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Submergent macrophytes in Theresa Marsh

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SUBMERGENT MACROPHYTES IN THERESA MARSH

Marshes form the interface between upland and aquatic systems and, like most transitional zones, provide habitat diversity which may support a great variety of life. Marshes may act as valves or sinks to regulate the flow of mineral nutrients from terrestrial systems (especially from agricultural or urban systems) to aquatic zones. Freshwater marshes and wetlands are ranked with coastal estuaries as highly productive areas and play an important role in converting the sun's energy to organic matter.

Theresa Marsh, an impoundment managed by the Wisconsin Department of Natural Resources, is located in northwestern Washington and eastern Dodge Counties. Since the 1850's it has been cleared, drained, pastured and reflooded several times. However, not until 1968—with the construction of a one mile-long dike and dam complex—did the impoundment come under controlled management. Fourteen hundred acres comprise the flowage which has a drainage basin of approximately 47,000 acres, chiefly of agricultural land. In late fall of 1970, the water was drawn down to facilitate treatment with a carpicide. By June 1971, the marsh was completely dry save for the main river channels; the carpicide, an antimycin, was applied in mid-August. Reflooding of the marsh began in September and the marsh reached normal levels the following spring. Average depth of the marsh outside of the main tributary channels is approximately 0.7 to 1.0 m. This study investigated the effects of the draw-down on the occurrence and productivity of submergent higher plants. Prior to the drawdown, the productivity of these submergents was estimated by Washa (1971). Similar studies elsewhere include those of Beard (1973), Kadlec (1962), and Meeks (1969).

All indications suggest that Theresa Marsh is potentially highly productive. Moyle (1946) states that alkalinity above 91 ppm is an index of high productivity; outflow from Theresa Marsh averages about 300 ppm throughout the year. Marshes surrounded by good agricultural land have been found to be more productive than those surrounded by degraded lands (Cook and Powers, 1958). Nearly all of the acreage making up Theresa's drainage basin is in intensive agricultural production with crops such as sweet corn, peas, and oats—all of which receive lavish amounts of fertilizer. Nutrient content of the outflow water from the marsh during the 1972 growing season ranged from .28 to .65 ppm for total phosphorus and from 1.59 to 2.56 ppm for total nitrogen (.15-.53 ppm NO_3-N, .14-.75 NH_3-N). These nutrient levels are capable of supporting nuisance algal blooms (Mackenthum, 1969); massive algal blooms were observed in the marsh as early as March 1972 underneath a layer of ice, and continued periodically throughout the growing season. Soil nutrient values for the area range from 14 to 103 ppm available phosphorus and .96 to 2.52% total nitrogen.

For comparison with Washa's (1971) pre-drawdown study, his sampling areas and methods were followed as closely as possible. Four major sampling areas were designated, and although they did not include the total diversity and complexity of the marsh, delineation of four distinct areas enabled intensive sampling.

All samples areas were located immediately east of the dike and dam structure and were either in, or adjacent to, the main "pool" or open water portion. On the west, the first area (#1) is bounded by the main dike and a subimpoundment dike, on the south with stands of cattail (*Typha* spp.), river bulrush (*Scirpus fluviatilis*), and willow (*Salix* spp.) border it on the north and east. Water depth varies from 0.6 to 0.15 meters. A second area (#2) in the open water of the main-pool is encircled by the oxbow-like structure of the main river channel. Depths varied from 1.0 to 1.6 m and the substrate is complicated by the many old sedge hummocks that arise from the bottom to a height of 0.2 to 0.6 m. This open water section is subject to severe wind and wave action.

Washa (1971) designated a third area as shrub shallows (#3) but in 1972 most of the shrubs, largely *Salix* spp., were dead. Existing boles and branches tend to moderate both wave and wind action and offer epiphytic vegetation a place of attachment. A fourth area (#4) consisted of a transect running diagonally across the main river channel on the eastern edge of the main pool. Water depth ranged from 1.4 to 3.3 meters and was subject to the constant influence of the river current.

A north-south transect was established in each area with reference stakes 50 meters apart. Transects varied from 400 to 750 meters long. Samples were taken at weekly intervals along each transect. Since sampling was destructive, no location was sampled twice. A sampling frame $0.2m^2$, open at the top and bottom and enclosed on sides by fine mesh screen, was used. Rooted plants were cut at ground level with a sharpened hoe and collected by hand or with a rake with screening woven between the teeth. Floating material was collected by hand or with a dip net. A $.05m^2$ sample tube was used instead of the frame where the water depth exceeded 1.5 meters.

Samples were rinsed, washed and separated in the laboratory. Plants were allowed to drip dry, were weighed, dried in an oven at 75°C for 72 hours and reweighed to determine dry weight.

Four groups of submergent or floating vegetation comprised the majority of plants sampled. These were pond weeds (*Potamogeton* spp), smartweed *Polygonum natans*, coontail *Ceratophyllum demersum*, and duckweeds (*Lemna minor, L. triscula, Spirodela polyrhiza,* and *Wolfia* spp.) *Potomogeton* spp. included *P. foliosus, P. natans, P. zosteriformis,* and *P. pectinatus.* Other taxons found were *Bidens* spp., *Alisma plantago-aquatica, Drepanocladus* spp., *Nymphaea odorato, Sagittaria rigida,* and *Utricularia vulgaris.* Occurrence of these last named species was erratic and their distribution scattered. Except for bladderwort (*U. vulgaris*), in the latter half of the season, frequency data were not tabulated and species were grouped for biomass calculations.

Frequency data for 1968 (the first year of impoundment) were obtained from a DNR survey and for 1970 from Washa's study (Table 1). Most species follow abundance patterns found in other drawdown studies. Waterweed, *Anacharis canadensis,* was not sampled in 1972 although it seemed on the in-

SPECIES	FREQUENCY (%) 07/15/68	07/16/70	07/14/72
Polygonum natans	11	8	22
Lemna minor	66	95	49
Lemna trisulca	14	84	30
Anacharis canadensis	29	67	0
Utricularia vulgaris	9	42	4
Ceratophyllum demersum	49	100	17
Potamogeton spp.	56	92	17

Table 1. Frequency of occurrence (in %) of selected macrophyte species in Theresa Marsh.

crease in 1970, thus demonstrating its susceptibility to removal by drawdown, as reported by Beard (1973) in a northern Wisconsin flowage. *Ceratophyllum demersum* was not observed in the marsh until July 7 and never reached the abundance found by Washa in the pre-drawdown study. Presumably the drawdown eliminated most of the vegetative reproductive structures and the *Ceratophyllum* present in 1971 under the drastic changes resulting from drawdown did not produce adequate seed for re-establishment.

Pondweeds showed a significant decrease in frequency in 1972 as compared to the pre-drawdown surveys. *Potomogeton* spp., unlike free-floating *Ceratophyllum,* are rooted and most species reproduce vegatatively from tubers, creeping rootstocks, or winter buds. Secondary effects of the drawdown probably had much to do with the reduction of *Potomogeton.* A luxuriant growth of moist soil species occurred in 1971 on the mudflats exposed by the drawdown (Linde, 1972). Production of these species was over 1100 g/m^2 (Klopatek, 1972); this resulted in a tremendous amount of undecayed vegetation that, after reflooding, restricted light penetration necessary for photosynthesis at the lower depths. Light penetration is usually the most important limiting factor responsible for the distribution and growth of submerged hydrophytes (Ricket, 1922; Russell-Hunter, 1970).

Polygonum natans, a floating-leafed seed-producer, was the only species that showed a significant increase in abundance over the preceding years. Kadlec (1962) also indicated that *P. natans* showed improved growth after a drawdown and reflooding. Thus, this treatment encourages the establishment of *P. natans.*

Frequency values, although useful in describing the patterning of submergent plants over time or their nuisance effects on recreational activities, do little to explain their ecological role. Aquatic macrophytes play an active part in carbon and energy fixation, the accumulation and release of nutrients, and the manufacture of protein for higher trophic levels. Prior to the determination of these specific roles, productivity of each species must be known to quantify their true environmental impact. Productivity of emergent species was greatly reduced

in the 1972 growing season as compared to 1970. Although much of this reduction can be attributed to the drawdown, another important influence was the above-average rainfall in 1972. Several times water levels rose one to two feet in the marsh within a one week period with a resultant increase in current, which flushed away many of the free-floating, and loosely attached macrophytes (i.e. duckweed).

The pattern of biomass production was similar in all areas. The macrophyte species exhibited a bimodal peak of standing crop (Fig. 1). Washa (1971) also found this bimodal pattern at Theresa and Loucks, et. al. (1971) showed the same pattern in Lake Wingra. Odum (1957) working in Silver Springs, Florida, likewise found a bimodal pattern in primary productivity as did Penfound (1956) working with *Pistia* spp. Russell-Hunter (1970) suggests that with certain diatom species the spring peak is based on light availability, and a lesser, fall peak results from release of nutrients as organisms that perished earlier in the growing season decompose. Adams et. al. (1972) found a bimodal biomass pattern for *Myriophyllum spicatum* and attributed it to a sloughing off of lower leaves midway in the growing season and an increase in leaves near the water surface later in the season. A combination of these causes may explain the several production peaks at Theresa.

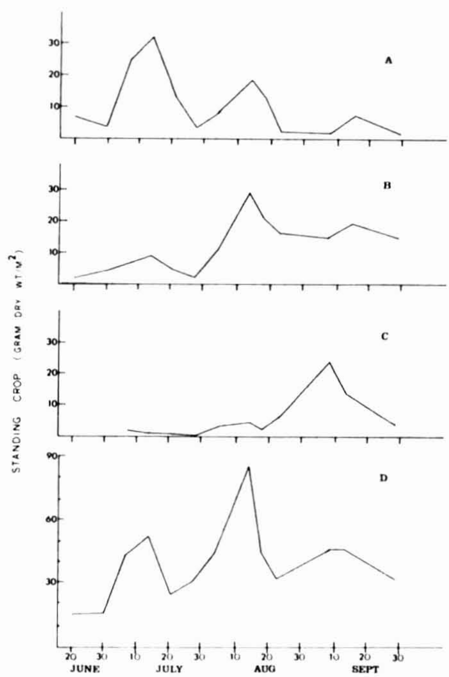

Figure 1. 1972 standing crop values (grams dry wt/m^2) of submergent macrophyte species in Theresa Marsh. A- *Polygonum natans;* B- Lemnaceae; C- *Ceratophyllum demersum;* D- Total for all species sampled. Graphs represent the combined averages of all four sampling areas.

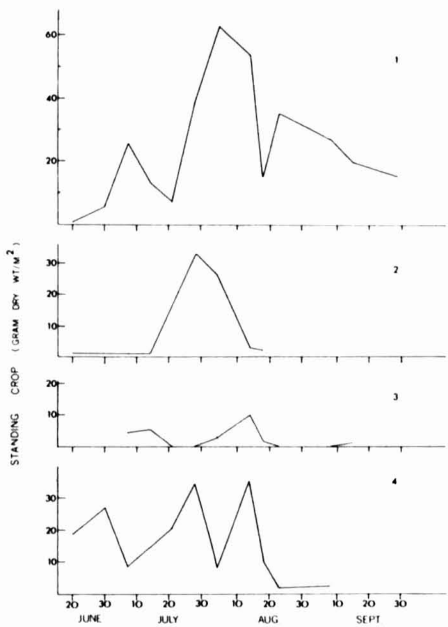

Figure 2. Seasonal standing crop values (grams dry wt/m^2) of *Potamogeton* spp. during 1972 in Theresa Marsh. 1, 2, 3, and 4 correspond to the number of the sampling area.

The shallowest and most protected area (Area 1) had the higher biomass production throughout the season. The standing crop patterns for *Potamogeton* spp. in all four sampling areas (Fig. 2) clearly show the effects of the modified physical parameters in Area 1. The largest accumulation at any one time, 104.0 g/m^2, composed primarily of *Potamogeton* spp., was found in Area 1 on August 14. In Area 2, duckweeds comprised three quarters of the maximum standing crop (on August 14) of 81.9 g/m^2. The maximum standing crop in Area 3 was 99.4 g/m^2 on August 14, one half of which was *Utricularia vulgaris.* The average maximum standing crop on August 14 for all areas was 91.6 g/m^2.

Like the frequency values, standing crop is lower than that found by Washa in 1970. Washa (1971) reported peak values of a 231.9 g/m^2 in a *Ceratophyllum* bed (Area 1), pure stands normally produce higher values than mixed communities (Boyd, 1971); 189.6 g/m^2 for the open flowage (Area 2); and 99.5 g/m^2 for the shrub shallows (Area 3). Many investigators have reported values substantially higher (Table 2). In all probability future productivity of submergent aquatics at Theresa Marsh will equal or exceed the values reported here. Reasons for this assumption are: 1) the increased clarity of the water brought about by the carpicide treatment; 2) the continued inflow of nutrients into the marsh from agricultural runoff, the upstream sewage treatment plants, and private septic systems, and 3) the control of water levels within the impoundment.

SPECIES	LOCATION	STANDING CROP	SOURCE
Ceratophyllum demersum	Wisconsin	208	Rickett (1924)
Ceratophyllum demersum	Sweden	680	Forsberg (1960)
Myriophyllum verticillatum	Sweden	240	Forsberg (1960)
Myriophyllum spicatum	Wisconsin	385	Nichols & Mori (1971)
Potamogeton pectinatus	Illinois	722	Low & Bellrose (1944)
Pontederia sp.	Florida	980	Odum (1957)
Eichornia crassipes	Louisiana	1276	Penfound (1956)

Table 2. Standing crop values for several species of submergent macrophytes.

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