Net primary productivity of macrophyte communities after seven growing seasons in experimental planted and unplanted marshes

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Introduction

One of the wetland functions estimated every year in the experimental marshes at the ORWRP is the aboveground net primary productivity (NPP) of the wetland macrophyte communities. Productivity indicates the general health of the wetland community and its trophic status. NPP is an indicator of biomass that can be utilized by heterotrophs. The assessment of the vegetation in a newly created wetland through the measurement of NPP, coupled with estimations of plant structure such as diversity and cover, provide essential data on the functional capacity of the macrophyte communities.

Direct measurements of macrophyte primary productivity were first made at the experimental wetland basins at the Olentangy River Wetland Research Park (ORWRP) in 1997. This study in 2000 represents the fourth set of such measurements. Before 1997 (the fourth growing season), harvesting was not considered a good option when vegetation was just getting started in the basins. By the fourth year (1997), we determined that limited harvesting of plants to estimate the productivity of the system was possible without affecting the general succession and productivity of the overall system.

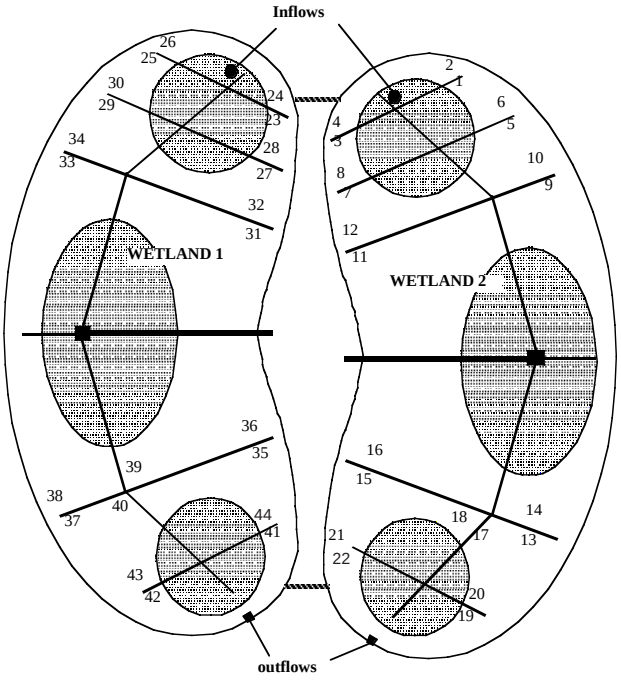

Figure 1. Sampling stations used for macrophyte harvesting, August 2000.

Methods

Aboveground net primary productivity (NPP) was estimated by harvesting peak biomass at the end of the growing season (end of August 2000) at selected stations in the two experimental wetland basins at the ORWRP (Figure 1). The same stations established from the boardwalk system in 1997 (Mitsch and Bouchard, 1998) and used in 1998 and 1999 were visited again in 2000. To avoid harvesting the exact same spots, quadrats were not established at points were there had been harvesting in previous years. In each station, we used 1-m^2 quadrats to delineate the area of vegetation for harvest. When no vegetation was present, the station was skipped. Overall, there are potentially 22 stations in each wetland (increased by one in 2000 from previous years). Only 16 quadrats were sampled in each wetland, 8 out of 12 in the northern or inflow half of each basin and 8 out of 10 in the southern or outflow half of each basin. In each quadrat, plants were clipped at ground level (water was lowered in the wetlands to make sampling easier and to allow rapid recovery of the clipped plants). Samples were segregated both by quadrat and by species, placed in plastic bags and weighed in the field with a hanging balance (accuracy ± 40 g). Sub-samples were taken to the laboratory where both wet weight and dry weight (dried at 105°C for 48 hours) were determined to estimate dry/wet ratios. Average ratios for each species were multiplied by total wet weight of each species in a quadrat to estimate total dry weight production. The sum of all species in a quadrat was the estimated peak biomass and hence annual aboveground net primary productivity (NPP).

Results and Discussion

Comparison of Basins and Location

In 2000, macrophyte aboveground NPP was 482±64 g m^{-2} yr^{-1} in the planted Wetland 1 and 1013±105 g m^{-2} yr^{-1} in the naturally colonizing Wetland 2 (Table 1). Productivity decreased by 27% in Wetland 1 while remaining about the same in Wetland 2 from 1999 to 2000 (1999 rates: 657±76 g m^{-2} yr^{-1} in Wetland 1 and 1023±94 g m^{-2} yr^{-1} in Wetland 2

(Table 1). Overall, macrophyte plot productivity continued to be statistically higher (α = 0.05) in the colonizing Wetland 2 than in the planted Wetland 1 seven growing seasons after planting. Productivity also continued to be significantly higher near the outflow than the inflow in the naturally colonizing Wetland 2 but productivity was 62% higher near the inflow compared to the outflow in Wetland 1 (Figure 2).

Dry/wet Ratios

As in the previous annual reports, dry/wet ratios of individual plants which are necessary for estimating NPP are provided (Table 2). Dry/wet ratios ranged from 25-35% for *Schoenoplectus* over the past two years to 13-15% for *Sagittaria*. *Typha* had a dry/wet ratio of 26-31%.

Comparison with Previous Years

Overall, macrophyte NPP decreased in 2000 in Wetland 1 and remained about the same in Wetland 2 (Figure 3). In 1999 NPP averaged 657 in Wetland 1 and 1023 in Wetland 2. In 1998, NPP averaged 729 g m^{-2} y^{-1} in Wetland 1 and 1127 g m^{-2} yr^{-1} in Wetland 2 for the areas covered by macrophytes (Figure 3). The productivity in Wetland 2 was significantly higher than the productivity of Wetland 1 (t-test, n=16, α=0.05). Overall, productivity per unit area in the last three years (1998-2000) has remained high and consistent in the naturally colonizing Wetland 2 because of the dominance of *Typha*. Productivity in Wetland 1, the planted wetland, has consistently dropped over the past 3 years to where it is now only 48% of the productivity of Wetland 1.

Species Dominating the Productivity

As was the case in 1998, the species harvested in the two basins indicate differences that are still attributable to the planting of 1994 (Figure 4). Wetland 1, which was planted with 12 species in May 1994, had 3 of those species contributing significantly to macrophyte productivity (*Schoenoplectus tabernaemontani*, *Sparganium eurycarpum*, and *Sagittaria latifolia*). These species represented 55% of the macrophyte aboveground productivity in the harvested quadrats in 2000. In comparison, these three species plus another planted species *Scirpus fluviatilis* represented 67% of the productivity in 1999 and 90% of the productivity in 1998. Of the three introduced species still predominant in Wetland 1 in 2000, the order of most importance were *Sparganium* > *Schoenoplectus tabernaemontani* > *Sagittaria*. *Scirpus fluviatilis* almost completely disappeared from Wetland 1 in 2000 and did not appear at all in the productivity sample plots.

Colonizing *Typha* provided the remaining 33% of the aboveground productivity in 2000 in Wetland 1. *Typha* contribution to the wetland NPP in the planted Wetland 1 was 33% in 1999, 10% in 1998, and 14% in 1997, (Mitsch and Bouchard, 1998; Bouchard and Mitsch, 1999, 2000). *Typha* was found in 6 quadrats in Wetland 1, all in the

Table 1. Estimated net above-ground primary productivity (NAPP) of macrophyte communities in the Olentangy River experimental wetlands, late August 1999 and 2000, based on peak biomass harvest. Numbers are ave±std error [# samples].

Wetland/ Year	Total NPP, g m^{-2} yr^{-1}	Inflow NPP, g m^{-2} yr^{-1}	Outflow NPP, g m^{-2} yr^{-1}
Wetland 1			
1999	657±76 [16]	601±126 [8]	714±90 [8]
2000	482±64 [16]	597±87 [8]	368±79 [8]
Wetland 2			
1999	1023±94 [16]	790±75 [8]	1256±130 [8]
2000	1013±105 [16]	882±126 [8]	1144±163 [8]

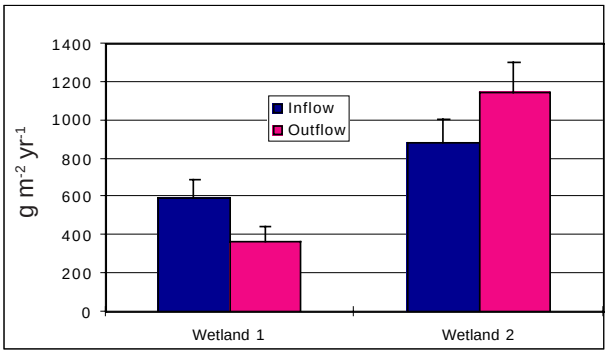

Figure 2. Aboveground net primary productivity in Wetland 1 and 2 in inflow and outflow areas for 2000.

Table 2. Dry/wet ratios (ave±std error (# samples)) of dominant macrophytes in the Olentangy River wetlands in 1999.

Species/	Wetland 1	Wetland 2
Schoenoplectus tabernaemontani		
1999	0.35±0.01 (13)	0.33±0.01 (14)
2000	0.25±0.30 (6)	
Scirpus fluviatilis		
1999	0.30±0.01 (4)	
2000	na	
Sagittaria latifolia		
1999	0.13±0.02 (4)	
2000	0.15±0.07 (4)	
Sparganium eurycarpum		
1999	0.23±0.00 (11)	
2000	0.24±0.07 (8)	
Typha spp.		
1999	0.26±0.00 (4)	0.26±0.01 (15)
2000	0.30±0.07 (7)	0.31±0.04 (16)

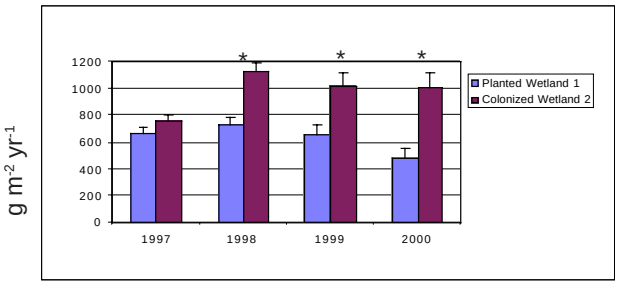

Figure 3. Aboveground net primary productivity for 1997-2000 in the experimental wetlands. * indicates significant differences between the two wetlands (α=0.05).

outflow half of the wetland. It was found in only 4 quadrats in 1999, 5 quadrants in 1998 and 7 quadrats in 1997. It appeared to be losing dominance for several years until 2000 when it became a more important producer of biomass in Wetland 1. The opposite pattern appeared with *Sparganium* which decreased to 8 quadrats in 2000 in Wetland 1 after it was found in 11 quadrats in 1999, 9 quadrats in 1998 and 7 in 1997.

Only one taxa (*Typha* spp.) was found in the naturally colonizing Wetland 2. *Schoenoplectus tabernaemontani*, which contributed 19% of the productivity in Wetland 2 in 1999, has almost completely disappeared from Wetland 2 between 1999 and 2000 where it was also a colonizer. Between 1997 and 2000, we observed a rapid increase of *Typha* dominance in Wetland 2. In 1997, *Typha* spp. contributed only 15% of the NPP; in 1998, it contributed up to 48% of the production; in 1999 it contributed 81% of the NPP; and in 2000 it contributed 100%.

Autochthonous Carbon Sources from Macrophytes

Based on the aboveground productivity estimates and the estimates of vegetation cover presented elsewhere in this annual report (Mitsch et al., 2001 in this annual report; W1 = 4068 m^2; W2 = 4210 m^2), aboveground productivity by macrophytes is an estimated 1960 kg and 4265 kg per year in Wetlands 1 and 2 respectively. [This is calculated as the overall NPP in Table 1 multiplied by the "vegetation cover" in Mitsch et al., 2001; this report]. These numbers are lower than the 3300-3500 kg and 5800-6800 kg in Wetland 1 and Wetland 2, respectively calculated for 1998 and 1999. Both the productivity per unit area and the overall macrophyte cover in the basins led to this decline in carbon sequestration in 2000.

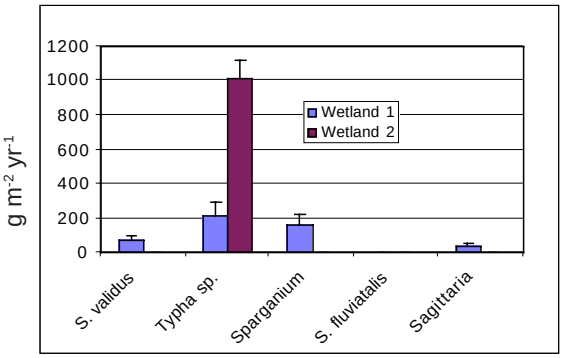

Figure 4. Distribution of peak biomass in August 2000 in the two experimental wetland basins.The 4 species other than *Typha* were planted in May 1994 in Wetland 1. Three of those species remain as *Scirpus fluviatilis* disappeared in 2000. Wetland 2 was left as an umplanted control and was dominated by *Typha* in 2000.

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Appendix A. Harvested wet weight of plants in ORW experimental wetlands, August 2000. Station locations are shown in Figure 1. Weights are kg wet wt/m^2.

Station #	S. validus	Typha sp.	Sparganium	S. fluviatalis	Sagittaria	Total
Wetland 2						
1	0.0	3.3	0.0	0.0	0.0	3.3
2	0.0	4.4	0.0	0.0	0.0	4.4
3	skipped	skipped	skipped	skipped	skipped	skipped
4	0.0	2.9	0.0	0.0	0.0	2.9
5	0.0	4.9	0.0	0.0	0.0	4.9
6	0.0	3.4	0.0	0.0	0.0	3.4
7	skipped	skipped	skipped	skipped	skipped	skipped
8	0.0	2.4	0.0	0.0	0.0	2.4
9	0.0	2.0	0.0	0.0	0.0	2.0
10	skipped	skipped	skipped	skipped	skipped	skipped
11	0.0	1.1	0.0	0.0	0.0	1.1
12	skipped	skipped	skipped	skipped	skipped	skipped
13	0.0	1.4	0.0	0.0	0.0	1.4
14	0.0	2.2	0.0	0.0	0.0	2.2
15	0.0	5.0	0.0	0.0	0.0	5.0
16	skipped	skipped	skipped	skipped	skipped	skipped
17	0.0	3.2	0.0	0.0	0.0	3.2
18	skipped	skipped	skipped	skipped	skipped	skipped
19	0.0	5.2	0.0	0.0	0.0	5.2
20	0.0	3.4	0.0	0.0	0.0	3.4
21	0.0	4.1	0.0	0.0	0.0	4.1
22	0.0	3.2	0.0	0.0	0.0	3.2
TOTAL	0.0	52.2	0.0	0.0	0.0	52.2
AVERAGE	0.00	3.26	0.00	0.00	0.00	3.26
# OBSERV	16	16	16	16	16	16

Station #S. tabernaemontani		Typha sp.	Sparganium	S. fluviatalis	Sagittaria	Total
Wetland 1						
23	0.0	0.0	2.7	0.0	0.00	2.7
24	0.0	0.0	1.9	0.0	0.00	1.9
25	skipped					
26	0.0	0.0	1.2	0.0	0.00	1.2
27	0.0	0.0	2.4	0.0	0.17	2.6
28	0.0	0.0	1.1	0.0	0.00	1.1
29	skipped					
30	skipped					
31	0.0	3.4	0.0	0.0	1.54	4.9
32	0.0	2.8	0.0	0.0	0.77	3.6
33	0.0	2.4	0.0	0.0	0.00	2.4
34	skipped					
35	0.3	2.0	0.0	0.0	0.0	2.4
36	0.5	0.8	0.0	0.0	0.0	1.3
37	skipped			0.0		
38	1.3	0.0	0.5		0.0	1.8
39	1.5	0.0	0.0	0.0	0.0	1.5
40	0.5	0.0	0.0	0.0	0.0	0.5
41	0.0	0.3	0.6	0.0	0.0	0.9
42	0.3	0.0	0.5	0.0	0.0	0.8
43	skipped					
44	0.0	1.0	0.0	0.0	0.0	1.0
TOTAL	4.4	12.8	11.0	0.0	2.5	30.6
AVERAGE	0.27	0.80	0.68	0.00	0.16	1.91
# OBSERV	16	16	16	16	16	16

Appendix B. Laboratory-measured dry/wet ratios from sub-samples for species harvested in experimental wetlands in August 2000. *Schoenoplectus* = *Schoenoplectus tabernaemontani*; *S. fluviatalis* = *Scirpus fluviatalis*; *Sagittaria* = *Sagittaria latifolia*; *Sparganium* = *Sparganium eurycarpum*. Sampling stations (Stations) shown in Figure 1. Weights are in grams.

Wetland 1

St. #	Species	Wet	Dry	Dry/wet
27	Sagittaria	153.9	15.4	0.100
31	Sagittaria	334.5	85.1	0.254
32	Sagittaria	359.3	36.9	0.103
35	Sagittaria	4	0.5	0.125
35	Schoenoplectus	270.7	63.4	0.234
36	Schoenoplectus	462.9	106.2	0.229
38	Schoenoplectus	257.5	56.1	0.218
39	Schoenoplectus	225.4	62.4	0.277
40	Schoenoplectus	71.7	21.2	0.296
42	Schoenoplectus	192.1	46.9	0.244
23	Sparganium	90.6	24.3	0.268
24	Sparganium	733.7	147.6	0.201
26	Sparganium	205.1	57.6	0.281
27	Sparganium	202.8	47	0.232
28	Sparganium	288.1	71.4	0.248
38	Sparganium	79.3	25.3	0.319
41	Sparganium	432.8	43.1	0.100
42	Sparganium	130.7	37.8	0.289
31	Typha	660.2	107.4	0.163
32	Typha	577.9	138.6	0.240
33	Typha	326.4	103.8	0.318
35	Typha	312.6	115.2	0.369
36	Typha	263.6	84.9	0.322
41	Typha	196.8	57.6	0.293
44	Typha	142.4	53.9	0.379

Wetland 2

St.#	Species	Wet	Dry	Dry/wet
1	Typha	207.7	54.6	0.263
2	Typha	462.2	133.4	0.289
4	Typha	293.6	95.2	0.324
5	Typha	444.5	128.7	0.290
6	Typha	476.7	130.7	0.274
8	Typha	266.8	81	0.304
9	Typha	373.4	102.6	0.275
11	Typha	900	272.2	0.302
13	Typha	294.8	76.3	0.259
14	Typha	308.9	100.7	0.326
15	Typha	457.8	172	0.376
17	Typha	234.4	89.8	0.383
19	Typha	195.2	55.3	0.283
20	Typha	653.8	210.1	0.321
21	Typha	488	156.5	0.321
22	Typha	382.7	127	0.332