Fish and Macroinvertebrate Trapping Data Report in Relation to Flowering Rush Infestations

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Non Technical Summary

Salish Kootenai College and the University of Montana are leading investigations of the aquatic invasive macrophyte flowering rush (*Butomus umbellatus*) in the Flathead Basin. The goal of this research is to gather basic information to assess how flowering rush expansion will impact native fish recovery in the Flathead Basin. Flathead Lake has experienced non-native fish and macroinvertebrate introductions that alter food webs resulting in a fishery dominated by 80% non-natives, and culturally and ecologically important native westslope cutthroat and bull trout natives have declined to 15% of the fish assemblage (Ellis 2011). The Flathead region is the Columbia headwaters and is the source for downstream invasion of the entire system. This study is the first to document environmental conditions created by flowering rush and will provide information as to the future conditions of an unmitigated spread. We will evaluate presence and use of flowering rush by non-native fish compared to open water and native vegetation. We will produce an inventory of the macroinvertebrate population classified by functional guilds for baseline aquatic health and productivity. Based on fish, macroinvertebrate, and structure studies we will provide a fisheries perspective to the long-term impacts of unabated flowering rush establishment in Flathead Lake and rivers on non-native fish populations with implication to native species. We will produce an inventory of the flowering rush invasion over several hundred miles of river and adjacent wetlands. Expected outcomes will support a need for active management of flowering rush to reduce spawning and foraging habitat for non-native fish and protect native fish and native habitat. Management will reduce the spread, reduce recreation impacts, protect native fishery and protect water quality, reduce irrigation water delivery costs, and maintain open water conditions. We will document the locations and size of the invasion for implementing active management projects. This study will support the need for a complete scientific assessment along the Columbia River, implementation of local management efforts, and the involvement by additional tribal, federal, state, and private interests. Given the results from the spatial modeling research and field, and the results from this research, we expect to find evidence that an unabated flowering rush invasion will significantly result in habitat favoring additional non-native fish. This may result in the lessened ability of natives to compete and maintain viable populations.

Sampling Results

Using pop nets, dip net, and light traps 167 samples were acquired in 2012 and 152 in 2013 (Table 1).

Table 1. Summary of samples acquired.

2012	Method	Sum
Faust Slough (River)	pop net	3
East Bay (Lake)	pop net	18
Faust Slough (River)	light trap	84
East Bay (Lake)	light trap	48
Faust Slough (River)	dip net	14
		167
2013	**Method**	**Sum**
Fennon Slough (River)	light trap	118
East Bay (Lake)	light trap	34
		152

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Water boatman (Corixidae) were the predominant macroinvertebrate species capture by light traps in the river sloughs in 2012 followed by scuds (Hyallelidae) (Table 2). Only 13 taxa were captured by this method.

Table 2. Macroinvertebrate taxon counts for 2012 Faust Slough light trap samples (n=30).

Common Name	Family	Sum of Counts
Water Boatman	Corixidae	2,222
Scud	Hyallelidae	487
Minnow Mayfly	Baetidae	58
Predaceous Diving Beetle	Dysticidae	38
Case Maker Caddis Fly	Lepidostomatidae	13
Whirligig Beetles	Gyrinidae	13
Water Mite	Hydrachnida	5
Snail	Physidae	4
Damselfly	Lestidae	3
Burrowing Mayfly	Ephemeridae	2
Mosquito	Culicidae	2
Midges	Chironomidae	1
Water Scavenger Beetles	Hyrophilidae	1

The light traps were quite effective in capturing small juvenile fish, but only 1 fish (a yellow perch, ***Perca flavescens***) was captured in the 18 pop nets that were deployed in July 2012, all the other fish were obtained by light traps. We captured four fish species by light traps (Table 3). Northern pikeminnow (***Ptychocheilus oregonensis*)** dominated the juvenile fish community in the river sloughs in 2012, followed by smallmouth bass. We did not capture any northern pike (*Esox lucius*) in 2012 as we only began to sample by light trap in August when there are very few or no small juvenile northern pike remaining.

Table 3. Juvenile fish species counts for 2012 Faust Slough light trap samples*.

Name		Sum of Counts
Northern Pikeminnow	*Ptychocheilus oregonensis*	3,486
Smallmouth Bass	*Micropterus dolomieu*	378
Yellow Perch	*Perca flavescens*	121
Brook Stickleback	*Culaea inconstans*	414

*only 1 yellow perch caught in pop nets

Although light trap sampling was effective for capturing juvenile fish it grossly under sampled the macroinvertebrate diversity; dip nets wee much more effective in sampling full community species richness and abundance weighted diversity indices (Table 4)

Table 4. Mean organism counts and diversity parameters for river slough dip net (2012) and light trap (2013) sampling methods.

Method	Organisms Count	Species Richness	S-W Diversity	Simpson's Diversity	Evenness
Dip Net (n=11)	445	34.9	2.351	0.813	0.663
Light Trap (n=34)	78	6.9	1.386	0.667	0.732

However the limited number of 2012 same sampling date dip net river slough samples did not indicate any significant difference ($p \leq 0.05$) difference in the calculated diversity parameters (Table 5). Dip net capture rates tended ($p \leq 010$) highest for samples taken in open water and lowest when sweeping in the dense flowering rush infestations.

Table 5. Habitat means for organism counts and diversity parameters for 2012 Faust Slough dip net samples.

Parameter	Habitat	N	Mean	ANOVA p
Richness	Flowering Rush 100%	3	35.7	0.139
	Native 100%	3	36.0	
	Native 25-90%	3	37.0	
	Open Water	2	29.0	
Evenness	Flowering Rush 100%	3	0.672	0.981
	Native 100%	3	0.649	
	Native 25-90%	3	0.667	
	Open Water	2	0.664	
S-W Diversity	Flowering Rush 100%	3	2.404	0.884
	Native 100%	3	2.323	
	Native 25-90%	3	2.404	
	Open Water	2	2.235	
Simpson's Diversity	Flowering Rush 100%	3	0.819	0.994
	Native 100%	3	0.809	
	Native 25-90%	3	0.814	
	Open Water	2	0.810	
Organism Count	Flowering Rush 100%	3	362	0.099
	Native 100%	3	427	
	Native 25-90%	3	462	
	Open Water	2	574	

More total macroinvertebrate taxa were captured by light traps in 2013 in the upper river Fennon Slough (Table 6) than we obtained in the 2012 light trap samples, however the overall mean richness is 2012 light trap sample was still only 7, still far below that obtainable by dip nets. The ANOVA's for the 2013 Fennon Slough light trap samples (fish & macroinvertebrates together) were significant ($p \leq 0.05$) for the capture totals and the diversity parameters (Table 7). Pairwise comparisons among vegetative habitat types were made for this data set were the habitat sample sizes were 11 to 13 (Table 8). For these data flowering rush had the highest total organisms counts, highest species richness, and correspondingly the abundance weighed diversity indices ($p \leq 0.05$) (Table 8). The open water samples had higher total organisms counts and species richness than the native vegetation ($p \leq 0.05$) (Table 9); suggesting higher capture efficiency in open water than in vegetated habitats and/or sampling date difference in species availability.

Table 6. Taxa captured by light traps in Fennon Slough in 2013.

Order/Class	Taxon	Totals
Fish	Largemouth Bass	168
	Yellow Perch	12
	Northern Pike	9
	Northern Pikeminnow	0
	Pumpkinseed	8
Diptera	Bezzia	81
	Chironomidae (Pupae)	299
	Chironomidae (Larva)	203
	Tanypodidae	394
	Chaoboridae	137
	Tipulidae	2
Odonata	Enallagma	1
	Libellulidea	1
Ephemeroptera	Caenidae	584
	Callibaetis	12
Hemiptera	Corixidae	0
Amphipoda	Hyalella	1198
Coleoptera	Dystiscidae (Hygrotus)	12
	Gerridae (Gyrinus)	4
Trichoptera	Hydroptila	0
Hydracarina	Water Mites	2376
Mollusks	clams	2
	snails	3
		5497

Table 7. Habitat means for organism counts and diversity parameters for 2013 Fennon Slough light trap samples (n=11 to 13).

Parameter	Habitat	N	Mean	ANOVA p
Count Sum	Flowering Rush	13	99	0.040
	Native	10	40	
	Open Water	11	89	
Richness	Flowering Rush	13	8.5	<0.001
	Native	10	5.1	
	Open Water	11	6.8	
Evenness	Flowering Rush	13	0.745	0.037
	Native	10	0.795	
	Open Water	11	0.659	
SW Diversity	Flowering Rush	13	1.589	<0.001
	Native	10	1.263	
	Open Water	11	1.259	
Simpsons Div.	Flowering Rush	13	0.726	0.010
	Native	10	0.653	
	Open Water	11	0.611	

Table 8. Pairwise (LSD) comparisons of means for organism counts and diversity parameters for 2013 Fennon Slough light trap samples were n=11 to 13 flowering rush habitat versus native vegetation and open water habitats.

Parameter	(I) Habitat	(J) Habitat	Mean Difference (I-J)	LSD p.
Count Sum	Flowering Rush	40 Native	59 (*)	.016
	99	89 Open Water	10	.670
Richness	Flowering Rush	5.1 Native	3.4(*)	.000
	8.5	6.8 Open Water	1.6 (*)	.000
Evenness	Flowering Rush	.795 Native	-.050	.318
	.745	.659 Open Water	.0862	.082
SW Diversity	Flowering Rush	1.263 Native	.326 (*)	.001
	1.549	1.259 Open Water	.330 (*)	.000
Simpsons Div.	Flowering Rush	.653 Native	.073	.056
	.726	.611 Open Water	.115(*)	.003

* The mean difference is significant at <0 .05 level.

Table 9. Native vegetation and open water habitats pairwise (LSD) comparisons of means for organism counts and diversity parameters for 2013 Fennon Slough light trap samples.

Parameter	(I) Native	(J) Open Water	Mean Difference (I-J)	LSD p.
Count Sum	40	89	-49.6 (*)	.049
Richness	5.1	6.8	-1.7(*)	<.001
Evenness	.795	.659	.136(*)	.012
SW Diversity	1.263	1.259	.004	.967
Simpsons Div.	.653	.61	.042	.274

* The mean difference is significant at <0 .05 level.

The Fennon Slough fish community was predominately introduced fish; we did not capture any natives in the 2013 light trap samples on the upper river (Table 10). These introduced fish made primary use of the dense flowering rush habitat. Northern pike juveniles were only captured in the flowering rush infestations. Flathead Lake East Bay (Ducharme) light trap samples taken in flowering rush habitat were dominated by juvenile yellow perch and sheltered few native northern pikeminnows (Table 11).

Table 10, Percent of positive light trap detects for juvenile fish in Fennon Slough (2013).

	# of light traps	Largemouth Bass	Yellow Perch	Pumpkin-seed	Northern Pike
100% Flowering Rush	44	77.3	31.8	6.8	11.4
100% Native	36	55.6	2.8	0	0
Open Water	36	25.0	0	0	0

Table 11. Percent of positive light trap detects for fish in East Bay (2013).

	# of light traps	Northern Pikeminnow	Yellow Perch
100% Flowering Rush	31	3	29

Ordination (by non-metric multidimensional scaling) of the 2012 dip net samples indicates that the macroinvertebrate communities across habitats differed strongly in species composition and relative abundance (Figure 1). The shifts in species composition follow a consistent increasing vegetative gradient from open water to partial native vegetation cover to 100% cover by native vegetation, to 100% canopy cover of flowering rush (BUTUMB).

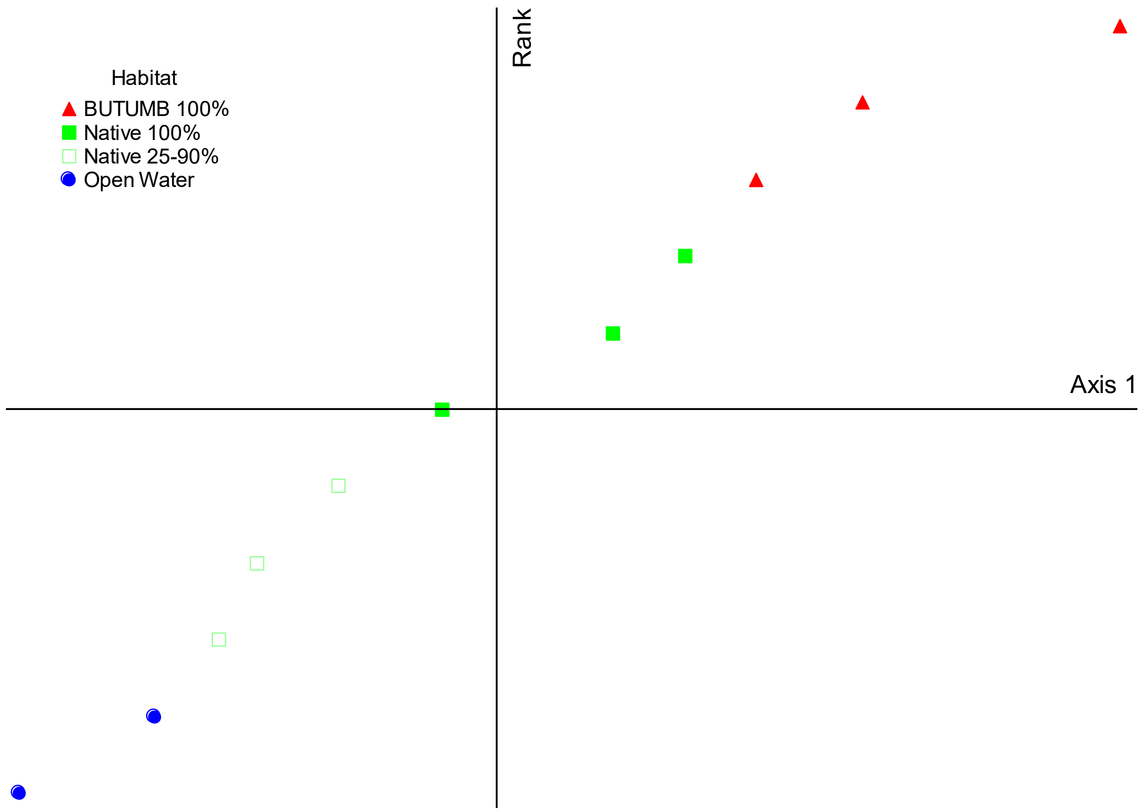

Figure 1. Aquatic plant community (all fish & macroinvertebrates) ordination for Faust Slough 2012 dip net samples (BUTUMB = flowering rush) (1D rank NMS stress 14.1).

The magnitude of the difference in relative species composition is statistical significant (Table 12). The magnitude of the differences in ecological effect size correspond to shifts indicated by the ordination graph (Figure 1). We believe that these differences in ecological effect size are ecologically important as well as statistically significant. Effect sizes of this magnitude (.1 to .3) are generated by spraying herbicides on diverse plant communities.

Table 12. Ecological Effect Size (A) for Faust Slough 2012 dip net samples (Multi-Response Permutation Procedure *p≤0.05 ***p≤0.001).

	Flowering Rush	**100% NATIVE**	**25-100% NATIVE**
100% NATIVE	.103*		
25-100% NATIVE	.363*	.280***	
OPEN WATER	.370***	.280***	.342***

The 2013 light trap data for Fennon Slough shows similar species composition segregation by habitat type (Figure 2). The community utilizing the flowering rush habitat is clearly different than that occupying the native vegetation. Ecological effects size differences are also statistically significant and ecologically important (Table 13).

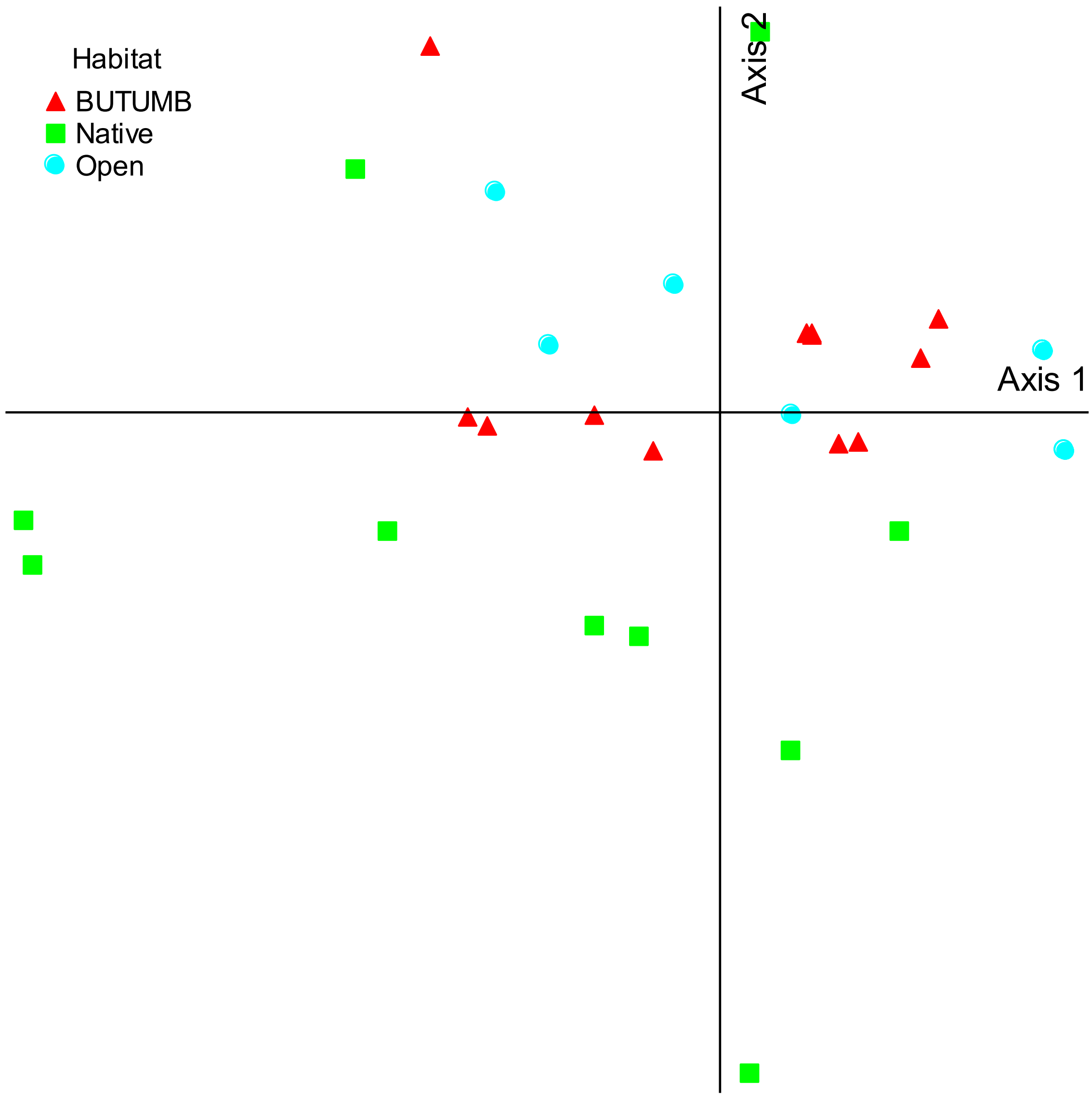

Figure 2. Aquatic plant community (all fish & macroinvertebrates) ordination for Fennon Slough 2013 light trap samples (BUTUMB = flowering rush) (2D NMS stress 16.3).

Table 13. . Ecological Effect Size (A) for Fennon Slough 2013 light trap samples (Multi-Response Permutation Procedure **p≤0.01 ***p≤0.001).

	Flowering Rush	**Native Veg**
Native Veg	0.168***	
Open Water	0.092**	0.190***

A summary of the 2012 Faust Slough dip net macroinvertebrate samples by functional feeding groups indicated that the slough is dominated by gatherers (Table 14). The sample size across habitat types is too small (n=2 to 4) to warrant inference testing. However as would be expected scrapers are more prevalent in the dense vegetation habitats filters in the open water.

Table 14. Proportional functional feeding groups summary (percent of total counts) for 2012 Faust Slough dip net samples.

Functional Feeding Group	Flowering Rush 100%	Native 100%	Native 50%	Open Water
Filterers	3.8	1.2	2.5	11.3
Gatherers	58.6	65.6	65.1	65.8
Omnivore†	0.0	0.0	0.3	0.0
Piercer-Herbivore	0.0	0.2	0.0	0.3
Predators	11.6	10.7	10.0	12.3
Predators/Gatherers$^{\Pi}$	2.6	0.3	8.5	2.1
Scrapers	22.2	21.2	12.4	6.4
Shredders	1.2	0.8	1.2	1.7
	100.0	100.0	100.0	100.0

†crayfish, $^{\Pi}$water boatman

A similar summary of the 2012 Faust Slough dip net macroinvertebrate samples by functional habit groups is presented in Table 15. As above the sample size across habitat types is too small (n=2 to 4) to warrant inference testing. However there are some trends indicated that would be expected with the difference in vegetative structure. Burrower numbers are highest for the unvegetated substrate. Climbers are more numerous in the vegetated habitats, and nominally highest in the flowering rush with its dense array of vertical linear leaves providing and extensive and easily grazed periphyton community.

Table 15. Proportional functional habit groups summary (percent of total counts) for 2012 Faust Slough dip net samples.

Functional Habit Group	Flowering Rush 100%	Native 100%	Native 50%	Open Water
Burrowers	2.0	1.7	2.4	6.0
Climbers	26.6	21.2	15.0	5.9
Climbers (L), Divers (A)	2.1	3.7	2.8	4.3
Clingers	6.6	8.0	6.6	18.1
Clingers/Varied	16.6	30.9	46.7	45.1
Sprawlers	4.3	1.8	2.2	4.8
Swimmers	3.6	2.1	9.2	2.2
Swimmers/Varied	38.2	30.5	14.8	13.6
Crayfish	0.0	0.0	0.3	0.0
Whirligig Beetles	0.1	0.0	0.0	0.0
	100.0	100.0	100.0	100.0

L=larval life stage, A=adult life stage

Over the two years of sampling 89 taxa were captured. The species are listed in Table 16.

Table 16. Taxa (n=89) captured by dip nets and light traps in 2012 and 2013.

Order/Class	**Taxon**	**Functional Group**	**Habit**
Acari (water mites)	*Atractides*		
Acari (water mites)	*Hydrachna*	Predators	Swimmer
Acari (water mites)	*Limnesia*	Predators	Swimmer
Acari (water mites) ?	*Elyais*	Predators	Swimmer
Clitellata (Leeches/Worms)	*Erpobdella punctata*	Gatherers	Swimmer
Clitellata (Leeches/Worms)	*Tubificidae*	Gatherers	Sprawler
Coleoptera (Beetles)	*Coptotomus longulus*	Gatherers	Clinger,SP,CM(la), DI,SW(ad)
Coleoptera (Beetles)	*Desmppachria convexa*	Predators	Climbers (L), Divers (A)
Coleoptera (Beetles)	*Dineutus*	Predators	CM (la), DI, SW (ad)
Coleoptera (Beetles)	*Enochrus*	Gatherers	Clinger,SP,CM(la), DI,SW(ad)
Coleoptera (Beetles)	*Gyrinus affinis*	Predators	Swimmer
Coleoptera (Beetles)	*Haliplus*	Gatherers	Clinger/50%, Climber/50%
Coleoptera (Beetles)	*Hydrobius*		
Coleoptera (Beetles)	*Hygrotus*	Predators	Climbers (L), Divers (A)
Coleoptera (Beetles)	*Ilybius*	Predators	Climbers (L), Divers (A)
Coleoptera (Beetles)	*Laccophilus*	Predators	Climbers (L), Divers (A)
Coleoptera (Beetles)	*Nebrioporus marginatus*	Predators	Climbers (L), Divers (A)
Coleoptera (Beetles)	*Peltodytes*	Gatherers	Clinger/50%, Climber/50%
Coleoptera (Beetles)	*Rhantus*	Predators	Climbers (L), Divers (A)
Coleoptera (Beetles)	*Tropisternus lateralis*	Gatherers	Clinger,SP,CM(la), DI,SW(ad)
Coleoptera (Beetles)	*Zaitzevia*	Scrapers	Clinger
Crustaceans (Amphipoda/Crayfish)	*Caecidotea*	Gatherers	Sprawler/75%, SW/25%
Crustaceans (Amphipoda/Crayfish)	*Gammarus lacustris*	Gatherers	SW/50%, SP/50%
Crustaceans (Amphipoda/Crayfish)	*Hyalella azteca*	Gatherers	SW/50%, SP/50%
Crustaceans (Amphipoda/Crayfish)	*Orconectes virilis*	Omnivore	Invader
Crustaceans (Amphipoda/Crayfish)	Ostracoda	Gatherers	SW/50%, SP/25%, BU/25%
Diptera (True Flies)	*Ablabesmyia*	Predators	Sprawler
Diptera (True Flies)	*Aedes*	Filterers	Sprawler
Diptera (True Flies)	*Bezzia*	Predators	Climbers
Diptera (True Flies)	*Chrysops*	Predators	Sprawler
Diptera (True Flies)	*Corynoneura*	Gatherers	Sprawler
Diptera (True Flies)	*Cricotopus*	Shredders	Clinger
Diptera (True Flies)	*Doliochopodidae*	Predators	Burrower
Diptera (True Flies)	*Ephydra*		

Diptera (True Flies)	*Euparyphus*		
Diptera (True Flies)	*Glyptotendipes*	Filterers	Clinger
Diptera (True Flies)	*Polypedilum*	Shredders	Clinger
Diptera (True Flies)	*Procladius*	Predators	Sprawler
Diptera (True Flies)	*Psectrocladius*	Gatherers	Burrower
Diptera (True Flies)	*Sciomyzidae*	Scrapers	Clinger
Diptera (True Flies)	*Stempellina*	Gatherers	Burrower
Diptera (True Flies)	*Tanytarsus*	Filterers	Clinger
Ephemeroptera (Mayflies)	*Caenis youngi*	Gatherers	Sprawler/75%, Climber/25%
Ephemeroptera (Mayflies)	*Callibaetis*	Gatherers	Clinger/90%, Swimmer/10%
Ephemeroptera (Mayflies)	*Paraleptophlebia bicornuta*		
Ephemeroptera (Mayflies)	*Tricorythodes minutus*	Gatherers	Clinger
Fish	Brook Stickleback (yoy)		
Fish	Largemouth Bass (yoy)		
Fish	Northern Pikeminnow (yoy)		
Fish	Northern Pike (ypy)		
Fish	Pumpkinseed		
Fish	Yellow Perch (yoy)		
Hemiptera (True Bugs)	*Belastoma fluminea*	Predators	Clinger
Hemiptera (True Bugs)	*Corixidae*	Predators/ Gatherers	Swimmer
Hemiptera (True Bugs)	*Gerridae*		
Hemiptera (True Bugs)	*Hesperocorixa*	Gatherers	Swimmer
Hemiptera (True Bugs)	*Neoplea*	Piercer-Herbivore	Clinger
Hemiptera (True Bugs)	*Notonecta*	Predators	Swimmer
Mollusks (Snails/Clams)	*Fossaria humilis*	Scrapers	Climbers
Mollusks (Snails/Clams)	*Gyraulus circumstriatus*	Scrapers	Climbers
Mollusks (Snails/Clams)	*Gyraulus parvus*	Scrapers	Climbers
Mollusks (Snails/Clams)	*Helisoma anceps*	Scrapers	Climbers
Mollusks (Snails/Clams)	*Physella acuta*	Scrapers	Climbers
Mollusks (Snails/Clams)	*Physella gyrina*	Scrapers	Climbers
Mollusks (Snails/Clams)	*Pisidium*	Filterers	Burrower
Mollusks (Snails/Clams)	*Planorbella trivolvis*	Scrapers	Climbers
Mollusks (Snails/Clams)	*Promenetus umbilicatellus*		
Mollusks (Snails/Clams)	*Sphaerium simile*	Filterers	Burrower
Mollusks (Snails/Clams)	*Stagnicola caperata*	Scrapers	Climbers
Mollusks (Snails/Clams)	*Valvata humeralis*	Scrapers	Climbers
Mollusks (Snails/Clams)	*Valvata sincera*	Scrapers	Climbers
Mollusks (Snails/Clams)	*Valvata tricarinata*	Scrapers	Climbers
Odonata (Dragonflies/Damselflies)	*Aeshna*	Predators	Climbers
Odonata (Dragonflies/Damselflies)	*Aeshna palmata*	Predators	Sprawler

Odonata (Dragonflies/Damselflies)	*Enallagma*	Predators	Clinger
Odonata (Dragonflies/Damselflies)	*Enallagma annexum*	Predators	Clinger
Odonata (Dragonflies/Damselflies)	*Ischnura cervula*	Predators	Clinger
Odonata (Dragonflies/Damselflies)	*Ischnura perparva*	Predators	Clinger
Odonata (Dragonflies/Damselflies)	*Lestes disjunctus*	Predators	Climbers
Odonata (Dragonflies/Damselflies)	*Sympetrum*	Predators	Climbers
Odonata (Dragonflies/Damselflies)	*Sympetrum internum*	Predators	Climbers
Odonata (Dragonflies/Damselflies)	*Sympetrum obtrusum*	Predators	Climbers
Trichoptera	*Hydroptila*	Piercer-Herbivore	Clinger
Trichoptera	*Lepidostoma*	Shredders	Climbers
Trichoptera	*Limnephilus*	Shredders	Sprawler
Trichoptera	*Nectopsyche diarina*	Gatherers	Clinger/Sprawler/Climber
Trichoptera	*Polycentropus*	Predators	Clinger/50%, AT/50%
Trichoptera	*Ptilostomis*	Shredders	Sprawler
Turbellaria	*Turbellaria*	Predators	Sprawler