EFFECTS OF FIRE ON

PHRAGMITES AUSTRALIS (CAV.) TRIN. EX STEUDEL

AND ASSOCIATED SPECIES AT DELTA MARSH MANITOBA

BY

DONALD JAMES THOMPSON

A thesis submitted to the Faculty of Graduate Studies of
the University of Manitoba in partial fulfillment of the requirements
of the degree of

MASTER OF SCIENCE

ABSTRACT

In Delta Marsh the responses of a *Phragmites australis* dominated community were monitored after prescribed burning performed in the spring, summer and fall.

The aerial standing crop produced by *Phragmites australis* in 1979 in this stand was similar to that reported for similar habitats in other temperate regions. Much of the within stand variation in *P. australis* performance was explained with reference to a soil moisture gradient within the stand and to the uneven age structure of the stand at different parts of the gradient. *P. australis* accounted for 91% of the aerial standing crop of the community, which contained seven substorey species. To a greater degree than that of the dominant the performance of the substorey species was related to the moisture gradient. Two upland species (*Cirsium arvense* and *Urtica dioica*) occurred more frequently in the drier part of the stand but labiates such as *Lycopus asper*, *Mentha arvensis* and *Teucrium occidentale* were more frequent at intermediate moisture levels.

Several microenvironmental changes occurred after summer burning. Light intensity increased and air and soil temperatures fluctuated more. There was a release of mineral nutrients including nitrate, phosphate and potassium. Reed regrowth began approximately a week after burning and mowing, and continued until frost in late October. The aerial standing crop of regrowth was similar after burning and mowing but shoot

density was greater following mowing. Shoots on summer burned plots were more phenologically advanced than those produced on mowed plots. There was a decline in rhizome reserves following burning and mowing in comparison with the controls. Seeds of several substorey species germinated after burning and mowing which was related to the microenvironmental changes resulting from litter and canopy removal. Of the substorey species C. arvense and U. dioica sprouted regrowth most vigorously following both treatments.

In the 1980 growing season the aerial standing crop of P. australis increased after fall and spring burning but declined following summer burning. Shoot density increased dramatically after all burning treatments due to the production of many smaller vegetative shoots. Flowering shoot density increased after spring burning, but declined after fall and to a greater extent after summer burning. Both flowering and vegetative shoots were shorter and of smaller basal diameter following summer burning, which has potential as a method of controlling P. australis growth. Below-ground production was greater following fall and spring burning but after summer burning was similar to the controls. Changes in the performance of P. australis were related to changes in its morphology and seasonal growth cycle which occurred because of the burning treatments.

After spring and summer burning, with the onset of vernal growth, the total non-structural carbohydrate (TNC) content of P. australis rhizomes declined to lower levels than in the controls but by the end of the growth season rose to higher levels than in the controls. There were differences in the timing of the drop in rhizome reserves related to differences in the phenological development of the aerial shoots which arose from the rhizomes. The greater decline in reserve levels with the onset of vernal growth after spring burning was related to increased shoot density and in inflorescence production. The decline after summer burning was related to increased shoot density as well as an initally lower TNC level at the begining of the growing season as a result of the production of regrowth in the previous fall.

In the 1980 growing season the magnitude of changes in the dynamics of the plant community depended upon the season of burning. The changes were greatest after summer burning and mowing where the competitive ability of _P. australis_ was reduced. In contrast almost no change in substorey composition or production occurred after spring burning, which enhanced _P. australis_ performance. Fall burning had intermediate effects with increased production of _P. australis_ but there were changes in species composition. The species diversity (based on the biomasses of individual substorey species) increased on summer burned and mowed plots but not on fall or spring burned plots. Species diversity increased following summer burning lun to increased production by _C. arvense_ and due to the establishment of _Sonchus arvensis_ and _Atriplex patula_ which produced considerable biomass.

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ACKNOWLEDGEMENTS

I would like to thank the numerous persons who contributed to the conception, birth and maturation of this thesis.

Foremost I would like to thank my major advisor, Dr. J.M. Shay for her continued encouragement and support. No less encouragement was offered by Dr. T. Booth who served as my supervisor during Dr. Shay's absence and who devoted a great deal of time to this project. The guidance and advice of my other committee members, Drs. D. Punter, J. Reid and A. Storgaard is much appreciated.

I would like to thank Dr. B. Johnston for statistical advice and Mr. Enri Chew for introducing me to MANTES and SCRIPT. Advice on soil and ash analysis was offered by Dr. Racz of the Soil Science Department. Drs. A. Storgaard and R.D. Hill of the Plant Science Department offered me valuable advice on experimental design and tissue analysis techniques respectively.

The staff of the Delta Waterfowl Station provided financial support, equipment and much useful encouragement and advice. In particular thanks go to Dr. B. Batt and Mr. P. Ward for a great number of ideas and much needed encouragement.

Thanks go to the staff of the University Field Station for excellent lodging and meals. I would like to thank the following students and staff for help in my fieldwork, Susan Cosens, Roger Garrard, Marc Lichtenberg, Mike McKernan, Joan Morgan and Mike Watson.

I would also like to thank Dr. R. Jones, marsh manager, for the loan of fire-fighting equipment. Also thanks go to the Portage Country Club for the use of their land and dock.

The advice and support of the staff and students in the Botany and Zoology Departments was very valuable. Especially I would like to thank Dr. V.J. Lieffers, for his friendship and help in designing and carrying out this project, and Mr. C. Day, who offered a great deal of encouragement while writing this thesis. Lastly, I would like to thank my relatives for continued help throughout this thesis, especially Ron Drysdale, Don and Mary Popien, and Tom Thompson who helped me with different parts of the fieldwork and provided encouragement throughout.

Research funds for this study included a University of Manitoba grant to Dr. Shay and support for the 1979 and 1980 field seasons from the Delta Waterfowl Research Station. Contributors to the Waterfowl Station reseach funds included, the Canadian National Sportsmen's Fund, the North American Wildlife Foundation and the Government of Manitoba. The Natural Sciences and Engineering Research Council of Canada provided a scholarship during the last two years of this thesis.

INTRODUCTION

This study describes the responses of an emergent plant community located at Delta Marsh, Manitoba, to prescribed burning carried out at three different times of the year.

Delta marsh stretches along the southern shore of Lake Manitoba and consists of a series of shallow bays separated from the lake by a forested dune ridge. Around these bays extensive stands of marsh emergents such as *Phragmites australis*, *Typha glauca* and *Scirpus acutus* and *S. validus* have become established. Water is exchanged between the marsh and the lake through a number of channels which cut through the dune ridge.

In the past the extent of the emergent marsh communities has changed in response to periodic fluctuations in the level of Lake Manitoba (Walker, 1965) but such fluctuations have been less extreme since the installation of a control structure at Fairford on the north outlet of the lake in 1961. Thus,interest in methods of managing these communities has arisen. One of the management options which has received some study in the Delta marsh is the use of prescribed burning which centered on *P. australis* stands (Ward,1942 and Ward,1968). The site chosen for detailed study of burning in summer (August 1, 1979), fall (October 11, 1979) and spring (May 11, 1980) was part of an extensive *P. australis* stand 5.5 ha in area which is located 1.5 km from the Cram Creek channel in the west part of the marsh.

The climate is mild to cool continental (Wier, 1960) with a mean January temperature of -5° C and a mean July temperature of 20°C. Annual preciptation is 52.1 cm with 70% of this falling as rain between April and October.

This study offered a valuable opportunity to integrate the responses of the dominant (both morphological and physiological) with that of the substorey species to the various burning treatments. Changes in community composition and structure could be related to the responses of the dominant.

This thesis is divided into five sections. The first describes the pre-burn aerial production, community composition, and aspects of the dynamics of a plant community dominated by *P. australis*. The second section describes regrowth on parts of this stand which occured in the autumn of 1979 following burning or mowing. The third section describes the performance of the dominant, *P. australis*, during 1980 after burning in the summer or fall of 1979 or the spring of 1980. Included are estimates of aerial and below-ground standing crop and shoot morphological measurements. In section four the response of *P. australis* rhizome reserve levels to the burning treatments are described. The final section deals with the effects of the various burning treatments on the diversity, composition and community aerial standing crop along with the individual responses of the more abundant substorey species.

Chapter I

THE SPECIES COMPOSITION AND PRODUCTION OF A MARSH COMMUNITY

1.1 INTRODUCTION

The primary production of aquatic macrophytes has been the subject of many investigations in Europe but such studies have been less numerous in North America. There is a paucity of literature concerning the production by macrophytes in prairie marshes.

One of the most studied species in terms of production is reed, *Phragmites australis*, (Cav.) Trin. ex Steudel (1) because of its importance in the overgrowing of lakes, ponds, and other water bodies (Iwata and Ishizuka,1967; Mochnacka-Lawacz,1975). Only one study to date (van der Valk,1976) has reported estimates of production by this species in prairie marshes. *P. australis* is especially important in Manitoba because of the number of large marshes in which it predominates, forming extensive monotypic stands.

This chapter describes the production, community composition and aspects of community dynamics of a *P. australis* stand in the Delta marsh, Manitoba. These data were collected as a preliminary step toward a study in which the responses of *P. australis* to fire were to be investigated.

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(1) Formerly named *Phragmites communis* Trin. Taxomomic change according to Clayton (1968).

1.2 METHODS

In late July 1979 part of one dense *P. australis* stand was divided into a grid of twenty, 400 m^2 plots (Figure 1-1). This grid was set out so that it ran perpendicular to a water depth gradient within the stand. The most elevated side of the grid was free of standing water by June and at the lowest lying end the water depth was approximately 30 cm. To evaluate within stand variation, four 0.25 m^2 (0.5 by 0.5 m) quadrats were randomly located within each plot. All living and dead plant material was clipped at ground level and separated as living (2) *P. australis*, dead *P. australis* stems and the substorey species combined. Shoot densities of each species within the quadrats were recorded. Additional information collected for *P. australis* included flowering stem density, and the leaf number and height of the quadrats' tallest shoot. All plant material was oven dried to constant weight at 80° C. The characteristics recorded were compared between moisture levels using analysis of variance (Snedecor and Cochran,1967).

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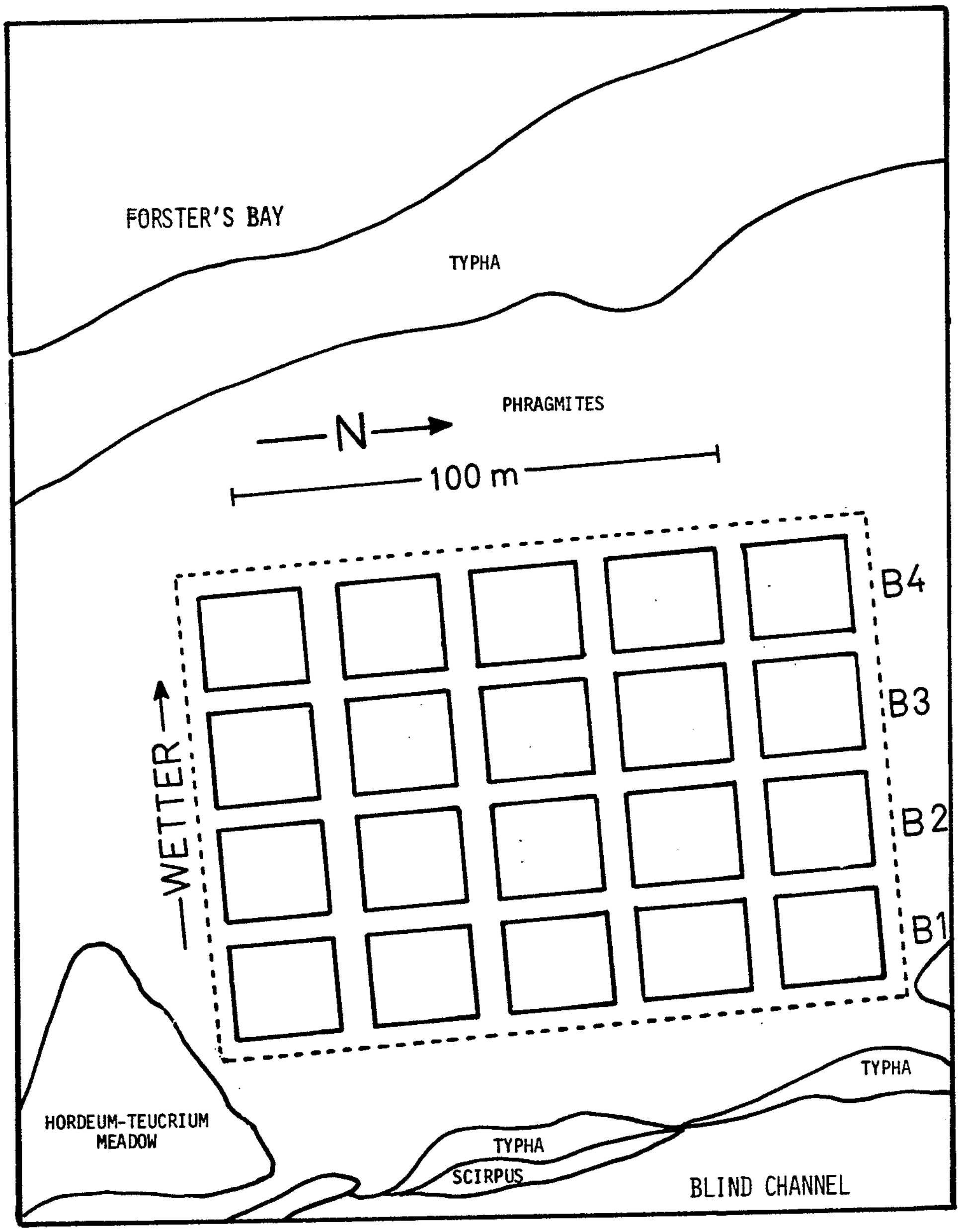
(2) Biomass is used to denote living aerial standing crop where below-ground biomass is reported the qualifier below-ground is used.

Figure 1-1. Site preparation at time of August sampling, 1979.


FORSTER'S BAY
TYPHA
PHRAGMITES
N
100 m
B4
B3
B2
B1
WETTER
HORDEUM-TEUCRIUM MEADOW
TYPHA
TYPHA
SCIRPUS
BLIND CHANNEL

1.3 RESULTS

1.3.1 P. australis

Mean biomass for the stand was 812 $\pm$ 38.4 g/m 2, which was less than the mass of its litter (984 $\pm$ 32.8 g/m 2) Mean biomass differed significantly (α= .01) between rows of plots at different moisture levels. This effect was mainly due to lower biomass in the second row of plots, biomass being relatively constant over the other three moisture levels. Litter weight varied significantly (α= .05) between water levels, declining from the first (driest) row of plots to the last (wettest) row.

Mean shoot density was 78.3 $\pm$ 2.9 shoots/m 2 There was a consistent trend where density increased with increasing mositure (α= .01). Flowering density averaged 31.2 $\pm$ 2.4 shoots/m 2, and varied significantly between moisture levels (α= .001). It was high in the first and third rows of plots but lower in the second and fourth row, there being no consistent trend across moisture levels.

The mean height of the quadrats' tallest shoot was 225.1 $\pm$ 2.4 cm and varied significantly between water levels (α= .0001), due to a dramatic reduction in shoot height in row two. The mean number of leaves for these shoots was 13.9 $\pm$ 0.1 which did not vary significantly across water levels.

Average weight per stem varied significantly between moisture levels (α= .01), being highest in the driest row and declining toward the wettest row.

There were significant correlations between several of the P. australis characteristics measured (Table 1-1).

Table 1-1. Correlations between *P. australis* characteristics.

Characteristics	Correlation (*r*)	Significance level
Density vs. Biomass	0.680	.0005
Total Density vs. Flowering density	0.533	.0010
Max. Height vs. Biomass	0.478	.0010

1.3.2 Substorey

The combined biomass of substorey species averaged 67.9 g/m^2, which varied between mositure levels ($\alpha = .01$). Substorey biomass declined with increasing moisture, except that the mean for row two was somewhat higher than for row one.

There were seven substorey species present in this community (Table 1-2). The most abundant was *Teucrium occidentale* Gray which had an average biomass of 25.6 g/m^2 and a density of 19.5 $\pm$ 2.2 shoots/m^2 The density of this species varied across the water level gradient ($\alpha =$ .0001). Its biomass was lowest in the driest row (one), increased dramatically in row two and declined somewhat in rows three and four. Frequencies of *Mentha arvensis* L. var. *villosa* (Benth.) Stewart and *Urtica dioica* L. were similar but less than that of *T. occidentale*. *Lycopus asper* Greene, *Cirsium arvense* L. (Scop.) and *Scutellaria epilobiifolia* Hamilton had consecutively lower frequencies. The frequencies of individual substorey species varied along the moisture gradient. *C. arvense* and *U. dioica* decreased in frequency with increasing moisture. The labiates, including *L. asper*, *M. arvensis* and *T. occidentale* increased with increasing moisture but declined somewhat in the last, wettest, row of plots.

1.3.3 Relationship between *P. australis* and Substorey

Total substorey biomass was weakly negatively related to the density of *P. australis* ($r = -.252, \alpha = .05$) but was not significantly related to its biomass. There was a stronger relationship between substorey biomass and the weight of *P. australis* litter ($r = -.548, \alpha = .0001$).

Table 1-2. Frequencies of substorey species, 1979.

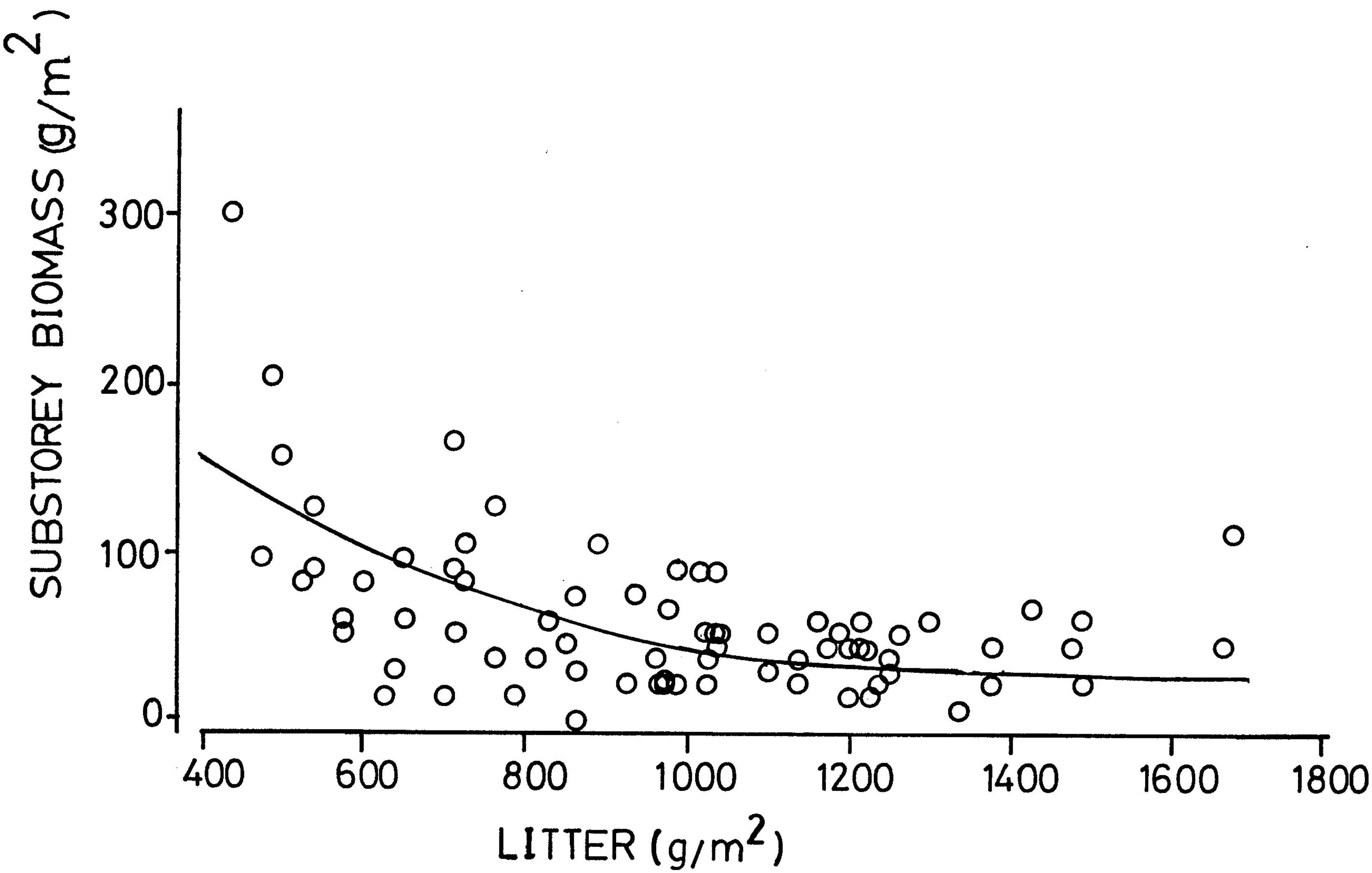
MOISTURE LEVEL

---------------------------------- WETTER --------------------------[>

SPECIES	ROW1	ROW2	ROW3	ROW4	OVERALL *
Teucrium occidentale	50	90	100	95	84
Mentha arvensis	25	60	65	45	49
Urtica dioica	80	60	25	25	48
Cirsium arvense	50	36	20	5	26
Lycopus asper	0	30	50	45	31
Scutellaria galericulata	25	15	0	30	19
Stachys palustris	10	0	0	0	3

* Overall denotes frequency for the whole stand.

Figure 1-2. Relationship between combined dry weight of substorey species and the dry weight of *P. australis* litter. Fitted curve is Y= 66500/X - 12.3.


SUBSTOREY BIOMASS (g/m2)
300
200
100
0
400
600
800
1000
1200
1400
1600
1800
LITTER (g/m2)

This relationship was curvilinear (Y = 66500/X - 12.8) with little constraint on substorey biomass at low litter loadings but a strong constraint at higher litter loadings (Figure 1-2).

1.4 DISCUSSION

1.4.1 *Phragmites australis*

The biomass of *P. australis* in this stand is similar to that of Shay (unpublished) for Delta Marsh and to that reported by van der Valk (1976) for an Iowa fen. It was also similar to that reported by van der Toorn (1972) for a riverbank ecotype, by Kvet (1973) for a drier stand, and by Ho (1979) for a mesotrophic stand. Similar *P. australis* biomasses were also reported by Kowalczeweski and Wasilewski (1966), Mason and Bryant (1975), Anderson (1976) and by Brooker (1976). This biomass is higher than that reported in oligotrophic environments (van der Toorn, 1972 and Mason and Bryant, 1975). Higher *P. australis* biomasses were reported in estuarine marshes (Hopkinson et al.,1978; Linthurst et al.,1978) and in some eutrophic environments (Dykyjova and Pribil,1972; van der Toorn,1972). Several authors reported that *P. australis* production increases from the drier to the wetter parts of stands (Buttery and Lambert,1965; Kowalczewski and Wasilewski,1966; Haslam,1972; Dykyjova and Hradecka,1973; and Mochnaka-Lawacz,1974). The within stand differences in biomass seen in my study were due to the thinning of the canopy in the second row of plots. This may have been due to edaphic conditions or perhaps more likely to the uneven age structure of the stand. If invasion of the habitat was from the two channels on the east and west sides of the penninsula studied, then this part of the stand would be the last to be colonized. Comparable somewhat erratic profiles for *P. australis* have been reported by several authors (Husak and Kvet,1973; Mochnacka-Lawacz,1974) and by Smith (1973) for *Scolochloa festucacea*. *P. australis* declined in performance in row two in terms of maximum height, flowering density, and weight per stem in addition to biomass (see 1.3.1). These may be indications of a younger part of a stand.

Some characteristics exhibited definite reactions to the moisture gradient- including density, which increased with increasing moisture and weight per stem, which declined with increasing moisture. Mochnacka-Lawacz (1974) reported no consistent trends in density with increasing moisture but increasing density with increasing moisture was reported by Buttery and Lambert (1965) and Anderson (1976). Nikolajevski (1971) and Mochnacka-Lawacz (1974) reported that average stem weight declines with increasing water depth. Nikolajevski (1971) found that in deeper water reed stems have less conductive and supportive tissue and larger lumens and therefore average stem weight declines.

Similar correlations between various *P. australis* characteristics were reported by Ondok (1970 and 1971), with a higher correlation between density and biomass in the drier (r = 0.82) than in the wetter part (r = 0.50) of the same stand. He reported a positive relationship between average height and biomass ($r = .329, \alpha = .05$). I found a positive correlation between flowering and total density (r= +.533, n= 80) in contrast with Onkok (1970) who found a negative correlation (r= -.740). Haslam (1972) emphasized that many factors such as stand age, moisture regime, and nutrient status can effect the flowering response of *P. australis*. The very different relationship reported by Ondok may have been due to differences in one or more of these factors.