinae	Synorthocladius	4	0	0	1.3	1.33
Diptera	Muscidae	Limnophora	0	0	4	1.3	1.33
Diptera	Chironominae	Pseudochironomus	0	0	0	0.0	0.00
Diptera	Tanypodinae	Thienemannimyia gr.	24	16	48	29.3	9.61
Diptera	Tanypodinae	Pentaneura	0	0	8	2.7	2.67
Diptera	Chironominae	Polypedilum	0	0	4	1.3	1.33
Diptera	Chironominae	Phaenopsectra	0	0	4	1.3	1.33
Diptera	Chironominae	Microtendipes	4	6	0	3.3	1.76
Diptera	Orthocladiinae	Eukiefferella	4	0	0	1.3	1.33
Diptera	Orthocladiinae	Tvetenia bavarica	36	2	32	23.3	10.73
Diptera	Chironominae	Rheotanytarsus	4	0	0	1.3	1.33
Diptera	Tipulidae	Tipula	0	2	0	0.7	0.67
Ephemeroptera	Attenella	Attenella margarita	32	0	24	18.7	9.61
Ephemeroptera	Baetidae	Acentrella turbida	4	4	0	2.7	1.33
Ephemeroptera	Baetidae	Baetis tricaudatus	1120	34	552	568.7	313.61
Ephemeroptera	Baetidae	Baetis flavistriga	44	6	20	23.3	11.10
Ephemeroptera	Baetidae	Diphetor hageni	4	2	0	2.0	1.15
Ephemeroptera	Ephemerella	Ephemerella excrucians	40	36	108	9.0	23.36
Ephemeroptera	Paraleptophlebia	Paraleptophlebia	4	8	0	4.0	2.31
Ephemeroptera	Paraleptophlebia	Choroterpes	12	4	0	5.3	3.53
Ephemeroptera	Heptagenidae	Ecdyonurus	8	0	0	2.7	2.67
Ephemeroptera	Tricorythodes	Tricorythodes explicatus	156	108	272	178.7	48.68
Hemiptera	Corixidae	Corixidae	0	0	0	0.0	0.00
Non-Insect taxa	Oligochaeta	Tubificidae	4	10	4	6.0	2.00
Non-Insect taxa	Oligochaeta	Lumbricidae	0	2	0	0.7	0.67
Non-Insect taxa	Hirudinea	Erpobdella punctata	0	0	4	1.3	1.33
Non-Insect taxa	Pisidiidae	Sphaerium	4	0	0	1.3	1.33
Non-Insect taxa	Hyalella	Hyalella	4	0	4	2.7	1.33
Non-Insect taxa	Gammarus	Gammarus	0	0	4	1.3	1.33
Non-Insect taxa	Caecidotea	Caecidotea	8	12	0	6.7	3.53
Non-Insect taxa	Turbellaria	Turbellaria	24	34	20	26.0	4.16
Non-Insect taxa	Physa_Physella	Physella acuta	0	0	4	1.3	1.33
Non-Insect taxa	Orconectes virilis	Orconectes virilis	4	6	4	4.7	0.67
Plecoptera	Pelodidae	Skwala	0	2	0	0.7	0.67
Trichoptera	Hydropsyche_Ceratops	Hydropsyche occidentalis	88	20	532	213.3	160.54
Trichoptera	Hydropsyche_Ceratops	Hydropsyche morosa gr.	56	10	200	88.7	57.23
Trichoptera	Brachycentrus occiden	Brachycentrus occidentalis	8	0	0	2.7	2.67
Trichoptera	Cheumatopsyche	Cheumatopsyche	368	62	308	246.0	93.62
Trichoptera	Leptoceridae	Oecetis	4	0	0	1.3	1.33
Trichoptera	Hydroptila	Agraylea	4	0	16	6.7	4.81
Trichoptera	Hydroptila	Hydroptila	16	0	68	28.0	20.53
		Totals	**2172**	**406**	**2284**	**1620.7**	**608.19**

APPENDIX C. Macroinvertebrate 2018 summer taxa lists and raw data across all sites.

			1/2fs	1/2fs	1/2fs		
MO_Cascade_01	**Summer 2018**	**OM Biomass**	**11/12**	**6/12**	**9/12**		
Order	**OTUname2**	**FinalID**	**Hess 1**	**Hess 2**	**Hess 3**	**Avg.**	**SE**
Coleoptera	Microcylloepus	Microcylloepus pusillis	2	0	0	0.7	0.73
Coleoptera	Optioservus	Optioservus quadrimaculatus	24	52	24	33.4	9.30
Coleoptera	Zaitzevia	Zaitzevia	2	0	0	0.7	0.73
Diptera	Chironominae	Microtendipes	11	0	0	3.7	3.67
Diptera	Chironominae	Dicrotendipes	2	8	0	3.4	2.39
Diptera	Chironominae	Polypedilum	37	28	29	31.6	2.94
Diptera	Chironominae	Phaenopsectra	9	8	3	6.5	1.93
Diptera	Chironominae	Pseudochironomus	0	8	13	7.1	3.87
Diptera	Chironominae	Rheotanytarsus	0	0	5	1.8	1.78
Diptera	Orthocladiinae	Corynonura	0	4	0	1.3	1.33
Diptera	Orthocladiinae	Cricotopus	178	200	136	171.4	18.79
Diptera	Orthocladiinae	Eukiefferella	4	12	8	8.1	2.19
Diptera	Orthocladiinae	Paraphaenocladius	4	4	3	3.7	0.52
Diptera	Orthocladiinae	Parakiefferiella	2	0	8	3.4	2.39
Diptera	Orthocladiinae	Tvetenia bavarica	2	8	3	4.3	1.86
Diptera	Orthocladiinae	Cardiocladius	0	0	3	0.9	0.89
Diptera	Orthocladiinae	Synorthocladius	0	4	0	1.3	1.33
Diptera	Simuliidae	Simulium	0	0	3	0.9	0.89
Diptera	Tanypodinae	Thienemannimyia gr.	20	24	5	16.4	5.65
Diptera	Tipulidae	Tipula	15	8	5	9.6	3.01
Ephemeroptera	Baetidae	Baetis tricaudatus	108	596	235	312.8	146.25
Ephemeroptera	Baetidae	Fallceon quilleri	0	0	3	0.9	0.89
Ephemeroptera	Baetidae	Acentrella turbida	7	4	13	8.0	2.78
Ephemeroptera	Baetidae	Acentrella insignificans	0	0	13	4.4	4.44
Ephemeroptera	Choroterpes	Choroterpes	134	128	315	192.3	61.22
Ephemeroptera	Ephemera	Ephemera simulans	0	0	0	0.0	0.00
Ephemeroptera	Ephemerella	Ephemerella excrucians	37	32	24	31.1	3.89
Ephemeroptera	Ephemerellidae	Attenella margarita	15	28	8	17.1	5.84
Ephemeroptera	Heptagenia	Ecdyonurus simpliciodes	29	16	37	27.3	6.19
Ephemeroptera	Plauditus	Plauditus punctiventris	13	12	11	12.0	0.73
Ephemeroptera	Tricorythodes	Tricorythodes explicatus	264	476	387	375.6	61.45
Lepidoptera	Petrophila	Petrophila	0	8	0	2.7	2.67
Non-Insect taxa	Acarina	Acarina	2	0	3	1.6	0.82
Non-Insect taxa	Caecidotea	Caecidotea	0	0	0	0.0	0.00
Non-Insect taxa	Ferrissia	Ferrissia	0	0	0	0.0	0.00
Non-Insect taxa	Gammarus	Gammarus	7	4	5	5.3	0.75
Non-Insect taxa	Hirudina	Erpobdella punctata	4	4	0	2.8	1.40
Non-Insect taxa	Oligochaeta	Lumbricina	2	4	3	3.0	0.54
Non-Insect taxa	Oligochaeta	Tubificidae	7	60	37	34.6	15.47
Non-Insect taxa	Orconectes virilis	Orconectes virilis	2	0	3	1.6	0.82
Non-Insect taxa	Physa_Physella	Physella acuta	0	4	0	1.3	1.33
Non-Insect taxa	Pisidiidae	Pisidium	0	4	0	1.3	1.33
Non-Insect taxa	Potamopyrgus	Potamopyrgus antipodarum	0	4	0	1.3	1.33
Non-Insect taxa	Turbellaria	Turbellaria	2	0	5	2.5	1.55
Hemiptera	Corixidae	Corixidae	11	16	0	9.0	4.73
Odonata	Ophiogomphus	Ophiogomphus severus	18	0	0	5.9	5.87
Plecoptera	Claasennia sabulosa	Claasennia sabulosa	0	0	3	0.9	0.89
Trichoptera	Brachycentridae	Brachycentrus occidentalis	2	4	0	2.1	1.16
Trichoptera	Cheumatopsyche	Cheumatopsyche	66	108	139	104.2	21.06
Trichoptera	Hydropsyche_Ceratopsyc	Hydropsyche morosa gr.	103	200	291	198.0	54.07
Trichoptera	Hydropsyche_Ceratopsyc	Hydropsyche occidentalis	4	44	0	16.1	13.99
Trichoptera	Hydroptila	Hydroptila	51	168	56	91.5	38.27
Trichoptera	Hydroptila	Orchotrichia	2	16	3	7.0	4.52
Trichoptera	Glossosomatidae	Glossosoma	4	12	11	9.0	2.34
Trichoptera	Oecetis	Oecetis avara	2	0	0	0.7	0.73
Trichoptera	Limnephilidae	Onocomoecus unicolor	2	0	0	0.7	0.73
		Totals	**1214**	**2320**	**1851**	**1795**	**320**

APPENDIX C. Macroinvertebrate 2018 fall taxa lists and raw data across all sites.

MO_LPPC_US01	Fall 2018	Subsample	0.25	0.33	0.33		
Order	OTUname2	FinalID	Hess 1	Hess 2	Hess 3	Avg.	SE
Coleoptera	Optioservus	Optioservus quadrimaculatus	64	45	45	51.6	6.18
Coleoptera	Haliplus	Haliplus	0	3	0	1.0	1.01
Diptera	Chironominae	Microtendipes	48	18	9	25.1	11.75
Diptera	Chironominae	Dicrotendipes	4	9	0	4.4	2.63
Diptera	Chironominae	Phaenopsectra	12	6	3	7.0	2.63
Diptera	Chironominae	Pseudochironomus	4	6	3	4.4	0.89
Diptera	Orthocladiinae	Cardiocladius	0	3	6	3.0	1.75
Diptera	Orthocladiinae	Cricotopus	32	52	73	52.1	11.76
Diptera	Orthocladiinae	Eukiefferella	12	30	24	22.2	5.38
Diptera	Orthocladiinae	Tvetenia	0	3	3	2.0	1.01
Diptera	Orthocladiinae	Parametriocnemus	4	3	3	3.4	0.32
Diptera	Orthocladiinae	Parakieffierella	4	3	3	3.4	0.32
Diptera	Simuliidae	Simulium	300	118	336	251.5	67.49
Diptera	Tanypodinae	Thienemannimyia gr.	20	0	6	8.7	5.92
Diptera	Tipulidae	Tipula	12	0	3	5.0	3.60
Diptera	Tipulidae	Limnophila	0	0	3	1.0	1.01
Ephemeroptera	Baetis	Baetis tricaudatus	104	70	18	64.0	24.94
Ephemeroptera	Ephemerella	Ephemerella excrucians	20	18	27	21.8	2.78
Ephemeroptera	Rhithrogena	Rhithrogena	0	3	0	1.0	1.01
Ephemeroptera	Tricorythodes	Tricorythodes explicatus	64	30	70	54.7	12.29
Non-Insect taxa	Hirudina	Erpobdella punctata	8	6	3	5.7	1.45
Non-Insect taxa	Glossiphoniidae	Glossiphonia complanata	0	3	0	1.0	1.01
Non-Insect taxa	Caecidotea	Caecidotea	240	197	155	197.2	24.67
Non-Insect taxa	Hyalella	Hyalella	28	55	30	37.6	8.49
Non-Insect taxa	Acarina	Acarina (Sperchon)	8	0	3	3.7	2.33
Non-Insect taxa	Oligochaeta	Lumbriculidae	0	0	3	1.0	1.01
Non-Insect taxa	Oligochaeta	Lumbricina	0	6	3	3.0	1.75
Non-Insect taxa	Physa_Physella	Physella acuta	60	112	67	79.6	16.38
Non-Insect taxa	Stagnicola	Stagnicola	4	3	0	2.3	1.20
Non-Insect taxa	Pisidiidae	Pisidium	12	18	15	15.1	1.78
Non-Insect taxa	Potamopyrgus	Potamopyrgus antipodarum	32	27	9	22.8	6.98
Non-Insect taxa	Gyraulus	Gyraulus	8	0	3	3.7	2.33
Non-Insect taxa	Menetus	Menetus dilatatus	20	9	3	10.7	4.96
Non-Insect taxa	Oligochaeta	Tubificidae	0	0	0	0.0	0.00
Non-Insect taxa	Gammarus	Gammarus	24	6	6	12.0	5.98
Non-Insect taxa	Turbellaria	Turbellaria	312	170	118	200.0	57.96
Non-Insect taxa	Nematoda	Nematoda	288	215	118	207.1	49.19
Plecoptera	Perlodidae	Isoperla	0	0	0	0.0	0.00
Lepidoptera	Petrophila	Petrophila	24	15	39	26.2	7.08
Trichoptera	Ceraclea	Ceraclea	48	39	21	36.2	7.90
Trichoptera	Brachycentrus	Brachycentrus occidentalis	12	6	3	7.0	2.63
Trichoptera	Cheumatopsyche	Cheumatopsyche	180	145	121	148.9	17.06
Trichoptera	Glossosomatidae	Culoptila	0	0	0	0.0	0.00
Trichoptera	Limnephilidae	Dicosmoecus gilvipes	0	0	0	0.0	0.00
Trichoptera	Hydropsyche_Cera	Hydropsyche morosa gr.	32	15	21	22.8	4.93
Trichoptera	Hydropsyche_Cera	Hydropsyche occidentalis	48	33	45	42.3	4.52
Trichoptera	Helicopsyche	Helicopsyche borealis	0	3	3	2.0	1.01
Trichoptera	Hydroptila	Hydroptila	0	3	3	2.0	1.01
Trichoptera	Oecetis	Oecetis avara	168	91	109	122.7	23.27
		per sample	**2260**	**1600**	**1539**	**1799.8**	**230.77**

APPENDIX C. Macroinvertebrate 2018 fall taxa lists and raw data across all sites.

MO_LPPC_DS01	Fall 2018		1	1	1		
Order	**OTUname2**	**FinalID**	**Hess 1**	**Hess 2**	**Hess 3**	**Average**	**SE**
Coleoptera	Optioservus	Optioservus quadrimaculatus	7	2	5	4.7	1.45
Coleoptera	Zaitzevia	Zaitzevia	2	3	2	2.3	0.33
Diptera	Ceratopogonidae	Probezzia	0	1	0	0.3	0.33
Diptera	Tipulidae	Hexatoma	1	3	2	2.0	0.58
Diptera	Simulium	Simulium	7	12	9	9.3	1.45
Diptera	Tipulidae	Tipula	0	1	2	1.0	0.58
Diptera	Muscidae	Limnophora	1	1	0	0.7	0.33
Diptera	Chironominae	Microtendipes	0	1	1	0.7	0.33
Diptera	Chironominae	Rheotanytarsus	3	1	0	1.3	0.88
Diptera	Orthocladiinae	Tvetenia	0	1	1	0.7	0.33
Diptera	Orthocladiinae	Eukiefferella	1	1	2	1.3	0.33
Diptera	Orthocladiinae	Parakiefferella	0	2	1	1.0	0.58
Diptera	Orthocladiinae	Parametriocnemus	1	0	0	0.3	0.33
Diptera	Orthocladiinae	Cardiocladius	0	2	5	2.3	1.45
Diptera	Orthocladiinae	Synorthocladius	1	1	2	1.3	0.33
Diptera	Tanypodinae	Thienemannimyia gr.	0	0	0	0.0	0.00
Ephemeroptera	Acentrella	Acentrella	0	0	0	0.0	0.00
Ephemeroptera	Baetidae	Baetis tricaudatus	8	10	17	11.7	2.73
Ephemeroptera	Ephemerellidae	Ephemerella excrucians	2	2	3	2.3	0.33
Ephemeroptera	Ephemerellidae	Attenella margarita	0	0	2	0.7	0.67
Ephemeroptera	Ephemerellidae	Drunella grandis	1	0	1	0.7	0.33
Ephemeroptera	Rhithrogena	Rhithrogena	61	99	78	79.3	10.99
Ephemeroptera	Tricorythodes	Tricorythodes explicatus	0	0	1	0.3	0.33
Non-Insect taxa	Acarina	Acarina (Hygrobates)	0	0	1	0.3	0.33
Non-Insect taxa	Oligochaeta	Lumbriculidae	5	1	6	4.0	1.53
Non-Insect taxa	Oligochaeta	Lumbricidae	0	0	1	0.3	0.33
Non-Insect taxa	Physa_Physella	Physella acuta	4	0	3	2.3	1.20
Non-Insect taxa	Pisidiidae	Pisidium	0	0	0	2.0	1.15
Non-Insect taxa	Menetus	Menetus dilatatus	1	1	1	1.0	0.00
Non-Insect taxa	Gyraulus	Gyraulus	1	0	1	0.7	0.33
Non-Insect taxa	Potamopyrgus	Potamopyrgus antipodarum	0	0	1	0.3	0.33
Non-Insect taxa	Valvata	Valvata	1	0	2	1.0	0.58
Non-Insect taxa	Gammarus	Gammarus	0	0	0	0.0	0.00
Non-Insect taxa	Gammarus	Hyalella	0	2	1	1.0	0.58
Non-Insect taxa	Caecidotea	Caecidotea	0	3	6	3.0	1.73
Non-Insect taxa	Oligochaeta	Tubificidae	5	1	2	2.7	1.20
Non-Insect taxa	Turbellaria	Turbellaria	4	1	5	3.3	1.20
Plecoptera	Skwala	Skwala	1	0	1	0.7	0.33
Plecoptera	Perlidae	Claassenia sabulosa	0	1	0	0.3	0.33
Plecoptera	Pteronarcys	Pteronarcys californica	0	0	0	0.0	0.00
Trichoptera	Brachycentrus	Brachycentrus occidentalis	3	4	5	4.0	0.58
Trichoptera	Cheumatopsyche	Cheumatopsyche	0	1	5	2.0	1.53
Trichoptera	Hydropsyche_Ceratops	Hydropsyche occidentalis	2	2	1	1.7	0.33
Trichoptera	Hydropsyche_Ceratops	Hydropsyche morosa gr.	0	2	0	0.7	0.67
Trichoptera	Glossosomatidae	Glossosoma	19	75	55	49.7	16.38
Trichoptera	Lepidostoma	Lepidostoma	3	0	1	1.3	0.88
Trichoptera	Oecetis	Oecetis avara	2	1	2	1.7	0.33
		Totals	**258**	**238**	**234**	243.0	**44.74**

APPENDIX C. Macroinvertebrate 2018 fall taxa lists and raw data across all sites.

MO_Craig_US01	**Fall 2018**		**5/12ss**	**4/12ss**	**9/24ss**		
Order	**OTUname2**	**Final ID**	**Hess 1**	**Hess 2**	**Hess 3**	**Avg.**	**SE**
Coleoptera	Optioservus	Optioservus quadrimaculatus	21	3	141	55	43
Diptera	Orthocladiinae	Cricotopus trifascia	7	15	0	7	4
Diptera	Orthocladiinae	Tvetenia	0	0	3	1	1
Diptera	Chironominae	Microtendipes	112	21	128	87	33
Diptera	Chironominae	Pseudochironomus	10	3	0	4	3
Diptera	Tanypodinae	Thienemannimyia gr.	19	0	29	16	9
Diptera	Tabanidae	Chrysops	0	3	5	3	2
Diptera	Simuliidae	Simulium	24	27	13	21	4
Diptera	Tipulidae	Tipula	0	3	0	1	1
Ephemeroptera	Baetis	Baetis tricaudatus	0	3	3	2	1
Ephemeroptera	Ephemerella	Ephemerella excrucians	24	0	16	13	7
Ephemeroptera	Tricorythodes	Tricorythodes explicatus	43	0	11	18	13
Non-Insect taxa	Caecidotea	Caecidotea	131	354	40	175	93
Non-Insect taxa	Orconectes virilis	Orconectes virilis	2	0	0	1	1
Non-Insect taxa	Hirudina	Erpobdella punctata	2	3	0	2	1
Non-Insect taxa	Hirudina	Helobdella stagnalis	0	3	0	1	1
Non-Insect taxa	Hyalella	Hyalella	198	129	16	114	53
Non-Insect taxa	Gammarus	Gammarus	36	9	21	22	8
Non-Insect taxa	Nematoda	Nematoda	71	252	48	124	65
Non-Insect taxa	Physa_Physella	Physella acuta	43	42	35	40	3
Non-Insect taxa	Valvata	Valvata humeralis	0	0	3	1	1
Non-Insect taxa	Menetus	Menetus dilatatus	5	27	13	15	6
Non-Insect taxa	Pisidiidae	Pisidium	55	246	125	142	56
Non-Insect taxa	Potamopyrgus	Potamopyrgus antipodarum	7	9	16	11	3
Non-Insect taxa	Oligochaeta	Tubificidae	0	3	5	3	2
Non-Insect taxa	Turbellaria	Turbellaria	7	27	51	28	13
Lepidoptera	Petrophila	Petrophila	0	0	3	1	1
Trichoptera	Cheumatopsyche	Cheumatopsyche	393	63	395	284	110
Trichoptera	Hydropsyche_Ceratops	Hydropsyche occidentalis	48	3	141	64	41
Trichoptera	Helicopsyche	Helicopsyche borealis	0	3	5	3	2
Trichoptera	Hydroptila	Hydroptila	0	9	0	3	3
Trichoptera	Ceraclea	Ceraclea	7	18	13	13	3
Trichoptera	Limnephilidae	Dicosmoecus gilvipes	0	0	3	1	1
Trichoptera	Ljeptoceridae	Nectopsyche	0	3	0	1	1
Trichoptera	Oecetis	Oecetis avara	107	84	112	101	9
		Totals	**1371**	**1366**	**1395**	**1377.5**	**8.7**

APPENDIX C. Macroinvertebrate 2018 fall taxa lists and raw data across all sites.

MO_Dear_US01	Fall 2018		1/4sub	1/4sub	1/4sub		
Order	**OTUname2**	**FinalID**	**Hess 1**	**Hess 2**	**Hess 3**	**Avg.**	**SE**
Coleoptera	Optioservus	Optioservus quadrimaculatus	4	28	20	17.3	7.06
Coleoptera	Zaitzevia	Zaitzevia	0	0	4	1.3	1.33
Coleoptera	Ordobrevia	Ordobrevia nubifera	0	0	4	1.3	1.33
Diptera	Orthocladiinae	Cricotopus	32	0	36	22.7	11.39
Diptera	Chironominae	Microtendipes	296	168	388	284.0	63.79
Diptera	Chironominae	Dicrotendipes	40	0	80	40.0	23.09
Diptera	Chironominae	Glyptotendipes	20	0	60	26.7	17.64
Diptera	Chironominae	Micropsectra	8	0	24	11	7
Diptera	Chironominae	Pseudochironomus	192	188	148	176.0	14.05
Diptera	Chironominae	Rheotanytarsus	0	4	0	1.3	1.33
Diptera	Chironominae	Polypedilum	0	24	20	14.7	7.42
Diptera	Orthocladiinae	Tvetenia bavarica	0	8	0	2.7	2.67
Diptera	Tanypodinae	Thienemannimyia gr.	32	36	24	30.7	3.53
Diptera	Tipulidae	Hexatoma	0	4.0	0.0	1.3	1.33
Diptera	Simuliidae	Simulium	8	24	4	12.0	6.11
Ephemeroptera	Baetis	Baetis tricaudatus	40	208	60	102.7	52.98
Ephemeroptera	Ephemerella	Ephemerella excrucians	40	64	44	49.3	7.42
Ephemeroptera	Tricorythodes	Tricorythodes explicatus	36	32	16	28.0	6.11
Ephemeroptera	Ephemera simulans	Ephemera simulans	8	0	0	2.7	2.67
Ephemeroptera	Heptageniidae	Macaffertium terminatum	0	4	0	1.3	1.33
Ephemeroptera	Paraleptophlebia	Choroterpes	4	0	0	1.3	1.33
Ephemeroptera	Paraleptophlebia	Paraleptophlebia	4	0	4	2.7	1.33
Lepidoptera	Petrophila	Petrophila	16	4	8	9.3	3.53
Odonata	Coenagrionidae	Enallagma	0	0	4	1.3	1.33
Non-Insect taxa	Caecidotea	Caecidotea	84	344	128	185.3	80.34
Non-Insect taxa	Crangonyx	Gammarus	8	4	40	17.3	11.39
Non-Insect taxa	Hirudina	Erpobdella punctata	0	0	0	0.0	0.00
Non-Insect taxa	Hyalella	Hyalella	8	4	32	14.7	8.74
Non-Insect taxa	Oligochaeta	Lumbricina	0	0	0	0.0	0.00
Non-Insect taxa	Oligochaeta	Lumbriculidae	4	24	16	14.7	5.81
Non-Insect taxa	Oligochaeta	Tubificidae	28	4	16	16.0	6.93
Non-Insect taxa	Nematoda	Nematoda	0	0	0	0.0	0.00
Non-Insect taxa	Physa_Physella	Physella acuta	4	24	16	14.7	5.81
Non-Insect taxa	Gyraulus	Gyraulus	0	0	4	1.3	1.33
Non-Insect taxa	Orconectes virilis	Orconectes virilis	4	4	4	4.0	0.00
Non-Insect taxa	Turbellaria	Turbellaria	116	212	56	128.0	45.43
Plecoptera	Perlidae	Claassenia sabulosa	0	4	0	1.3	1.33
Trichoptera	Ceraclea	Ceraclea	4	16	4	8.0	4.90
Trichoptera	Brachycentrus occiden	Brachycentrus occidentalis	0	4	0	1.3	1.33
Trichoptera	Cheumatopsyche	Cheumatopsyche	24	44	28	32.0	6.11
Trichoptera	Helicopsyche	Helicopsyche borealis	0	4	4	2.7	1.33
Trichoptera	Hydropsyche_Ceratops	Hydropsyche occidentalis	4	8	4	5.3	1.33
Trichoptera	Polycentropidae	Polycentropus	12	16	0	9.3	4.81
Trichoptera	Hydroptila	Hydroptila	16	24	4	14.7	5.81
Trichoptera	Oecetis	Oecetis avara	8	24	8	13.3	5.33
		Totals per hess	**1104**	**1560**	**1312**	**1325.3**	**131.80**

APPENDIX C. Macroinvertebrate 2018 fall taxa lists and raw data across all sites.

MO_Dearborn_DS01	Fall 2018		1/2 sub	1/2 sub	1/2 sub		
Order	**OTUname2**	**FinalID**	**Hess 1**	**Hess 2**	**Hess 3**	**Average**	**SE**
Coleoptera	Microcylloepus pusillis	Microcylloepus pusillis	2	0	2	1.3	0.67
Coleoptera	Optioservus	Optioservus quadrimaculatus	2	12	6	6.7	2.91
Coleoptera	Zaitzevia	Zaitzevia parvula	12	10	12	11.3	0.67
Diptera	Chironominae	Microtendipes	0	6	4	3.3	1.76
Diptera	Chironominae	Pseudochironomus	0	2	5	2.2	1.30
Diptera	Chironominae	Rheotanytarsus	2	16	10	9.3	4.06
Diptera	Orthocladiinae	Cricotopus	4	8	6	6.0	1.15
Diptera	Orthocladiinae	Eukiefferella	4	4	6	4.7	0.67
Diptera	Orthocladiinae	Tvetenia bavarica	4	4	2	3.3	0.67
Diptera	Simuliidae	Simulium	2	4	2	2.7	0.67
Diptera	Tipulidae	Limnophila	10	2.0	8.0	6.7	2.40
Diptera	Atherix	Atherix	2	0.0	4.0	2.0	1.15
Diptera	Empididae	Hemerodromia	0	2	2	1.3	0.67
Ephemeroptera	Baetis	Baetis tricaudatus	8	16	12	12.0	2.31
Ephemeroptera	Ephemerellidae	Ephemerella excrucians	0	4	2	2.0	1.15
Ephemeroptera	Tricorythodes	Tricorythodes explicatus	0	6	8	4.7	2.40
Ephemeroptera	Baetidae	Diphetor hageni	0	2	2	1.3	0.67
Ephemeroptera	Rhithrogena	Rhithrogena	106	76.0	88	90.0	8.72
Ephemeroptera	Paraleptophlebia	Paraleptophlebia	0	8	4	4.0	2.31
Non-Insect taxa	Physa_Physella	Physella acuta	0	2	2	1.3	0.67
Non-Insect taxa	Oligochaeta	Lumbriculidae	12	2	6	6.7	2.91
Non-Insect taxa	Turbellaria	Turbellaria	10	10	12	10.7	0.67
Plecoptera	Perlidae	Claassenia sabulosa	6	4	2	4.0	1.15
Plecoptera	Perlidae	Hesperoperla pacifica	4	0	2	2.0	1.15
Plecoptera	Perlodidae	Skwala	14	6	10	10.0	2.31
Plecoptera	Chloroperlidae	Sweltsa	2	4	2	2.7	0.67
Trichoptera	Brachycentrus occiden	Brachycentrus occidentalis	4	0	2	2.0	1.15
Trichoptera	Hydropsychidae	Cheumatopsyche	84	66	80	76.7	5.46
Trichoptera	Leptoceridae	Oecetis avara	4	20	12	12.0	4.62
Trichoptera	Leptoceridae	Ceraclea	0	0	0	0.0	0.00
Trichoptera	Hydroptila	Hydroptila	0	0	0	0.0	0.00
Trichoptera	Hydropsychidae	Hydropsyche	100	84	110	98.0	7.57
Trichoptera	Hydropsychidae	Hydropsyche morosa gr.	14	26	22	20.7	3.53
Trichoptera	Helicopsyche	Helicopsyche borealis	0	6	4	3.3	1.76
		Totals per hess	**412**	**412**	**450.5**	**424.8**	**12.83**

APPENDIX C. Macroinvertebrate 2018 fall taxa lists and raw data across all sites.

MO_Hardy_DS01	Fall2018		7/24 sub	5/24 sub	6/24 sub		
Order	**OTUname2**	**FinalID**	**Hess 1**	**Hess 2**	**Hess 3**	**Avg.**	**SE**
Coleoptera	Optioservus	Optioservus quadrimaculatus	79	81	16	58.8	21.38
Coleoptera	Stenelmis	Stenelmis	0	0	4	1.3	1.33
Coleoptera	Microcylloepus	Microcylloepus	0	5	4	2.9	1.48
Diptera	Simuliidae	Simulium	3	29	24	18.7	7.73
Diptera	Orthocladiinae	Cricotopus	3	14	32	16.6	8.32
Diptera	Orthocladiinae	Synorthocladius	10	0	0	3.4	3.45
Diptera	Chironominae	Pseudochironomus	7	5	2	4.6	1.42
Diptera	Tanypodinae	Thienemannimyia gr.	0	5	4	2.9	1.48
Diptera	Tanypodinae	Pentanura	0	5	0	1.6	1.59
Diptera	Chironominae	Polypedilum	14	38	84	45.3	20.58
Diptera	Chironominae	Phaenopsectra	3	5	0	2.7	1.42
Diptera	Chironominae	Cryptochironomus	0	5	0	1.6	1.59
Diptera	Chironominae	Microtendipes	279	162	140	193.7	43.25
Diptera	Orthocladiinae	Eukiefferella	55	305	0	120.0	93.75
Diptera	Orthocladiinae	Tvetenia bavarica	0	5	16	6.9	4.74
Diptera	Chironominae	Rheotanytarsus	3	0	4	2.5	1.25
Ephemeroptera	Attenella	Attenella margarita	0	0	0	0.0	0.00
Ephemeroptera	Baetis	Baetis tricaudatus	683	581	596	619.9	31.73
Ephemeroptera	Baetis	Baetis intercalaris	0	0	0	0.0	0.00
Ephemeroptera	Ephemerella	Ephemerella excrucians	517	881	596	9.0	110.48
Ephemeroptera	Paraleptophlebia	Paraleptophlebia	0	5	4	2.9	1.48
Ephemeroptera	Heptagenidae	Macaffertium	3	14	12	9.9	3.30
Ephemeroptera	Heptagenidae	Heptagenia	0	0	4	1.3	1.33
Ephemeroptera	Plauditis	Plauditus punctiventris	3	0	4	2.5	1.25
Ephemeroptera	Pseudocloeon	Pseudocloeon	0	0	0	0.0	0.00
Ephemeroptera	Tricorythodes	Tricorythodes explicatus	66	152	60	92.6	29.92
Ephemeroptera	Ephemera simulans	Ephemera simulans	0	0	4	1.3	1.33
Lepidoptera	Petrophila	Petrophila	0	4	0	1.3	1.33
Non-Insect taxa	Oligochaeta	Tubificidae	7	10	12	9.5	1.47
Non-Insect taxa	Hirudinea	Erpobdella punctata	0	5	4	2.9	1.48
Non-Insect taxa	Pisidiidae	Sphaerium	3	5	4	4.1	0.38
Non-Insect taxa	Pisidiidae	Pisidium	3	0	4	2.5	1.25
Non-Insect taxa	Hyalella	Hyalella	14	10	28	17.1	5.58
Non-Insect taxa	Gammarus	Gammarus	3	10	0	4.3	2.78
Non-Insect taxa	Caecidotea	Caecidotea	17	33	8	19.5	7.40
Non-Insect taxa	Turbellaria	Turbellaria	17	43	64	41.4	13.52
Non-Insect taxa	Physa_Physella	Physella acuta	0	5	0	1.6	1.59
Non-Insect taxa	Gyraulus	Gyraulus	0	5	4	2.9	1.48
Non-Insect taxa	Orconectes virilis	Orconectes virilis	7	10	4	6.8	1.60
Trichoptera	Hydropsyche_Ceratops	Hydropsyche occidentalis	28	167	164	119.4	45.92
Trichoptera	Hydropsyche_Ceratops	Hydropsyche morosa gr.	0	14	0	4.8	4.76
Trichoptera	Brachycentrus occiden	Brachycentrus occidentalis	0	0	4	1.3	1.33
Trichoptera	Cheumatopsyche	Cheumatopsyche	103	367	256	242.0	76.30
Trichoptera	Leptoceridae	Ceraclea	0	5	0	1.6	1.59
Trichoptera	Hydroptila	Hydroptila	3	5	0	2.7	1.42
Trichoptera	Helicopsyche	Helicopsyche borealis	10	0	8	6.1	3.13
Trichoptera	Polycentropidae	Polycentropus	0	0	20	6.7	6.67
		Totals	**1948**	**2990**	**2194**	**2377.3**	**314.3**

APPENDIX C. Macroinvertebrate 2018 fall taxa lists and raw data across all sites.

MO_Cascade_US01	Fall 2018		1/4ss	1/4ss	1/4ss		
Order	**OTUname2**	**FinalID**	**Hess 1**	**Hess 2**	**Hess 3**	**Avg.**	**SE**
Coleoptera	Dubiraphia	Dubiraphia	12	24	32	22.7	5.81
Coleoptera	Microcylloepus	Microcylloepus pusillis	20	8	24	17.3	4.81
Coleoptera	Optioservus	Optioservus quadrimaculatus	192	148	164	168.0	12.86
Coleoptera	Zaitzevia	Zaitzevia parvula	20	84	56	53.3	18.52
Diptera	Chironominae	Microtendipes	92	132	124	116.0	12.22
Diptera	Chironominae	Phaenopsectra	8	16	36	20.0	8.33
Diptera	Chironominae	Polypedilum	16	12	4	10.7	3.53
Diptera	Chironominae	Pseudochironomus	88	60	120	89.3	17.33
Diptera	Chironominae	Rheotanytarsus	0	16	20	12.0	6.11
Diptera	Chironominae	Tanytarsus	16	24	8	16.0	4.62
Diptera	Diamsinae	Potthastia	4	4	0	2.7	1.33
Diptera	Orthocladiinae	Cricotopus	100	140	88	109.3	15.72
Diptera	Orthocladiinae	Eukiefferiella	0	8	20	9.3	5.81
Diptera	Orthocladiinae	Nostoccocladius	0	8	4	4.0	2.31
Diptera	Orthocladiinae	Orthocladius	0	20	16	12.0	6.11
Diptera	Orthocladiinae	Thienemaniella	4	0	0	1.3	1.33
Diptera	Tanypodinae	Pentaneura	4	0	0	1.3	1.33
Diptera	Tanypodinae	Thienemannimyia gr.	16	8	32	18.7	7.06
Diptera	Simuliidae	Simulium	0	8	8	5.3	2.67
Ephemeroptera	Baetidae	Acerpenna pygmaea	4	4	8	5.3	1.33
Ephemeroptera	Baetis	Baetis intercalaris	8	0	0	2.7	2.67
Ephemeroptera	Baetidae	Baetis tricaudatus	88	48	44	60.0	14.05
Ephemeroptera	Choroterpes	Choroterpes	16	32	20	22.7	4.81
Ephemeroptera	Heptagenia	Ecdyonurus simpliciodes	4	4	8	5.4	1.37
Ephemeroptera	Ephemerella	Ephemerella excrucians	4	0	8	4.0	2.31
Ephemeroptera	Heptagenia	Heptagenia	4	0	0	1.3	1.33
Ephemeroptera	Heptagenia	Macaffertium terminatum	16	8	4	9.3	3.53
Ephemeroptera	Plauditus	Plauditus punctiventris	12	24	8	14.7	4.81
Ephemeroptera	Tricorythodes	Tricorythodes explicatus	84	76	36	65.3	14.85
Lepidoptera	Petrophila	Petrophila	20	24	40	28.0	6.11
Non-Insect taxa	Caecidotea	Caecidotea	100	132	155	129.0	15.95
Non-Insect taxa	Hirudinea	Erpobdella punctata	8	8	16	10.7	2.67
Non-Insect taxa	Ferrissia	Ferrissia rivularis	0	4	20	8.0	6.11
Non-Insect taxa	Gammarus	Gammarus	8	12	32	17.3	7.42
Non-Insect taxa	Hyalella	Hyalella	70	60	44	58.0	7.57
Non-Insect taxa	Oligochaeta	Lumbricina	48	20	36	34.7	8.11
Non-Insect taxa	Oligochaeta	Lumbriculidae	32	24	8	21.3	7.06
Non-Insect taxa	Orconectes	Orconectes virilis	12	8	10	10.0	1.15
Non-Insect taxa	Physa_Physella	Physella acuta	96	100	112	102.7	4.81
Non-Insect taxa	Potamopyrgus	Potamopyrgus antipodarum	4	8	8	6.7	1.33
Non-Insect taxa	Pisidiidae	Sphaerium	8	48	54	36.7	14.44
Non-Insect taxa	Oligochaeta	Tubificidae	60	78	88	75.3	8.19
Non-Insect taxa	Turbellaria	Turbellaria	142	82	100	108.0	17.78
Odonata	Ophiogomphus	Ophiogomphus severus	4	8	4	5.3	1.33
Trichoptera	Brachycentrus occi	Brachycentrus occidentalis	8	4	8	6.7	1.33
Trichoptera	Cheumatopsyche	Cheumatopsyche	24	32	60	38.7	10.91
Trichoptera	Helicopsyche	Helicopsyche borealis	88	68	124	93.3	16.38
Trichoptera	Hydropsyche_Cera	Hydropsyche morosa gr.	8	4	4	5.3	1.33
Trichoptera	Hydroptila	Hydroptila	48	20	44	37.3	8.74
Trichoptera	Nectopsyche	Nectopsyche	8	16	8	10.7	2.67
Trichoptera	Oecetis	Oecetis avara	96	80	78	84.7	5.70
		Totals	**1724**	**1756**	**1945.1**	**1808.4**	**68.99**

Appendix D. Site Habitat and Physical Conditions

Appendix D . Habitat and Water Quality Parameters measured for the UMOWA sites visited.

2016	MO_LPPC_US			MO_LPPC_DS			MO_Craig			MO_DEAR_US			MO_DEAR_DS			MO_HARDY_BR			MO_Cascade		
	May	July	Oct	May	July	Oct	May	July	Oct	May	July	Oct	May	July	Oct	May	July	Oct	May	July	Oct
Water Temp °C	9.7	15.6	14.3	6.5	14.1	12.6	10	17.9	14.5	14.2	17.1	na	16.4	19	na	15.6	17	14.5	16.7	18.2	15.1
Conductivity (µs/cm)	242	340	300	169	314	306	248	338	305	271	338	na	250	289	na	277	340	300	288	338	303
TDS (ppm)	121	179	166	85	135	155	125	144	152	136	149	na	132	137	na	138	141	151	143	176	155
pH	7.35	7.86	7.9	7.3	7.85	7.9	7.2	8.1	7.9	7.8	8	na	7.9	7.9	na	7.7	7.99	8.1	7.75	8	8.1
Discharge (cfs)	4300	4100	3580	4350	4130	3600	4350	4130	3600	4300	4130	3740	5000	4180	3790	5000	4280	3800	5000	4380	3800
Avg Sample Depth (cm)	23	20	24	23	22	25	25	29	22	25	29	28	28	27	33	35	41	35	20	26	24
Avg Sample Dist. From Bank (m)	28	32	35	23	32	33	11	12	15	7	8	9	3	8	11	5	7	9	6	6	14
% Fines in Hess	10	15	15	20	25	25	15	15	10	0	5	5	30	30	30	5	1	5	15	15	25
% Gravel Hess	70	65	70	55	50	50	65	70	60	25	25	25	55	60	60	20	24	20	75	75	60
% Cobble Hess	20	20	10	20	25	25	20	15	20	75	70	70	15	10	11	60	65	60	10	10	15
% Boulder Reach	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	10	15	0	0	0
Avg. Riparian Shade	0	0	0	0	0	0	10	10	10	20	20	20	0	0	0	5	5	5	5	5	5

Appendix D . Habitat and Water Quality Parameters measured for the UMOWA sites visited.

2017	MO_LPPC_US			MO_LPPC_DS			MO_Craig			MO_DEAR_US			MO_DEAR_DS			MO_HARDY_BR			MO_Cascade		
	Jun	July	Oct	Jun	July	Oct	Jun	July	Oct	Jun	July	Oct	Jun	July	Oct	Jun	July	Oct	Jun	July	Oct
Water Temp °C	15.2	19.5	14.1	6.5	18.7	11.1	15.7	20.7	14.2	na	19.4	14.2	na	22.2	12.8	na	19.2	14.5	na	21.1	14.6
Conductivity (µs/cm)	315	302	280	198	307	329	324	311	288	na	308	290	na	295	280	na	311	300	na	314	302
TDS (mg/l)	150	179	190	110	155	195	163	177	188	na	166	186	na	150	165	na	170	151	na	188	180
pH	7.35	7.9	7.9	7.3	7.85	7.9	7.4	8.1	8.0	na	7.9	8.0	na	7.9	7.9	na	7.99	8.1	na	8.1	8.1
Discharge (cfs)	8300	4200	3980	8450	4300	4080	8450	4300	4080	8450	4300	4080	8800	4350	4160	8800	4350	4160	9000	4380	4220
Avg. Sample Depth (cm)	50	20	24	33	25	25	35	28	22	na	29	28	na	33	30	na	40	35	na	25	22
Avg. Sample Dist. From Bank (m)	14	22	18	6	7	7	11	13	15	na	7	8	na	8	9	na	5	6	na	5	7
% Fines in Hess	5	15	15	0	10	25	15	15	10	na	5	5	na	10	10	na	1	5	na	15	25
% Gravel Hess	70	65	75	75	65	50	65	70	70	na	25	25	na	65	70	na	24	20	na	75	60
% Cobble Hess	20	20	10	25	25	25	20	15	20	na	70	70	na	25	20	na	65	60	na	10	15
% Boulder Reach	0	0	0	0	0	0	0	0	0	na	0	0	na	0	0	na	10	15	na	0	0
Avg. Riparian Shade	0	0	0	0	0	0	10	20	20	na	10	10	na	0	0	na	5	5	na	5	5