Short Papers and Notes

Primary Production and Seasonal Aspects of Emergent Plants in a Tidal Freshwater Marsh

ABSTRACT: Seasonal changes in aboveground plant biomass, cover, and frequency were monitored in Sweet Hall Marsh, a tidal freshwater marsh located on the Pamunkey River, Virginia, during the 1974 growing season. *Peltandra virginica* accumulated the most biomass, 423.40 g per m², followed by *Leersia oryzoides at* 67.75 g per m². Annual net community production was estimated to be 775.74 g per m² by using a multiple-harvest technique. Comparisons with other studies revealed that production was somewhat low for tidal freshwater marshes but mostly higher than production in Virginia brackish and saline wetlands. Measurements revealed an annual succession of plant species from spring to fall. The pattern observed was early dominance by *Peltandra* followed by a rise in importance of *Polygonum* spp., *Impatiens capensis* and *Leersia.*

Introduction

Primary production in nontidal freshwater marshes of the United States has been measured (Jervis 1969; Boyd 1970; Van Dyke 1972; Klopatek and Stearns 1978), but few geographic comparisons are available (Whigham, et al. 1978). The first major investigation of biomass primary production and plant community structure of tidal freshwater marshes was conducted by McCormick (1970) in Tinicum Marsh, Pennsylvania. Except for the work of Stevenson, et al. (1977), Odum (1978), and Flemer, et al. (1978), most research on tidal freshwater marshes has been conducted in the Delaware River estuary (McCormick and Ashbaugh 1972; Good and Good 1975; Whigham and Simpson 1976, 1977; McCormick 1977). A comprehensive listing of production studies is given in Whigham, et al. (1978). Although production has previously been determined for tidal freshwater marshes in Pennsylvania and New Jersey, similar observations on such marshes farther south have been lacking.

This study estimates the aboveground primary production and seasonal changes in plant biomass, cover, and frequency of a tidal freshwater marsh located on the Pamunkey River, Virginia. The results are compared with those of other freshwater wetland studies as well as those of Virginia brackish and saline marshes.

Methods

The study was conducted in Sweet Hall Marsh (37°33′N, 76°53′W), located approximately 19 km upstream from the mouth of the Pamunkey River, a tributary of the York River, Virginia.

Sweet Hall Marsh is a broad peninsular area consisting of over 444 ha of wetlands, including 29 ha of wooded swamp and 30 ha of open water in streams at least 15 m wide. The marsh also has a 7.4-km border with the river, which varies in salinity from 0 to 5‰, depending on the riverflow. Mean tidal range in the area is approximately 0.82 m.

A preliminary reconnaissance in February 1974 was made to determine sampling design. Transects and stations were then established with the aid of topographic maps and aerial photographs. The northwest sector of the marsh was sampled along four parallel transects, extending from the edge of a creek to a wooded swamp. Each transect averaged 285 m in length and consisted of 7–10 stations for a total of 34. Distances between transects and stations were obtained from a table of random numbers. Sampling began in late April, when spring growth was well underway, and continued monthly through September. At each station, a 1-m² quadrat frame was sampled for species present and species cover. Cover, defined as the percentage of the quadrat shaded by a species if the sun were at zenith, was visually estimated for each species. Near each station, a 0.1-m² quadrat was randomly located and all of the aboveground vegetation was clipped and returned to the laboratory. Samples were then separated by species, washed, placed in paper bags and oven-dried at 120 °C. The dried samples were weighed by species to the nearest 0.01 g.

Biomass of each species was defined as the dry weight per square meter for a given sampling date. Annual net primary production for each species was defined as the maximum monthly biomass value, and annual production for the total community was the sum of these values (Odum 1960).

Results

The results of five months' data are summarized in Table 1. Although over 35 species were collected, *Peltandra virginica* dominated the other species in terms of biomass until September (Table 1). *Peltandra* accounted for 55% (423.40 g per m²) of the total community production (775.74 g per m²) and was clearly the most common species through most of the season (Table 1). *Peltandra* also greatly exceeded the other species in terms of cover, but only early in the season. By August *Peltandra* cover had fallen to 17.97% from a peak of 52.41% in June, and by September *Peltandra* cover was actually surpassed by *Leersia oryzoides* cover. *Leersia* was the second highest producer at 67.75 g per m².

Discussion

Whigham, et al. (1978) noted the importance of multiple harvests in tidal freshwater marshes as contrasted with the single peak-biomass harvest technique often employed. In diverse freshwater marshes many species, mostly perennials, reach their biomass peaks

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TABLE 1. Aboveground biomass (B), cover (C), frequency (F) and anuual production (P) for species sampled in 1974. Biomass and production are expressed as g per m²; cover and frequency as percentages. Ranges represent ±1 standard error; n = 34.

Species	May			June			July			August			September			
	B	C	F	B	C	F	B	C	F	B	C	F	B	C	F	P
Peltandra virginica	297.83 ± 30.82	23.26 ± 3.02	100.00	353.40 ± 35.34	52.41 ± 5.24	100.00	423.40 ± 55.04	38.71 ± 3.87	100.00	418.58 ± 46.04	17.97 ± 2.88	100.00	93.68 ± 24.36	4.03 ± 1.01	88.24	423.40 ± 55.04
Leersia oryzoides	2.11 ± 0.65	0.26 ± 0.15	14.71	15.87 ± 2.86	4.45 ± 1.15	73.53	37.99 ± 8.74	4.17 ± 0.96	85.29	65.30 ± 16.98	14.41 ± 3.17	85.29	67.75 ± 16.26	8.79 ± 2.55	70.59	67.75 ± 16.26
Polygonum punctatum	0.01 ± 0.01	1.38 ± 0.77	44.12	0.86 ± 0.40	1.71 ± 0.68	61.76	12.40 ± 3.47	2.44 ± 0.95	64.71	32.11 ± 11.88	3.35 ± 0.77	70.59	48.72 ± 16.08	2.29 ± 0.76	67.65	48.72 ± 16.08
Pontederia cordata	2.54 ± 1.25	1.09 ± 0.52	23.53	20.68 ± 7.44	2.91 ± 0.84	50.00	35.86 ± 12.55	1.70 ± 0.56	52.94	31.15 ± 10.28	2.59 ± 0.73	50.00	34.23 ± 12.32	0.97 ± 0.41	47.06	35.86 ± 12.55
Polygonum arifolium	—	0.06 ± 0.04	5.88	1.08 ± 0.72	0.35 ± 0.08	35.29	1.14 ± 0.59	0.53 ± 0.30	35.29	8.24 ± 5.69	0.38 ± 0.09	38.24	4.92 ± 1.97	0.24 ± 0.07	23.53	8.24 ± 5.69
Impatiens capensis	—	0.06 ± 0.04	—	0.26 ± 0.21	0.26 ± 0.07	29.41	1.56 ± 0.87	0.59 ± 0.30	32.35	2.83 ± 1.53	2.85 ± 1.05	20.59	3.38 ± 1.93	0.18 ± 0.06	14.71	3.38 ± 1.93
Carex stricta	22.93 ± 16.40	2.21 ± 1.17	17.65	49.70 ± 49.55	3.41 ± 2.18	11.76	10.74 ± 8.23	1.94 ± 1.16	11.76	59.90 ± 41.75	3.24 ± 1.43	11.76	11.50 ± 8.01	1.18 ± 0.71	8.82	59.90 ± 41.75
Eleocharis quadrangulata	0.05 ± 0.05	0.03 ± 0.03	2.94	0.29 ± 0.21	0.06 ± 0.04	5.88	3.64 ± 2.46	0.15 ± 0.07	11.76	3.21 ± 2.38	0.53 ± 0.30	26.47	3.72 ± 1.48	0.32 ± 0.08	32.35	3.72 ± 1.48
Others[a]	16.47 ± 7.18			34.90 ± 11.56			35.39 ± 9.64			78.54 ± 25.46			74.54 ± 9.92			
Total	341.95 ± 29.30			477.18 ± 51.51			563.00 ± 47.59			699.84 ± 39.59			342.45 ± 32.65			775.74 ±240.24

[a] In order of decreasing frequency: *Aneilema keisak*, *Hibiscus moscheutos*, *Polygonum sagittatum*, *Spartina cynosuroides*, *Phragmites australis*, *Bidens coronata*, *Scirpus americanus*, *Rumex verticillatus*, *Carex hyalinolepis*, *Typha angustifolia*, *Scirpus validus*, *Zizania aquatica*, *Juncus effusus*, *Thelypteris palustris*, *Rosa palustris*, *Echinochloa walteri*, *Asclepias incarnata*, *Osmunda regalis*, *Amaranthus cannabinus*, *Aster* sp., *Hypericum* sp., *Cuscuta* sp., *Sagittaria latifolia*, *Vitis* sp., *Strophostyles umbellata*, *Spartina alterniflora*, unidentified grasses.

earlier in the season than others, and only multiple harvests during the growing season can detect this pattern (Whigham, et al. 1978). My research supports this view (Table 1). *Peltandra*, a perennial, reached its peak biomass in July, whereas *Leersia*, *Polygonum punctatum* and *P. arifolium* peaked one to two months later. The combined patterns of all species produced a peak community biomass in August.

The pattern of early rise and fall for *Peltandra* biomass and subsequent rise in other species was also observed by Whigham and Simpson (1976) and Odum (1978). In Sweet Hall Marsh young shoots of *Peltandra* were among the first plants to appear (February), and by May the species had already obtained a biomass of 297.83 g per m^2 (Table 1). However, as the season progressed, *Peltandra* biomass decreased, and the biomass of annuals such as *Polygonum* and *Impatiens* increased to peaks later in the season. The fact that *Peltandra* leaves senesced early and therefore increased the amount of available sunlight to other plants probably facilitated growth of species that reached peak biomass later in the growing season.

Species composition and density of vegetation so greatly influence aboveground biomass and production that comparisons among freshwater marshes are difficult (Whigham, et al. 1978). For example, the peak biomass of *Peltandra* from different studies (Table 2) varies from 67 to 1,286 g per m^2. The differences in *Peltandra* biomass may be largely attributed to 1) differences in spacing between individual plants or shoots and 2) the fact that some of the values, e.g., those of Jervis (1969), McCormick (1970), and Flemer, et al. (1978), were taken from samples in which *Peltandra* was mixed with one or more other species. Therefore, the highest values should be obtained from areas where *Peltandra* grows in pure stands and where shoot density is high. In the higher elevations of most tidal freshwater marshes, it is often difficult to obtain samples from pure stands of any species. In such areas it may be more convenient to determine total community biomass, which is also variable (Table 2). Community biomass of mixed communities is strongly dependent upon species composition, since any mixed community containing a significant proportion of prolific producers such as *Typha* or *Zizania* is likely to have a higher peak biomass than a community which is largely composed of *Peltandra* or *Pontederia*.

The peak community standing crop obtained in this study was 699.84 g per m^2 (Table 1) and falls within the range of 432 g per m^2 to 2,311 g per m^2 for peak aboveground biomass estimates in tidal freshwater wetlands reported by Whigham, et al. (1978). Whigham, et al. (1978) stated that the least productive of these wetlands were those dominated by *Peltandra*/*Pontederia*, *Nuphar*, *Scirpus* and *Sagittaria*. Because Sweet Hall Marsh was dominated by *Peltandra*, the biomass and production values in this study agree with their findings.

Peak biomass appears to be greater in Sweet Hall Marsh than values obtained from brackish and saline marshes in Virginia. Different floras and methodologies, however, may affect the results. Biomass values of 558 g per m^2 (Keefe and Boynton 1973) and 362 g per m^2 (Mendelssohn and Marcellus 1976) for *Spartina alterniflora*, 572 g per m^2 for a *S. alterniflora*-*S. patens*-

TABLE 2. Aboveground peak biomass for *Peltandra virginica* and mixed communities in freshwater marshes.

Reference	Species	Peak Biomass g per m^2
Jervis 1969	*Peltandra*	161
	Mixed vegetation	1,547
McCormick 1970	*Peltandra*	67
Good and Good 1975	*Peltandra*	1,286
	Mixed vegetation	786
Whigham and Simpson 1976	*Peltandra*	591
	Mixed vegetation	828
Flemer, et al. 1978	*Peltandra* and *Polygonum arifolium*	988
	Peltandra and *Zizania*	909
This study	*Peltandra*	423
	Mixed vegetation	700

Distichlis spicata mixture and 563 g per m^2 for *Spartina cynosuroides* (Mendelssohn and Marcellus 1976) are all less than the 699.84 g per m^2 obtained in this study. However, Wass and Wright (1969) obtained biomass estimates as high as 1,140 g per m^2 for *S. alterniflora* and 1,451 g per m^2 for *S. cynosuroides*.

Cover is a rough measure of biomass (Mueller-Dombois and Ellenburg 1974) and has been used in freshwater marshes as a measurement of species dominance (Jervis 1963; Kerwin 1966; McCormick 1970). Change in cover is also an indicator of temporal change in species distribution (Van Dyke 1972; Burk 1977; Doumlele and Silberhorn 1978). Although cover only approximates biomass, it has the advantage of being a nondestructive measurement, and thus the same plots can be sampled at different times. Silberhorn (pers. commun.) estimated herbaceous plant cover for Sweet Hall Marsh in July 1978 as: *Peltandra*/*Pontederia* 30%, *Spartina cynosuroides* 15%, *Zizania aquatica* 10%, *Polygonum punctatum* 10% and *Impatiens capensis* 10%. The remaining 25% was composed of numerous occasional and rare species, including *Typha* spp., *Phragmites australis*, *Hibiscus moscheutos* and *Leersia*. Silberhorn's data differ from cover values in Table 1 for several reasons: 1) small plots were not used in his cover determinations, but instead cover was estimated for the entire marsh, 2) unvegetated areas were not taken into account, and 3) my study focused on only a small sector of the marsh located in the marsh interior closer to upland freshwater sources, which probably explains Silberhorn's higher percentage of *Spartina cynosuroides*, a brackish-water species common along streambanks in Sweet Hall Marsh.

The only other seasonal cover data available from tidal freshwater marshes are those of Doumlele and Silberhorn (1978) from Herring Creek, Virginia. In that study *Peltandra* cover was observed to peak in June in both high and low marshes, although the species' decline in the high marsh was enhanced by insect grazing. Comparison between changes in cover through the season and biomass accumulation (Table 1) reveals similar trends; e.g., an early peak for *Peltandra* and a later peak for *Leersia*. However, the maximum cover for *Peltandra* occurred roughly one month earlier than its maximum biomass. One reason for this difference is probably the later formation of reproductive structures, which have higher biomass and less cover than the broad leaves. Another is that the foliage of *Peltandra* starts to decline as the reproductive structures appear.

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Damon G. Doumlele
General Delivery
Bena, Virginia 23018