Final Report

for

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Benthic Integrity of *Phragmites* Stands

in the Old Woman Creek Coastal Wetland

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Project Focus & Background:

The principle aim of the project was to compare benthic macroinvertebrate community structure between stands of the invasive common reed (*Phragmites australis* [Cav.] Trin. ex Steud.) and cattails (*Typha angustifolia* L.) in the Old Woman Creek (OWC) (Huron, OH; Erie County) coastal wetland. *Phragmites* can sometimes quickly decrease floral diversity in wetlands by displacing native flora to create near-monotypic stands (Fell et al. 1998, Amsberry et al. 2000, Able and Hagan 2003). Habitat homogeneity resulting from *Phragmites* spread and dominance can also lead to reductions in bird, mammal, and terrestrial insect diversity (Hellings and Gallagher 1992, Benoit and Askins 1999, Chambers et al. 1999, Lynch and Saltonstall 2002). Despite the general dislike for, and frequent removal of, *Phragmites* in wetland management programs in the U.S., little is known about its effects on benthic macroinvertebrate assemblages.

A key goal of the Lake Erie Protection and Restoration Plan is to eradicate *Phragmites*. However, 100% eradication may not be feasible, and in fact, *Phragmites* may only detrimentally affect macroinvertebrate diversity and densities when forming near-monotypic stands. Glyphosate herbicides (e.g., Glypro®, DowAgrosciences) have been used to chemically control some patches of Phragmites at OWC and other Lake Erie coastal wetlands. The herbicide is mixed with a surfactant to facilitate penetration when applied to aboveground foliage. Its transportation to the root system inhibits amino acid production, resulting in plant death (Giesy et al. 2000). This type of control is particularly useful because it can be applied locally to invasive patches, but overspray can kill non-target macrophytes. Effects of glyphosate herbicides on non-macrophyte organisms in the aquatic environment are not entirely clear. Accordingly, a second goal of the study was to compare benthic macroinvertebrate communities between Glypro®-treated and –untreated patches of *Phragmites*. A marked decrease in community metrics, such as diversity and density, or a pronounced shift in functional feeding group composition, soon after application would suggest a toxic effect on these taxa.

The third aim of the project was to experimentally address how food quality of *Phragmites* 1) is affected by herbicide application and 2) compares to its countertype, *Typha angustifolia* L. (narrow-leaf cattail). Specifically, we examined the performance measures, growth, survival, and fecundity of the widespread detritivorous amphipod, *Hyalella azteca* (Saussure), fed lab-conditioned leaves of either naturally senescent *Phragmites*, early senescent *Phragmites* treated with herbicide, and naturally senescent *Typha angustifolia* in indoor microcosms. *Typha angustifolia* is common to many Great Lakes coastal marshes (Reed 1988) but is rapidly being replaced by *Phragmites* (Marks et al. 1994). Narrow-leaf cattail is also an invasive macrophyte to many of these marshes but is not considered “weedy” or “undesirable” because it has not caused dramatic changes in plant composition, or supposedly altered wetland function and value, like *Phragmites*. Moreover, loss of cattail in these marshes may affect overall detrital food quality, and hence consumer performance, in part because *Typha* litter has higher nutrient concentrations than *Phragmites* (Findlay et al. 2002).

We hypothesized that amphipod performance would be greater when fed 1) *Typha* vs. *Phragmites,* and 2) early senescent, herbicide-treated *Phragmites* vs. naturally senescent *Phragmites*. Early senescence from herbicide application would presumably increase overall conditioning time (fungal colonization), making these leaves more palatable to macrodetritivores than leaves undergoing natural senescence and death in late autumn. This prediction was based on findings that standing dead plant matter in marshes undergoes considerable degradation by fungi before collapse (Kuehn and Suberkropp 1998, Kuehn et al. 1999).

Project Methods:

Benthic Macroinvertebrate Communities in Herbicide-Treated and Herbicide-free *Phragmites* and *Typha*

Herbicide Application and Study Plot Selection.—A 30% Glypro® solution with surfactant (SAC) was applied by hand (John McFadden, Ohio Department of Natural Resources) to a ~100 x 5 m stretch of *Phragmites* in the northwest embayment of the wetland on 17 July 2003. Three 10 x 5 m plots were selected and demarcated with flagging in each of the three stand types: sprayed *Phragmites*, unsprayed *Phragmites*, and *Typha angustifolia*. A total of nine plots were selected, and plots within stands were spaced ≥ 20 m apart. Study plots were selected mainly on the basis of water depth and accessibility by canoe and were restricted to the north end of the wetland because of the presence of nesting bald eagles.

Benthic Macroinvertebrate Sampling.— Macroinvertebrates were sampled in each plot on 19 July, 2 and 19 August, and 13 September 2003. Plots were sampled between 0730 h and 1530 h, and sampling order of stand type was randomly selected on each date. Each plot was divided into ten 1.0 x 5.0 m quadrats. Temperature (°C) and dissolved oxygen (mg/L) were recorded on each sampling date in the middle quadrat of each plot (~10 cm depth) using a model 550 YSI probe. Macroinvertebrates were then sampled along three, randomly chosen quadrats per plot using a 0.5 x 0.5 m throw trap (0.5 m high, open top and bottom), framed by wood and sided with nylon screening (5-mm mesh). The bottom was weighted with rebar to help sink and keep the trap flush with the sediments. Immediately after macrophyte stem counts and water depths (cm) were recorded in each throw, a standard D-frame net (800 x 900 μm mesh) was used to sweep the inside of the trap until no macroinvertebrates were captured in two consecutive sweeps. Three samples from each plot were combined into a composite sample (n = 3 composite samples per stand type each date) and preserved in 95% ethanol. Macroinvertebrates were sorted from vegetative debris in the laboratory and stored in 95% ethanol. Macroinvertebrates were usually identified to species, except chironomids which were identified to subfamily, using Brigham et al. (1982) and Peckarsky et al. (1990) as primary references.

Community Characterization and Analyses.—Macroinvertebrate communities in stand types were characterized using Shannon-Wiener diversity index (H') (Shannon and Wiener 1963), the Jaccard similarity index (J) (Mueller-Dombois and Ellenberg 1974, Wallwork 1976), functional feeding group composition, and density estimates. The Shannon-Wiener formula incorporates both species richness and evenness, and is expressed as:

$$H' = -\Sigma\, p_i \ln p_i\,,$$

where p_i is the proportion of individuals found in the ith species. H' was computed for each study plot on each sampling date. The Jaccard similarity index was used to compare similarities of macroinvertebrate community assemblages among stand types. This index uses presence/absence data to compare percent similarity of species from all combinations of stand types using the equation:

$$J = a/(b + c),$$

where a = number of species common to both stands, b = number of species in stand one, c = number of species in stand two. Taxa within stands were assigned to the four key functional feeding groups present in OWC, piercers, engulfers, grazers, collector-gatherers, and other (i.e., shredders, scavengers) (Harvell 2000), using mainly Merritt and Cummins (1996). Piercers suck fluids from cells or tissues of plants and animals, engulfers attack and ingest prey, grazers scrape mineral and organic surfaces, and collector-gatherers consume fine particulate organic matter by filtering or by sediment feeding. Last, densities were calculated from macroinvertebrate counts in throws for each replicate plot in stand types on each sampling, and expressed as individuals m^2.

Two-way repeated measures (rm) ANOVAs were used to compare Shannon-Wiener diversity indices, relative proportions of the dominant functional feeding groups, and macroinvertebrate densities among stand types (SYSTAT, version 9.0, SPSS 1999). Proportions of functional feeding groups in stand types were arcsine transformed, whereas densities were $\log_{10}$ (x + 1) transformed for analyses. Stem counts and water depths were compared among stand types using rm ANOVA (SYSTAT, version 9.0, SPSS 1999). Correlation analyses were used to assess relationships between macroinvertebrate densities ($\log_{10}$ [x + 1] transformed) and stem counts and water levels.

Hyalella Performance in Laboratory Microcosms

Microcosm Set-up.—We used 48 clear-glass jars (height 16.7 cm, 0.946 L capacity) as rearing chambers (microcosms) for amphipods. Each microcosm contained conditioned leaves of either *Phragmites* without herbicide, *Phragmites* sprayed with herbicide, or *T. angustifolia* as a food source. Standing leaves of each type were collected on 25 October 2003 from OWC, transported to the laboratory, and stored at 0 °C. Leaves in the sprayed *Phragmites* treatment were collected from a ~100 x 5 m stand treated with the herbicide Glypro® (30% solution) on 17 July 2003. Leaves were thawed on 2 June 2004, and types were kept separated in plastic tubs (36.5 x 31.0 cm, 14 cm height) filled with aerated OWC water for 13 d to allow microbial colonization.

Leaves were removed from tubs on 15 June, gently blotted with paper towels, and cut by knife into smaller pieces (~80% 1–5 mm, ~20% 5–10 mm). Ten grams (wet weight) of one leaf type and 500 mL of OWC water were added to each microcosm. Each leaf treatment was replicated 16 times, and treatments were randomly assigned to microcosms. Microcosms were aerated, held at 22–24 °C, and aligned in three rows near a south-facing window to expose animals to a natural photoperiod (~16 h daylight).

Hyalella Growth and Survival.—One amphipod was added to each microcosm on 16 June, a day after their collection from OWC. Each amphipod was blotted on a paper towel for 5 sec, and weight (mean ± 1 SE: 4.71 ± 0.22 mg) was recorded to the nearest 0.1 mg with an Ohaus® GA110 balance. Amphipods were re-weighed on 20 July 2004, 35 d after stocking. Growth was determined by subtracting initial mass at stocking from final mass at the end of the experiment and expressed as µg day^{-1}. ANOVA tested whether growth rate (log10-transformed) differed among treatments (SYSTAT 9; Wilkinson 2000). G-tests adjusted by Williams's correction determined whether number of amphipods surviving varied among treatments (Sokal and Rohlf 1995). For females that mated prior to microcosm stocking, we assessed the effect of leaf type on the interdependent response variables, number of offspring present, and mean offspring mass ($\log_{10}$-transformed), using multivariate analysis of variance (MANOVA).

Project Results:

Macroinvertebrate Communities in *Phragmites* and *Typha*

Macroinvertebrate species diversity (H') was similar among stands of sprayed *Phragmites*, unsprayed *Phragmites*, and *Typha* (rm ANOVA: $F_{2,6} = 0.884$, $P = 0.461$; Figure 1). However, Jaccard's similarity index (J) ranged from 29 to 51% (Table 1), indicating low to moderate assemblage similarities (≥50% is considered similar). Sixteen, 23, and 16 species were unique to *Typha*, unsprayed-*Phragmites*, and sprayed-*Phragmites* treatments, respectively (Appendix A). However, these differences in species presence did not apparently affect community function. Functional feeding group composition did not differ significantly between stand types (rm ANOVA: $F_{2,99} = 0.0019$, $P = 0.9981$; Table 2). Relative abundances of the dominant functional feeding groups were fairly uniform, although grazers (~29%) were slightly more abundant than other groups over the four sample dates.

Total macroinvertebrate densities varied among stand types (rm ANOVA: $F_{2,6} = 5.196$, $P = 0.049$; Figure 2) and were higher in September than on any other date (sample date effect: $F_{3,18} = 6.012$; $P = 0.005$). Densities of macroinvertebrates were generally higher in herbicide-treated *Phragmites* than in *Typha*. However, no differences in total densities were evident between sprayed and unsprayed *Phragmites*, even immediately after (i.e., 2 days) herbicide application (Figure 2, see 19 July). Gastropods (snails), Odonata (damselfly and dragonfly larvae), Hemipterans (true bugs), and Chironomids (midges) were the dominant taxa captured in throw traps, together comprising ~78% of the total macroinvertebrate density. Moreover, rank of these dominant taxa in stands was typically Gastropods > Odonata > Hemipterans > Chironomids. Densities of snails were significantly different among stand types (rm ANOVA: $F_{2,6} = 5.394$, $P = 0.046$), with the highest snail densities occurring in the sprayed *Phragmites* stands (Figure 3). Over 95% of captured snails were the species *Gyraulus deflectus* and *Physella gyrina.* Densities of larval Odonata did not statistically differ among stand types (rm ANOVA $F_{2,6} = 4.583$; $P = 0.062$). However, densities did differ among dates ($F_{3,18} = 22.119$; $P < 0.001$), with peak densities of larval odonates occurring on 13 September (Figure 3). Most (~75%) captured Odonata belonged to the genera *Ischnura* (forktail damselfly) and *Enallagma* (bluet damselfly). Densities of Hemipterans differed among stand types (rm ANOVA $F_{2,6} = 7.390$, $P = 0.024$; Figure 3) and were usually greater in *Phragmites* than in *Typha* stands. The most common species of Hemipterans (~53%) included *Palmacorixa* sp. and *Trichocorixa* sp. (water boatmen) and *Mesovelia* sp. (water treaders). Last, chironomid densities (38% *Orthocladiinae* sp., 30% *Chironominae* sp., 29% *Tanypodinae* sp., 3% *Diamesinae* sp.) were also significantly different among stand types (rm ANOVA $F_{2,6} = 16.362$; $P = 0.004$; Figure 3), with the highest densities occurring in unsprayed *Phragmites* stands.

Macroinvertebrate densities were not related to stem densities ($r = –0.004$, $P = 0.984$) or water depths ($r = 0.17$, $P = 0.320$), despite differences in both parameters among stand type (both $P \leq 0.020$). Average stem densities in throws were lower, and average water depths were higher (~4–10 cm), in unsprayed *Phragmites* than in the other two treatments (Table 3). Neither temperature (limits: 20.1–32.0 °C) nor oxygen level (limits: 0.32–9.65 mg/L) varied among stand types (rm ANOVA: both $P > 0.10$).

Hyalella Growth and Survival

Amphipods grew, on average, ~100 µg d^{-1}, and growth rates were similar among treatments ($F_{2,34} = 0.025$, $P = 0.975$). Numbers surviving on *Typha*, sprayed *Phragmites*, and unsprayed *Phragmites* leaves were 15, 10, and 12, respectively, and these numbers did not significantly differ among treatments ($G_{adj.} = 1.199$, df = 2, $P > 0.50$). Number of microcosms in which offspring were found in *Typha*, sprayed *Phragmites*, and unsprayed *Phragmites* treatments was 7, 5, and 6 respectively. Leaf type had no detectable effect on offspring number (avg. per treatment: 11–15) and average offspring mass (~1.75 mg) in microcosms (MANOVA: Wilks' λ = 0.923, $F_{4,28}$ = 0.285, P = 0.885).

Project Dissemination:

Various aspects of this study have been presented to the Fish and Wildlife Conference (2004: Columbus, OH), the meeting of the North American Benthological Society (2005: New Orleans, LA; 2006: Anchorage, AK), and the American Fisheries Society (2006: Lake Placid, NY). In addition, the results were presented in an open, public seminar at the Old Woman Creek Reserve in July, 2005.

Manuscripts generated from this study include:

Kulesza, A.E. and J.R. Holomuzki. 2006. Amphipod performance responses to decaying litter of *Phragmites australis* and *Typha angustifolia* from a Lake Erie coastal marsh. Wetlands, Dec. issue.

Kulesza, A.E. 2006. Effects of *Phragmites* Spread and Removal by Glyphosate Application on Benthic Macroinvertebrate diversity in the Old Woman Creek Freshwater Estuary. M. Sc. Thesis. The Ohio State University, Columbus, OH.

Kulesza, A.E., J.R. Holomuzki, & D.M. Klarer. Benthic Community Structure in Stands of Herbicide-treated and Herbicide-free *Phragmites Australis* and *Typha angustifolia*. To be submitted to Wetlands in ~4 weeks.

Project Benefits:

The results of this project have several management implications. 1) Benthic macroinvertebrate diversity and assemblages in real wetlands are apparently not affected by glyphosate application, based particularly on similarities of these metrics between sprayed and unsprayed *Phragmites* on the 19 July (2 d after application) and throughout summer. 2) Macroinvertebrates densities, particularly those of snails, hemipterans, and chironomids, were higher in *Phragmites* than in *Typha*, suggesting *Phragmites* does not adversely affect macroinvertebrate abundance. 3) The apparent ability of amphipods to perform equally well on reed and cattail implies that food quality of the leaf detritus of these macrophytes is a similar for detritivores.

Work from this project provided baseline data that helped secure funding from the Coastal Management Program and the Ohio Sea Grant Program to further study *Phragmites* impacts on benthic food webs and to devise a practical control strategy. One Master's student was completed through this project (Amy Kulesza), and an undergraduate student (Steven Bussell) from OSU-Mansfield completed an independent project using data generated from this work.

Lastly, the project adds to the species inventory list for OWC (see Appendix A).

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Tables

Table 1. Jaccard's similarity indices (%) for all stand type pairings on sample dates.

Sample Date	*Typha* & Unsprayed-*Phragmites*	*Typha* & Sprayed-*Phragmites*	Unsprayed & Sprayed *Phragmites*
19 July	36.1	30.8	38.0
2 Aug.	34.6	37.3	42.9
19 Aug.	41.5	45.8	57.1
13 Sept.	43.5	46.2	42.5

Table 2. Percent (mean ± 1 SE) composition of functional feeding groups in the three stand types. *N* = 4 (sample dates) for each functional feeding group for each stand type.

Functional Feeding Group	*Typha*	Unsprayed-*Phragmites*	Sprayed-*Phragmites*
Engulfers	27.1 ± 5.6	25.3 ± 11.5	28.2 ± 11.0
Piercers	22.2 ± 12.5	18.0 ± 1.3	19.3 ± 9.2
Shredders	3.0 ± 0.3	2.6 ± 2.2	2.0 ± 1.3
Collector-gatherers	21.9 ± 3.4	20.1 ± 8.5	12.7 ± 6.6
Grazers	25.6 ± 15.6	26.7 ± 6.2	35.5 ± 10.0
Scavengers	0.2 ± 0.1	7.2 ± 3.8	2.2 ± 2.2

Table 3. Live stem densities (numbers m^2) and water depths (cm) for the 9 study plots in the 3 stand types. Values are grand means ± 1 SE (n = 4 for each study plot).

Stand Type and Study Plot	Stem density (nos. m^{-2})	Water depth (cm)
Typha 1	37 ± 9	24.3 ± 6.5
Typha 2	23 ± 5	23.2 ± 6.6
Typha 3	23 ± 4	23.9 ± 6.6
Unsprayed-*Phragmites* 1	18 ± 3	39.8 ± 5.2
Unsprayed-*Phragmites* 2	18 ± 4	39.8 ± 4.5
Unsprayed-*Phragmites* 3	29 ± 9	34.9 ± 3.7
Sprayed-*Phragmites* 1	34 ± 11	30.5 ± 4.8
Sprayed-*Phragmites* 2	19 ± 3	33.0 ± 2.7
Sprayed-*Phragmites* 3	22 ± 4	27.4 ± 3.7

Figures

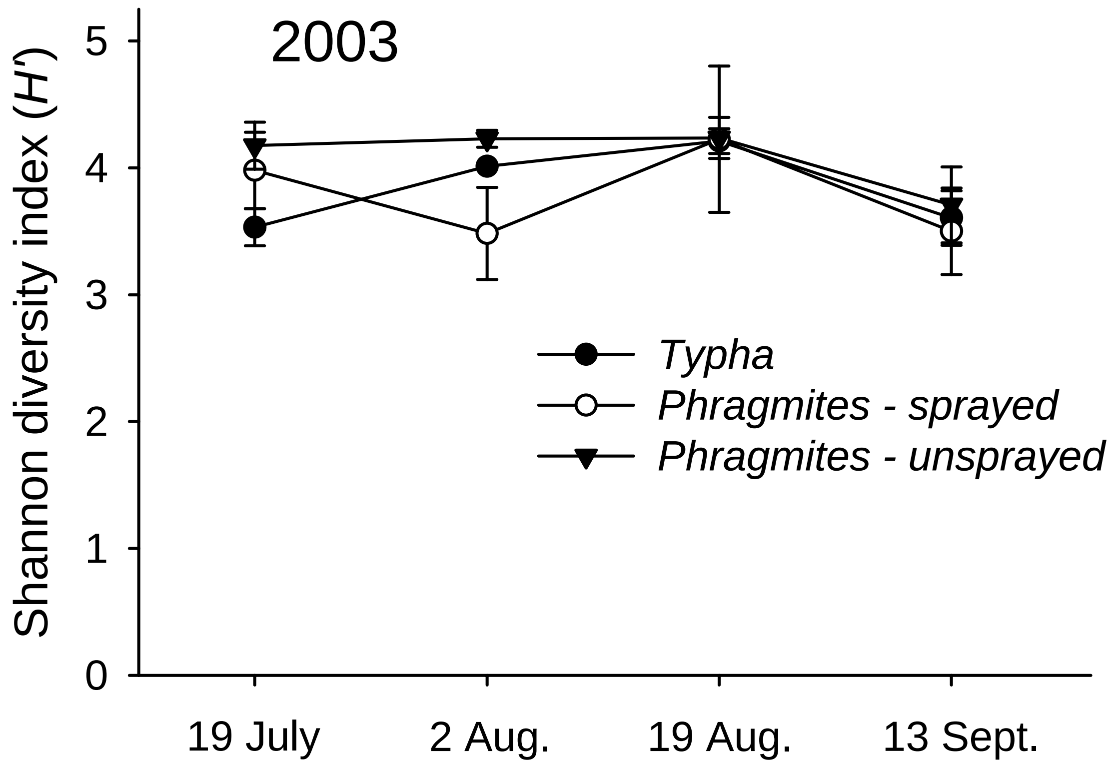

Figure 1. Mean (± 1SE) Shannon diversity indices (*H'*) for benthic macroinvertebrates in stands of *Typha*, herbicide-treated *Phragmites*, and herbicide-free *Phragmites* over the four sample dates in 2003. *N* = 4 indices for each stand type on each date.

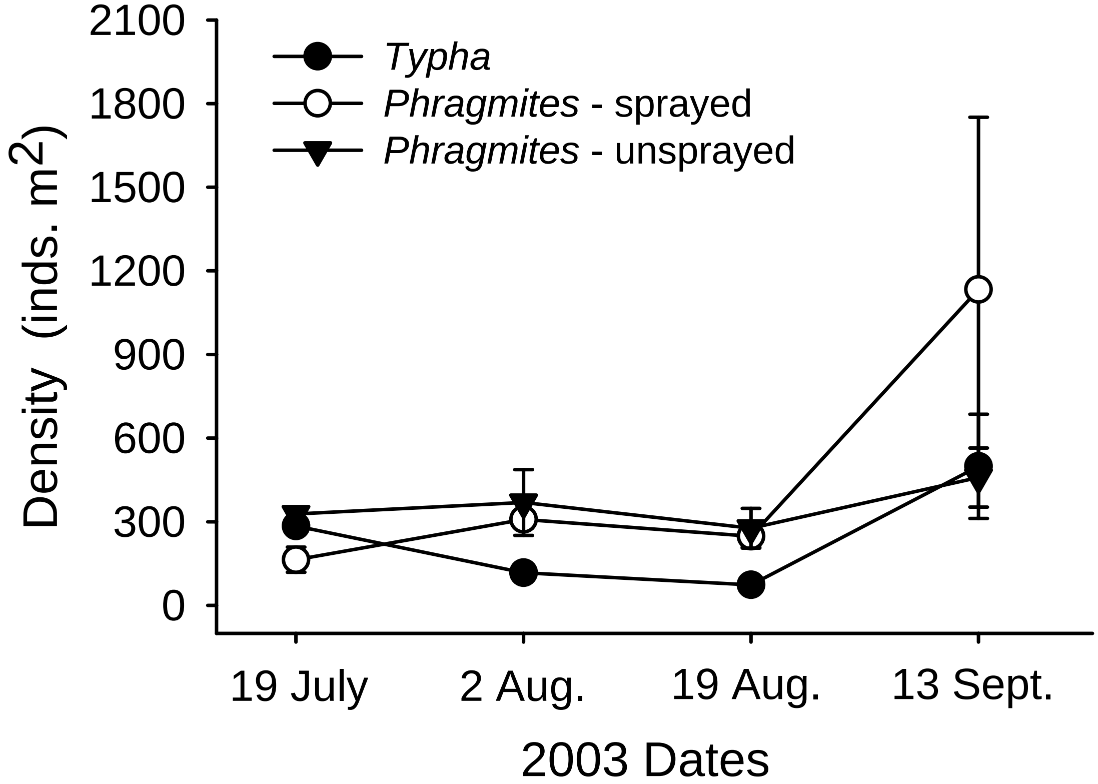

Figure 2. Mean (± 1 SE) densities (individuals m^2) of benthic macroinvertebrates in stand types over the four sample dates.

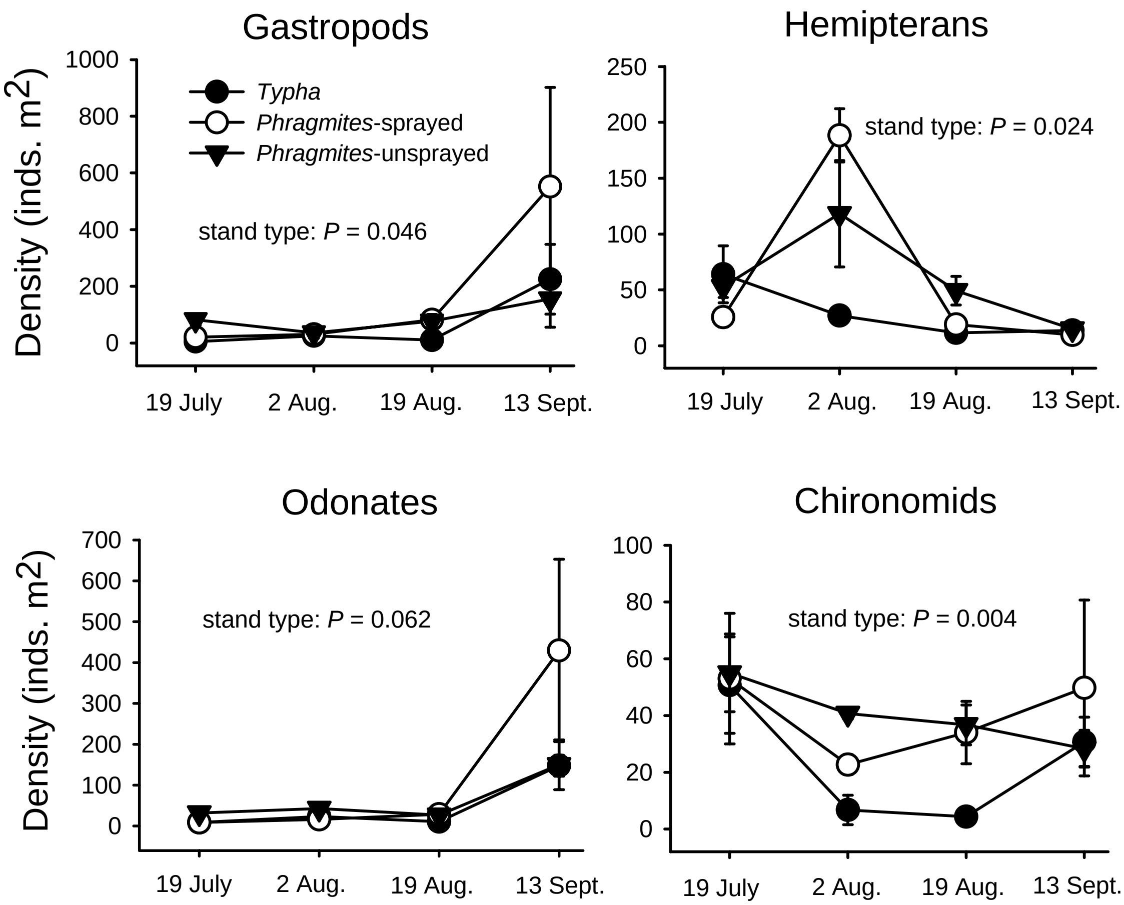

Figure 3. Mean (± 1 SE) densities of the dominant macroinvertebrate taxa in stand types over sampling dates in 2003. $N = 4$ for each stand type on each date for each taxon. Note that density intervals on the y-axis labels differ for each taxon.

Appendix A: List of macroinvertebrates by alphabetical order captured in throw traps in the three stand types over 2003. TU = *Typha* unsprayed, PS = *Phragmites* sprayed with herbicide, and PU = herbicide-free *Phragmites*.

Scientific name	Family	Common name	2003	
Acilius sp.	Dytiscidae	Striped diving beetle	TU	
Aedes sp.	Culicidae	Mosquito	TU, PU, PS	
Aeshna sp.	Aeshnidae	Darners	TU, PU	
Aeshna umbrosa	Aeshnidae	Blue Darner or Paddletail	TU, PU	
Aeshnidae sp.	Aeshnidae	Darners	TU, PU	
Agabus sp. Larvae	Dytiscidae	Diving beetle	TU, PU	
Anacaena limbata	Hydrophilidae	Water scavenger beetle	TU, PU, PS	
Anax junius	Aeshnidae	Big green darner	TU, PU, PS	
Ancyronyx sp. Larvae	Elmithidae	riffle beetle	PU, PS	
Anodontoides ferussacianus	Unionidae	Cylindrical papershell	*	
Asellus sp.	Asellidae	isopods	*	
Baetis sp.	Baetidae	Bluewing olive (mayfly)	TU, PU, PS	
Batracobdella phalera	Glossiphoniidae	leeches	*	
Belastoma flumineum	Belostomatidae	Giant water bug	TU, PU, PS	
Belastoma sp. (immature)	Belostomatidae	Giant water bug	TU, PU	
Berosus infuscatus	Hydrophilidae	Water scavenger beetle	TU	
Berosus peregrinus	Hydrophilidae	Water scavenger beetle	TU, PS	
Berosus sp.	Hydrophilidae	Water scavenger beetle	TU, PU, PS	
Berosus sp. Larvae	Hydrophilidae	Water scavenger beetle	PU, PS	
Bezzia sp.	Ceratopogonidae	biting midges	TU, PU, PS	
Bidessontus sp.	Dytiscidae	Diving beetle	TU	
Caecidotea racovitzai racovitzai	Asellidae	aquatic sowbug (isopods)	PU, PS	
Caecidotea sp.	Asellidae	aquatic sowbug (isopods)	TU	
Caenis sp.	Caenidae	squaregill mayfly	TU, PU, PS	
Carabidae	Carabidae	ground beetle	*	
Ceratopogonidae pupae	Ceratopogonidae	biting midges	TU, PU, PS	
Ceriodaphnia reticulata	Daphnidae	water fleas	*	
Chaoborus sp.	Chaoboridae	phantom midges	PU	

Scientific name	Family	Common name	2003	
Chironomidae pupae	Chironomidae	midge	TU, PU, PS	
Chironominae sp.	Chironomidae	midge	TU, PU, PS	
Chrysomelidae sp. Larvae	Chrysomelidae	leaf beetle	PU, PS	
Cipangopaludina japonicus	Viviparidae	Japanese mystery snail	PU, PS	
Coenagrionidae sp.	Coenagrionidae	Narrow-winged damselfly	TU, PU, PS	
Coptotomus sp. Larvae	Dytiscidae	Diving beetle	PU	
Corduliid sp.	Corduliidae	Emerald dragonfly	TU	
Corixidae immature	Corixidae	Water boatman	TU, PU, PS	
Cragonyx gracilis	Gammaridae	Sideswimmers	*	
Crambus sp.	Pyralidae	close-wings or grass moth	*	
Culex pipiens	Culicidae	Mosquito	TU	
Culex sp.	Culicidae	Mosquito	TU, PU	
Culicidae pupae	Culicidae	Mosquito	TU	
Culicidae sp.	Culicidae	Mosquito	TU, PU	
Curculionidae sp.	Curculionidae	Weevil	TU, PU, PS	
Cybister fimbriolatus	Dytiscidae	Diving beetle	TU	
Cyclopoida sp.	Copepoda	Copepod	*	
Cyphon sp.	Scirtidae	marsh beetles	*	
Derallus sp. Larvae	Hydrophilidae	Water scavenger beetle	PS	
Diamesinae sp.	Chironomidae	midge	TU, PU, PS	
Dineutus sp. Larvae	Gyrinidae	whirligig beetles	PU, PS	
Disonycha sp. Adult	Chrysomelidae	leaf beetle	PU	
Donacia sp. Adult	Chrysomelidae	leaf beetle	PU, PS	
Donacia sp. Larvae	Chrysomelidae	leaf beetle	*	
Dreissena sp.	Dreissenidae	Zebra and Quagga mussels	PU, PS	
Dubiraphia sp.	Elmithidae	riffle beetle	*	
Dytiscidae larvae	Dytiscidae	Diving beetle	PS	
Enallagma civile	Coenagrionidae	civil bluet (damselfly)	TU, PU, PS	
Enallagma exsulans	Coenagrionidae	bluet (damselfly)	PU	
Enallagma signatum	Coenagrionidae	bluet (damselfly)	TU, PU, PS	
Enallagma sp.	Coenagrionidae	bluet (damselfly)	TU, PU, PS	

Scientific name	Family	Common name	2003	
Erythemis simplicicollis	Libellulidae	Common skimmers	*	
Ferrissia parallela	Ancylidae	Oblong ancylid snail	PU, PS	
Forcipomyia sp.	Ceratopogonidae	biting midges	*	
Fossaria sp.	Lymnaeidae	Fossaria snail	TU, PU, PS	
Gammarus pseudolimnaeus	Gammaridae	Sideswimmers	*	
Gammarus sp.	Gammaridae	Sideswimmers	TU, PU, PS	
Gerridae sp.	Gerridae	Water strider	PU, PS	
Gerris sp.	Gerridae	Water strider	TU, PU, PS	
Glossiphoniidae sp.	Glossiphoniidae	leeches	TU	
Gomphidae sp.	Gomphidae	Clubtails	PU	
Gyraulus deflectus	Planorbidae	Flexed gyro snail	TU, PU, PS	
Haliplus immaculicollis	Haplidae	Crawling water beetle	*	
Haliplus sp.	Haplidae	Crawling water beetle	TU	
Haliplus sp.larvae	Haliplidae	Crawling water beetle	TU, PS	
Hebridae immature	Hebridae	Velvet water bug	PS	
Hebridae sp.	Hebridae	Velvet water bug	PU	
Helichus sp.	Dryopidae	long-toed water beetles	TU, PU	
Helicobia sp.	Sarcophagidae	flesh flies	*	
Helisoma anceps anceps	Planorbidae	Two-ridge rams-horn snail	TU, PU, PS	
Helobdella stagnalis	Glossiphoniidae	leeches	TU, PU, PS	
Helophorus linearis	Hydrophilidae	Water scavenger beetle	TU	
Helophorus sp. Larvae	Hydrophilidae	Water scavenger beetle	TU, PU, PS	
Hexatoma sp.	Tipulidae	cranefly	PU, PS	
Hyalella azteca	Talitridae	Sideswimmers	*	
Hydra americana	Hydridae	hydras	*	
Hydrachnida	Acariformes	mites	*	
Hydrobius fuscipes	Hydrophilidae	Water scavenger beetle	PS	
Hydrobius sp. Larvae	Hydrophilidae	Water scavenger beetle	PS	
Hydrocanthus iricolor	Noteridae	Burrowing water beetle	TU, PS	
Hydrocanthus sp. Adult	Noteridae	Burrowing water beetle	*	
Hydrocanthus sp. Larvae	Noteridae	Burrowing water beetle	TU, PU, PS	
Hydrochara sp. Larvae	Hydrophilidae	Water scavenger beetle	PU	
Hydrochus sp.	Hydrophilidae	Water scavenger beetle	*	
Hydrometra martini	Hydrometridae	Water measurer	PU	
Hydrophilus sp. Larvae	Hydrophilidae	Water scavenger beetle	PU	

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Hydroporus sp.	Dytiscidae	Diving beetle	TU	
Hydroporus sp. Larvae	Dytiscidae	Diving beetle	TU, PS	
Hydroptila sp.	Hydroptilidae	micro-caddisflies	*	
Hydrovatus sp.	Dytiscidae	Diving beetle	PS	
Ischnura posita	Coenagrionidae	forktail (damselfly)	PU	
Ischnura ramburi	Coenagrionidae	forktail (damselfly)	TU, PU, PS	
Ischnura sp.	Coenagrionidae	forktail (damselfly)	TU, PU, PS	
Ischnura verticalis	Coenagrionidae	forktail (damselfly)	TU, PU, PS	
Laccobius sp. Adult	Hydrophilidae	Water scavenger beetle	TU, PU, PS	
Laccobius sp. Larvae	Hydrophilidae	Water scavenger beetle	PU	
Laccophilus maculosus maculosus	Dytiscidae	Diving beetle	PU, PS	
Laccophilus sp. Adult	Dytiscidae	Diving beetle	TU	
Laccophilus sp. Larvae	Dytiscidae	predacious diving beetle	TU, PU, PS	
Leptoceridae	Leptoceridae	predacious diving beetle	*	
Lestes sp.	Lestidae	Marsh spreadwing	*	
Leucorrhinia sp.	Libellulidae	White-faced skimmer	*	
Libellula pulchella	Libellulidae	Tenspot dragonfly	PS	
Libellulidae sp.	Libellulidae	Common skimmers	TU, PU, PS	
Limnophila sp.	Tipulidae	cranefly	PS	
Lymnaea megasoma	Lymnaeidae	mammoth lymnaea	*	
Merragata sp.	Hebridae	Velvet water bug	TU, PU, PS	
Mesovelia mulsanti	Mesoveliidae	Water treader	TU, PU, PS	
Mesovelia sp.	Mesoveliidae	Water treader	PS	
Mesoveliidae sp.	Mesoveliidae	Water treader	PU	
Metrobates hesperius	Gerridae	Water strider	PU, PS	
Metrobates sp.	Gerridae	Water strider	PU	
Microcylloepus sp.	Elmithidae	riffle beetle	*	
Microvelia atrata	Vellidae	Small water striders	PU	
Microvelia sp.(immature)	Vellidae	Small water striders	PU, PS	
Musca sp.	Muscidae	house and stable flies	TU, PS	
Nannothemis sp.	Libellulidae	Common skimmers	PU	
Nehalennia sp.	Coenagrionidae	damselfly	PU	
Nepidadae sp.	Nepidae	Water scorpion	PU	

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Neumania sp.	Hydrachnidae	mites	*	
Noctuid sp.	Noctuidae	noctuid moth	PS	
Notonecta irrorata	Notonectidae	Backswimmer	PU, PS	
Notonecta raleighi	Notonectidae	Backswimmer	PU	
Notonecta sp. (immature)	Notonectidae	Backswimmer	PU, PS	
Notonecta undulata	Notonectidae	Backswimmer	PU	
Notonectid immature	Notonectidae	Backswimmer	PS	
Ochrotrichia sp.	Hydroptilidae	micro-caddisflies	*	
Odontomyia sp.	Stratiomyidae	soldier flies	TU, PU, PS	
Oligochaete	Oligochaeta	segmented worm	TU, PU, PS	
Orconectes rusticus	Cambaridae	Rusty crayfish	PU, PS	
Orconectes virilis	Cambaridae	crayfish	PS	
Orthocladiinae sp.	Chironomidae	midge	TU, PU, PS	
Ostrinia nubilalis	Pyralidae	pyralid moths	TU, PU, PS	
Oxeythira sp.	Hydroptilidae	micro-caddisflies	*	
Pachydiplax longipennis	Libellulidae	Blue pirate	TU, PU, PS	
Palaemonetes kadiakensis	Palaemonidae	Mississippi glass shrimp	TU, PU, PS	
Palmacorixa sp.	Corixidae	Water boatman	TU, PU, PS	
Pedicia sp.	Tipulidae	cranefly	TU, PU, PS	
Peltodytes duodecimpunctatus	Haliplidae	Crawling water beetle	TU, PU	
Peltodytes lengi	Haliplidae	Crawling water beetle	TU, PU, PS	
Peltodytes sexmacultus	Haliplidae	Crawling water beetle	TU, PU, PS	
Peltodytes sp. (larvae)	Haliplidae	Crawling water beetle	TU, PU, PS	
Perithemis sp.	Libellulidae	Amber-winged skimmer	PS	
phorid sp.	Phoridae	humpbacked flies	PS	
Physella gyrina	Physidae	Tadpole physa snail	PU, PS	

Scientific name	Family	Common name	2003	
Physella sp.	Physidae	Physa snail	TU, PU, PS	
Plathemis lydia	Libellulidae	Common skimmers		
Podura aquatica	Entomobryidae	Springtails	TU, PU, PS	
Pseudolimnophilia sp.	Tipulidae	cranefly	PU	
Pseudosuccinea columella	Lymnaeidae	Mimic lymnaea snail	TU, PU, PS	
Psychodidae pupae	Psychodidae		PS	
Pyralidae larvae	Pyralidae	pyralid moths	PS	
Pyralidae pupae	Pyralidae	pyralid moths	PS	
Ranatra sp.	Nepidae	Sticklike water scorpion	PS	
Rheumatobates tenuipes	Gerridae	Water strider	PU	
Salididae	Saldidae	Shore bug	TU	
Sciomyzid sp.	Sciomyzidae	marsh flies	TU, PS	
Stagnicola elodes	Lymnaeidae	snail	*	
Stenelmis sp. Adult	Elmithidae	riffle beetle	PU	
Stenelmis sp. Larvae	Elmithidae	riffle beetle	PU	
Stratiomys sp.	Stratiomyidae	soldier flies	PU, PS	
Sympetrum rubicundulum	Libellulidae	Red skimmer	PU, PS	
Sympetrum semicinctum	Libellulidae	Red skimmer	PS	
Sympetrum sp.	Libellulidae	Skimmer	TU, PS	
Tanypodinae sp.	Chironomidae	midge	TU, PU, PS	
Tipula sp.	Tipulidae	cranefly	TU, PU, PS	
Tipulidae pupae	Tipulidae	cranefly	TU	
Tramea carolina	Libellulidae	Raggedy skimmer	TU	
Tramea lacerata	Libellulidae	Skimmer	TU, PU, PS	
Tramea sp.	Libellulidae	Skimmer	TU, PS	
Trepobates sp.	Gerridae	Water strider	PU	
Trichorcorixa sp.	Corixidae	Water boatman	PU, PS	
Tropisternus lateralis nimbatus	Hydrophilidae	Water scavenger beetle	*	
Tropisternus sp. Larvae	Hydrophilidae	Water scavenger beetle	TU, PU, PS	

* Captured at OWC in 2004 but not in 2003.