Supplemental Materials

Methods: Non metric Multidimensional Scaling

To describe the species structure of the macrophyte assemblages across lakes and study plots we used Non-metric Multidimensional Scaling (NMS) in PC-ORD v6.30 (McCune, B.; Mefford, M.J. PC-ORD, Version 7.08 (Software), 2018). NMS ordination was resolved using "slow and thorough" defaults, which uses Sorensen distance measures, random starting position, 250 runs of real data, and 250 runs with randomized data through six to one-dimensional solutions. The main matrix composed of standing crop values of macrophytes for 12 sites x 25 species (Table S1); to achieve a stable ordination solution it was logarithmically transformed to reduce extreme left skewedness of distribution of standing crops while still preserving the original orders of magnitudes [1]. After transformation, rare species that were present only once in the matrix were removed, resulting in a transformed matrix of 12 sites x 15 species (Table S2). Rare species were removed as they can have disproportionate effects on multivariate analyses and contribute little to understanding general community relationships [2].

Results: Non metric Multidimensional Scaling

The NMS analysis of macrophyte assemblage produced an ordination from 87 iterations resolving a four-dimensional solution, stress of 1.15, and final stability < 0.00001 (Figure S1). 84% of variance of structure was captured by 3 of the ordination axes. Differences in ordination space between +IWM and -IWM plots were generally driven by differences in abundance of native macrophyte species and IWM (Figure S1, Table S3). The first axis (Axis 1) represented 57% of the variance. Macrophytes with strong positive correlation to Axis 1 were *Potamogeton robbinsii, P. amplifolius*, and IWM, while macrophytes with a strong negative correlation with Axis 1 were *Vallisneria americana*, *Najas flexilis, P. gramineus, Ceratophyllum demersum,* and *Bidens beckii* (Table S3). The second axis (Axis 2) represented 16% of the variance. Macrophytes with strong positive correlation to Axis 2 were *Elodea canadensis, B. beckii, Utricularia macrorhiza, P. richardsonii, C. demersum,* and IWM. Macrophytes with a strong negative correlation with Axis 2 were *N. flexilis* and *P. gramineus* (Table S3). The third axis (Axis 3) represented 11% of the variance. Macrophytes with strong positive correlation to Axis 3 were *B. beckii* and *P. robbinsii*, and macrophytes with strong negative correlations were *Chara* spp., *N. guadalupensis*, *P. zoosteriformis*, and *N. flexilis* (Table S3).

Table S1 (part 1 of 2). Matrix of macrophyte species standing crops (g m^{-2}) at study plots

Waterbody	Plot type	*Bidens beckii*	*Cerato-phyllum demersum*	*Chara* spp.	*Elodea cana-densis*	*Hetern-thera dubia*	Invasive Water-milfoil[1]	*Isoetes lacus-tris*	*Isoetes tenella*	*Najas flexilis*	*Najas guada-lupensis*	*Nymph-aea odorata*	*Potamo-geton ampli-folius*	*P. gramin-eus*
Horseshoe Lake	-IWM	0	0	109.59	0	0	5.27	0	0	0.13	1.97	0	0	0
	+IWM	0	0	0.36	0	0	20.55	0	0	1.09	0.04	0	0	0.37
Lake St. Helen	-IWM	1.52	0	0	0.16	0	1.04	0	0	0	0	0.39	0	9.75
	+IWM	0	0	6.28	28.98	0	67.93	0	0	0	3.43	0	0	0
Islington Bay of Lake Huron	-IWM	0	0	2.18	0	0.06	0	0	0	28.47	0	0	0	121.54
	+IWM	0	0.69	3.63	3.26	0	87.23	0	0	6.18	0	0	0	0.48
Sturgeon Sloughs of Portage Lake	-IWM	0.37	0.31	2.18	0.3	0.01	0	0	0	0.14	0	0	0	0
	+IWM	23.41	1.09	13.45	17.09	1.39	45.47	0	0	0	0	0	0	0
Iron Lake	-IWM	0	0	2.54	0	0	4.34	0	0	0	0	0	60.62	0
	+IWM	0	0	0	0	0	164.27	0	0	0	0	0	10.74	0
Torch Lake	-IWM	0.13	0.03	0.03	0	0	0	0.43	0.8	0.05	0	0	0	6.48
	+IWM	0.75	0	0	2.47	0	154.57	0	0	0	0	0	0	1.83

[1] Invasive water milfoil are possible mixtures of *Myriophyllum spicatum* and hybrids of *M. spicatum* with Northern watermilfoil (*M. spicatum* x *sibiricum*).

Table S1 (part 2 of 2). Matrix of macrophyte species standing crops (g m^{-2}) at study plots

Waterbody	Plot type	*P. oakesianus*	*P. perfoliatus*	*P. pusillus*	*P. richardsonii*	*P. robbinsii*	*P. vaseyi*	*P. zosterformis*	*Ranunculas aquatilis*	*Ranunculus flammula*	*Stuckenia pectinata*	*Utricularia macrorhiza*	*Vallisneria americana*
Horseshoe Lake	-IWM	0	0	0	0.77	0	0	2.66	0	0	0	0	0
	+IWM	1.03	0	0	0	0	0	1.12	0	0	0	0	0
Lake St. Helen	-IWM	0	0	0	0	294.73	0	0	0	0	0	0.01	0.14
	+IWM	0	1.5	0	0	84.15	0	4.14	0	0	0	0	0
Islington Bay of Lake Huron	-IWM	0	0	0	0	0	0	0	0	0	0	0	1.83
	+IWM	0	0	0	0	0	0	8.59	0	0	0	0	25.14
Sturgeon Sloughs of Portage Lake	-IWM	0	0	0	8.11	0	0	0	0	0	0	0	120.82
	+IWM	0	0	0	2.42	0	0.82	0	0.16	0	0	0.56	63.99
Iron Lake	-IWM	0	0	0	0	15.96	0	0	0	0	0	0	0
	+IWM	0	0	0	0	64.99	0	0	0	0	0	0	0
Torch Lake	-IWM	0	0	0	0	0	0	0	0	0.31	0	0	7.38
	+IWM	0	0	0.19	0	0	0	4.75	0	0	0.49	0	7.77

Table S2. Reduced and logarithmic transformed[2] matrix of macrophyte species used for NMS ordination analysis

Waterbody	Plot type	*Bidens beckii*	*Ceratophyllum demersum*	*Chara* spp.	*Elodea canadensis*	*Heterthera dubia*	Invasive Watermilfoil[1]	*Najas flexilis*	*Najas guadalupensis*	*P. amplifolius*	*P. gramineus*	*P. richardsonii*	*P. robbinsii*	*P. zosteriformis*	*Utricularia macrorhiza*	*Vallisneria americana*
Horseshoe Lake	-IWM	0	0	5.04	0	0	3.72	2.13	3.30	0	0	2.89	0	3.43	0	0
	+IWM	0	0	2.56	0	0	4.31	3.04	1.57	0	2.56	0	0	3.05	0	0
Lake St. Helen	-IWM	3.18	0	0	2.14	0	3.02	0	0	0	3.99	0	5.47	0	0.81	2.14
	+IWM	0	0	3.78	4.46	0	4.83	0	3.54	0	0	0	4.93	3.62	0	0
Islington Bay of Lake Huron	-IWM	0	0	3.34	0	1.77	0	4.45	0	0	5.08	0	0	0	0	3.26
	+IWM	0	2.84	3.56	3.51	0	4.94	3.79	0	0	2.69	0	0	3.93	0	4.40
Sturgeon Sloughs of Portage Lake	-IWM	2.56	2.50	3.34	2.47	1.15	0	2.15	0	0	0	3.91	0	0	0	5.08
	+IWM	4.37	3.04	4.12	4.23	3.14	4.66	0	0	0	0	3.38	0	0	2.75	4.81
Iron Lake	-IWM	0	0	3.40	0	0	3.64	0	0	4.78	0	0	4.20	0	0	0
	+IWM	0	0	0	0	0	5.22	0	0	4.03	0	0	4.81	0	0	0
Torch Lake	-IWM	2.11	1.48	1.53	0	0	0	1.71	0	0	3.81	0	0	0	0	3.87
	+IWM	2.88	0	0	3.39	0	5.19	0	0	0	3.26	0	0	3.68	0	3.89

[1] Invasive water milfoil are possible mixtures of *Myriophyllum spicatum* and hybrids of *M. spicatum* with Northern watermilfoil (*M. spicatum* x *sibiricum*)

[2] Logarithmic transformation follows this equation $b_{ij} = \log_{10}(x_{ij}+\log^{-1}(\text{Int}(\log(\text{Min}(x)))) - (\text{Int}(\log(\text{Min}(x)))$ where: Min(x) is the smallest nonzero value in the data and Int(x) is a function that truncates x to an integer with no decimal places (McCune and Grace 2002).

Table S3. Correlations of macrophyte species with NMDS ordination axes.

	Axis 1		Axis 2		Axis 3	
Species	***r***	***R*²**	***r***	***R*²**	***r***	***R*²**
Utricularia macrorhiza	-0.09	0.01	0.57	0.32	0.26	0.07
Chara spp.	-0.09	0.01	0.13	0.02	-0.71	0.50
P. richardsonii	-0.27	0.07	0.54	0.29	-0.29	0.08
Ceratophyllum demersum	-0.54	0.29	0.47	0.22	0.04	0.00
Vallisneria americana	-0.83	0.69	0.32	0.10	0.29	0.08
Elodea canadensis	-0.11	0.01	0.86	0.74	0.09	0.01
IWM	0.66	0.44	0.42	0.18	-0.17	0.03
P. robbinsii	0.77	0.59	0.00	0.00	0.48	0.23
P. zosteriformis	0.10	0.01	0.26	0.07	-0.67	0.45
P. amplifolius	0.72	0.51	-0.36	0.13	0.29	0.08
Najas flexilis	-0.57	0.33	-0.49	0.24	-0.51	0.26
Najas guadalupensis	0.35	0.12	0.18	0.03	-0.69	0.48
P. gramineus	-0.56	0.32	-0.46	0.21	0.27	0.07
Bidens beckii	-0.43	0.19	0.61	0.37	0.52	0.27
Heteranthera dubia	-0.39	0.15	0.28	0.08	0.07	0.01

Table S4. Pairwise comparison of variables for stepwise multiple linear regressions. Pearson correlations (*r*) are on the lower left and p values listed are gray on the upper right shaded in grey for each pairwise comparison. Significant collinearity was determined as $p \leq 0.05$ (bold).

	Light extinction	**Water temperature**	**Conductivity**	**TDN**	**DOC**	**NO_3^-+NO_2^- [1]**	**NH_4^+ [†]**	**Macrophyte standing crop**	**Benthic periphyton Chla[1]**	**Epiphyte Chla[1]**	**Phytoplankton Chla[1]**	**Benthic periphyton AFDM[1]**	**Epiphyte AFDM[1]**	**Phytoplankton AFDM[1]**	**Benthic periphyton GPP**	**Epiphyte GPP[1]**	**Phytoplankton GPP**	**GPP plot[1]**	**ER plot[1,2]**
Light extinction	-	0.25	**0.01**	0.08	0.00	0.17	0.70	0.65	0.56	0.89	0.09	0.20	0.35	0.86	0.35	0.68	0.51	0.82	0.92
Water temperature	-0.36	-	**0.04**	0.15	0.66	0.22	**0.01**	0.70	0.23	0.34	0.19	0.45	0.40	0.04	0.21	0.36	**0.01**	0.95	0.06
Conductivity	-0.72	0.61	-	0.45	0.11	0.97	0.51	0.54	0.53	0.31	0.22	0.27	0.73	0.20	0.08	0.46	0.32	0.72	0.32
TDN	0.52	0.45	-0.24	-	**0.00**	**0.01**	**0.05**	0.54	0.99	0.27	**0.00**	0.74	0.14	0.11	0.99	0.14	0.09	0.90	0.25
DOC	0.79	0.14	-0.49	0.88	-	**0.05**	0.39	0.17	0.42	0.55	**0.00**	0.87	0.21	0.42	0.39	0.37	0.58	0.86	0.44
NO_3^-+NO_2^- [1]	-0.43	-0.38	-0.01	-0.71	-0.58	-	0.13	0.71	0.35	0.22	0.13	0.17	0.10	0.11	0.40	0.23	0.05	0.57	0.46
NH_4^+ [1]	-0.12	0.75	0.21	0.58	0.27	-0.46	-	0.64	0.07	0.32	0.09	0.89	0.24	0.22	0.32	0.22	**0.01**	0.17	0.63
Macrophyte standing crop	0.15	0.13	-0.20	0.20	0.43	0.12	-0.15	-	**0.03**	0.19	0.17	**0.05**	0.38	0.96	**0.04**	0.20	0.59	0.32	0.74
Benthic periphyton chlorophyll a (Chla)[1]	-0.19	0.37	0.20	0	-0.25	-0.29	0.54	-0.61	-	0.65	0.94	0.06	0.65	0.80	**0.05**	0.73	0.74	0.23	0.76
Epiphyte Chla[1]	-0.04	-0.30	-0.32	-0.34	-0.19	0.38	-0.31	0.40	-0.15	-	0.65	0.53	**0.00**	**0.04**	0.25	**0.00**	0.07	0.35	0.04
Phytoplankton Chla[1]	0.51	0.41	-0.38	0.80	0.80	-0.47	0.51	0.42	0.03	-0.15	-	0.75	0.28	0.33	0.22	0.49	0.31	0.44	0.30
Benthic periphyton ash-free dry mass (AFDM)[1]	-0.40	0.24	0.34	-0.11	-0.05	0.43	0.05	0.58	-0.56	0.20	-0.10	-	0.42	0.78	0.52	0.58	0.49	0.78	0.85
Epiphyte AFDM[1]	-0.30	-0.27	-0.11	-0.45	-0.39	0.50	-0.37	0.28	-0.15	0.92	-0.34	0.26	-	**0.03**	0.40	**0.00**	0.08	0.42	0.10
Phytoplankton AFDM[1]	-0.06	0.60	0.40	0.49	0.26	-0.49	0.38	-0.02	0.08	-0.60	0.31	-0.09	-0.62	-	0.27	**0.02**	**0.01**	0.73	0.08
Benthic periphyton gross primary production (GPP)	-0.30	0.39	0.53	0	-0.27	-0.27	0.31	-0.61	0.57	-0.36	-0.38	-0.21	-0.27	0.34	-	0.32	0.08	0.64	0.32
Epiphyte GPP[1]	-0.13	-0.29	-0.24	-0.45	-0.29	0.37	-0.38	0.40	-0.11	0.95	-0.22	0.18	0.91	-0.67	-0.32	-	0.09	0.41	0.13
Phytoplankton GPP	-0.21	0.71	0.32	0.51	0.18	-0.57	0.70	-0.18	0.53	-0.54	0.32	-0.22	-0.52	0.71	0.53	-0.51	-	0.80	0.07
GPP plot[1]	-0.07	-0.02	0.12	0.04	0.06	-0.18	-0.43	0.32	-0.37	0.15	-0.25	0.09	0.26	0.11	0.15	0.26	0.08	-	0.39
Ecosystem respiration (ER) plot[1,2]	0.03	-0.56	-0.31	-0.36	-0.25	0.24	-0.16	-0.11	-0.10	0.59	-0.33	0.06	0.50	-0.53	-0.32	0.47	-0.54	-0.27	-

[1] log transformed

[2]converted from positive values from negative values

- not applicable

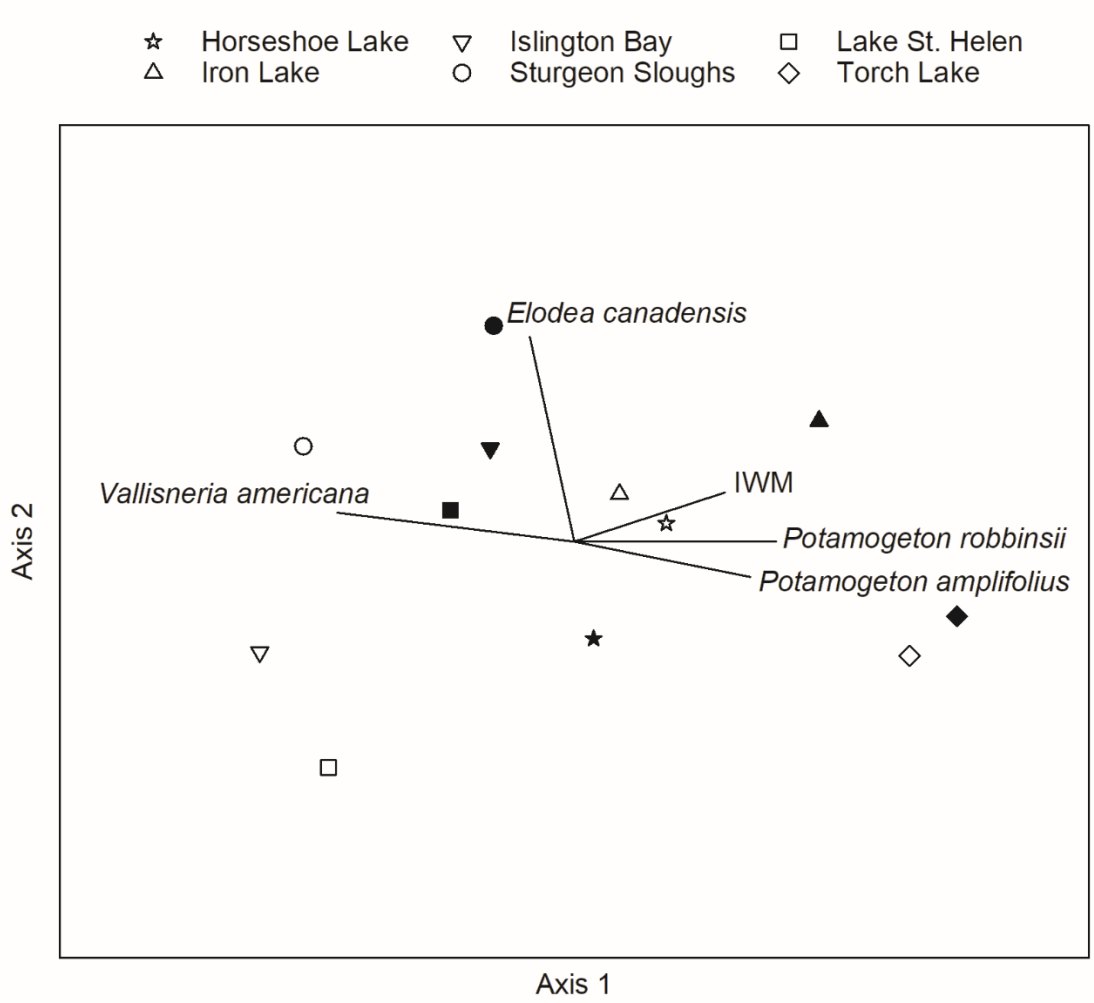

Figure S1. NMS ordination of paired plots in species space. Shaded symbols represent +IWM plots and unshaded symbols represent -IWM plots for each respective waterbody. Lines represent joint plots of macrophyte species variables (r^2 cutoff = 0.40, Table S5). Species shown are *Vallisneria americana* (Axis 1 $R^2 = 0.69$, Axis 2 $R^2 = 0.10$), *Elodea canadensis* (Axis 1 $R^2 = 0.01$, Axis 2 $R^2 = 0.74$), IWM (Axis 1 $R^2 = 0.44$, Axis 2 $R^2 = 0.18$), *Potomogeton robbinsii* (Axis 1 $R^2 = 0.59$, Axis 2 $R^2 = 0.00$), and *P. amplifolius* (Axis 1 $R^2 = 0.51$, Axis 2 $R^2 = 0.13$). Not shown are *Chara* spp. (Axis 3 $R^2 = 0.50$), *P. zosteriformis* (Axis 3 $R^2 = 0.45$), and *Najas guadalupensis* (Axis 3 $R^2 = 0.50$).

References

1. McCune, B.; Grace, J.B. *Analysis of Ecological Communities.* MjM Software Design: Oregon, USA, 2002.
2. Jackson, D.A.; Harvey, H.H. Biogeographic associations in fish assemblages: local vs. regional processes. *Ecology* **1989**, *70*, 1472-1484.