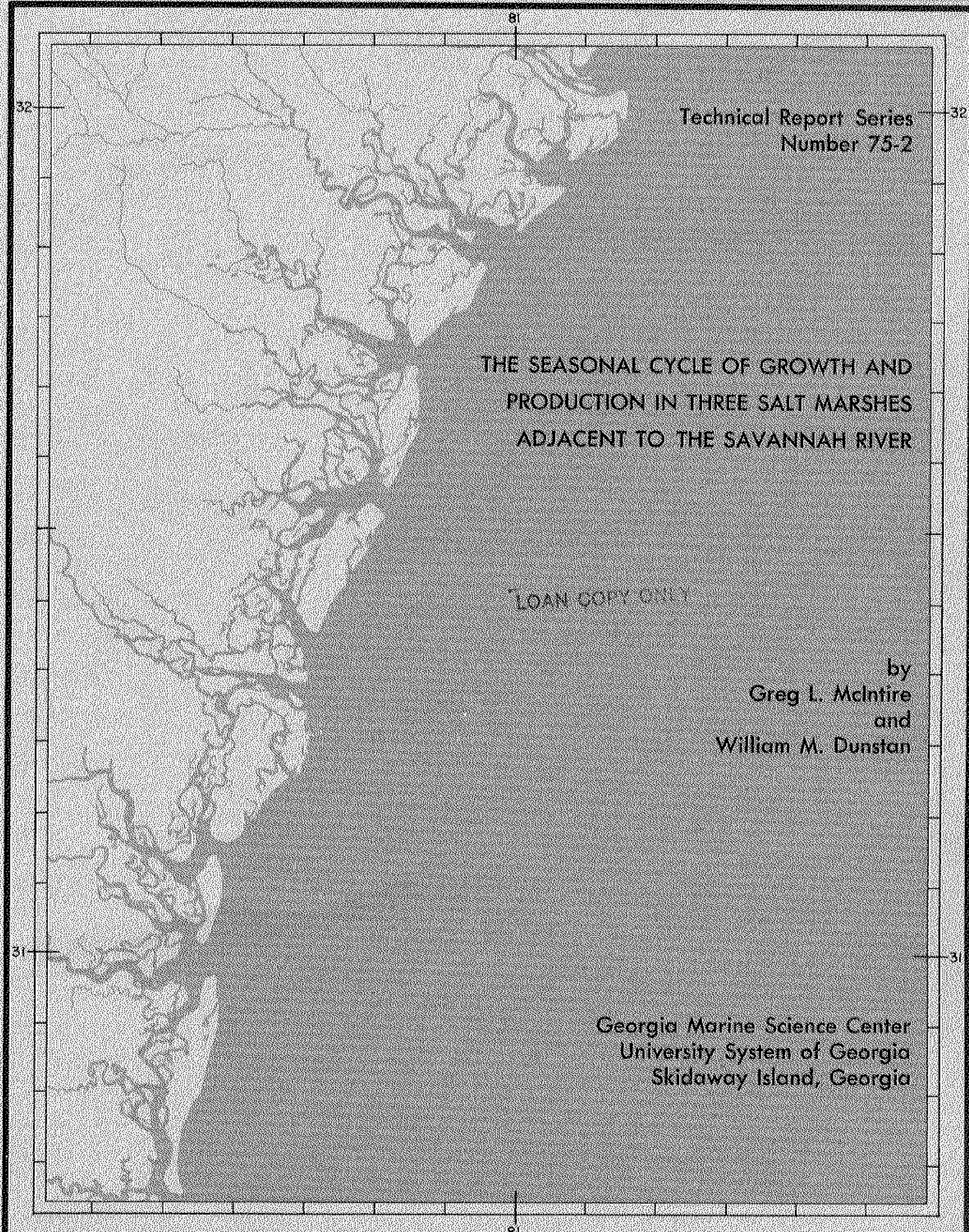

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THE SEASONAL CYCLE OF GROWTH AND PRODUCTION IN THREE SALT MARSHES ADJACENT TO THE SAVANNAH RIVER

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Abstract

Three geographically similar *Spartina alterniflora* marshes near Savannah, Georgia were studied monthly during 1974. Production levels, percent ash, and other growth parameters were measured. While general growth trends were similar at all three sites, the levels of production varied significantly with the marsh on the Savannah River showing the greatest production. Measurements of standing dead *Spartina* revealed a ready supply of detrital energy which is available to the adjacent estuarine regions throughout the year. The Savannah River marsh demonstrated that studies of river systems with high levels of industrial and municipal effluents must consider increased plant production as well as inhibitory or toxic effects. This study is a first step towards a "condition index" for coastal salt marshes which would enable industrial and governmental agencies to determine the effects of environmental perturbations on these important natural resources.

Introduction

The coastal salt marshes of Georgia provide the State with a wide variety of valuable assets. They are important geologically in stabilizing the coastal zone, and they provide feeding and nursery grounds for commercially important fisheries. These ecologically important areas support a unique flora and fauna which have adapted to the transition zone between terrestrial and oceanic environments. Despite ever changing environmental conditions, salt marshes are highly productive areas.

While many other important plants are found in salt marshes, *Spartina alterniflora* Loisel is particularly well adapted to the environment and contributes significantly to the coastal food web. *Spartina alterniflora* is a C_4 photosynthetic plant and grows well in conditions of high temperature and high light intensity (Black, 1971). A halophyte, *Spartina* can tolerate salinities as high as 40 to 50^o/oo (Keefe, 1972). However growth rates are affected by salinity changes. Nixon and Oviatt (1973) found a negative regression of growth with increasing salinity. Phleger (1971), working with a West Coast variety (*Spartina foliosa*), showed that growth and survival were greatest in fresh water. The reason that *Spartina alterniflora* may dominate marsh areas is that other plants are more affected by increases in salinity and not that optimal growth for *Spartina* is at increased salinity. Living *Spartina* is not utilized by grazers, but contributes to secondary production through a detrital food web. Dead *Spartina* enters the detrital food chain throughout the year, resulting in elevated levels of organic matter at the surface of the marsh and in surrounding estuarine waters.

Because of the commercial and ecological importance of salt marshes, it was felt that a study should be made of a marsh area proximate to a large municipal-industrial river system. While many surveys are available in the literature, none of these concern marshes near presumably polluted river systems.

This report presents the results of a one-year monthly survey of three river marshes near Savannah, Georgia. With this information, we are able to compare the production and the growth cycle of Savannah plants with those from non-polluted regions. Furthermore, it represents a first step in finding productivity levels, physiological characteristics or allometric relationships which could be used to characterize or "index" the condition of a local marsh.

Methods

Areal and individual plant samples were taken on a monthly basis. The marshes studied are located adjacent to the Savannah, Wilmington, and Skidaway Rivers (Fig. 1). All the samples were of medium to tall (non-creek bank) *Spartina alterniflora.* Samples for biomass determination were taken using a wire square 1/16 m^2 in area. The squares were thrown in a random manner and all of the material within was harvested to soil level. Three areal samples were taken from each marsh every month. The samples were separated into leaf, culm, and dead material, and the dry weight and percent ash were determined on each portion.

In addition 20 individual plants were taken from each marsh in a random manner every month. These plants were clipped at soil level and measured for length and number of live leaves. They were then separated into leaf, leaf sheath, and culm,and each portion was analysed for dry weight and percent ash. Dry weights were determined by drying in a forced air oven at 110°C overnight. Percent ash weight was determined by overnight combustion of a subsample in a Thermolyne muffle furnace at 400°C.

Results

Values for total dry weight (TDW/m^2), live dry weight/m^2, and dead dry weight/m^2 measured at the three study sites are shown in Figure 2. Data from the individual plant samples are listed in Table 1. Monthly values of average plant height are shown in Figure 3. Percent dead TDW/m^2 (Figure 4) shows large percentages during the summer. Levels of ash free dry weight/m^2 (AFDW) are shown in Figure 5 generally reflecting the trends in TDW from Figure 2.

Discussion

A. Measures of Growth Cycle and Variations Between Marshes

The study sites were chosen based upon their geographical similarities (Fig. 1). All three are close to a source of flowing water. The substrate in all three areas consists of brown-black mud which is regularly covered by the tides. Being well within the protective barrier islands, the areas are not exposed to wave action and other direct ocean influences. Levels of sunlight, temperature, and precipitation do not differ significantly over the areas. Broad trends in growth and the distribution of organic matter reflect these similarities,such as the point where live matter exceeds dead matter in April-May (Fig. 2).

Based upon their locations, the marshes studied were potentially similar, yet qualitatively they were very different. Figure 2 demonstrates that levels of production differed significantly in all three marshes. Peak values were obtained during August, yet the Wilmington site showed high production earlier in the season. TDW varied over 400 and 200% of the minimum values at both the Savannah and Skidaway sites respectively, while TDW at the Wilmington site varied less than 60% from minimum values. Absolute values of production in all three marshes clearly indicated how varied these areas were.

Data from the 20 plant random samples generally reflected areal changes in production and yielded information about plant physiology. The average heights of plants reached maximum values during August (Fig. 3). Other measures, such as dry weight/plant, leaves/plant, and ash free dry weight/plant, showed similar patterns (Table 1). It is notable that plants from the Savannah River site showed almost constant elongation to a peak in August, while the other sites showed little or no elongation during June and July (Figure 3). This demonstrates one advantage of studying individual plants rather than using ecological production surveys to determine a "healthy" marsh. The Savannah site clearly showed that *Spartina alterniflora* is capable of constant growth (elongation) during the summer months.

B. Food Chain Relationships

Levels of dead matter/m^2 were highest during the winter (Fig. 2). From November until April dead material made up over 50% of the TDW (Fig. 4). This bulk of dead matter forms an energy pool of organic material that supports the detritus food chain throughout the year by dampening seasonal fluxes. The standing crop of organic matter is reflected by levels of AFDW over the year and was relatively constant at two of the study sites (Fig. 5); this again emphasizes the steady supply of organic matter to the ecosystem from *Spartina* marshes. A gradual and continuous contribution of organic matter to the estuarine environment is probably the most important trophic function of *Spartina alterniflora*. Storing up energy as organic matter during summer growth, *Spartina alterniflora* provides an important source of detrital energy during periods of low production and guarantees a supply of stored energy for the ecosystem throughout the year.

C. High Savannah River Production

Levels of production at the Savannah River site were very high relative to the other sites. Using Nixon and Oviatt's (1973) estimate that standing crop represents 85-90% of the net production, Table 2 shows levels of standing crop and production from several areas along the east coast. Values from the present study compare well with those from other Georgia studies (Table 2). Those from the Savannah River are the highest on the table with the exception of Odum's surveys. This high level of growth may be associated with "pollution." The region just upstream from the study site is heavily industrialized. In addition, the Savannah River carries high levels of nitrogen into the coastal region (Windom and Dunstan, 1974). Nixon and Oviatt (1973) found similar production patterns in Narragansett Bay where marshes closer to nutrient inputs (sewage, pollution) were enhanced compared with marshes further away. While point sources of industrial pollutants might be expected to cause die-offs and growth reduction in *Spartina*, the flow of nutrient rich, industrially polluted water from the Savannah River supports highly productive marshes.

D. Appraisal of Marsh Conditions

From the results of our one year study, it is obvious that there are tremendous areal variations in marsh production. Thus, in appraising past or potential perturbations to salt marshes, consideration of local variations is essential. Efforts must be directed toward straightforward, inexpensive methods of production and condition appraisals that can be easily and readily performed.

One method of comparing marshes did show some promise. Williams and Murdock (1969) and Nixon and Oviatt (1973) have suggested using plant height as a measure of production. They have found a good correlation between plant height and the natural logarithm of production. Thus, by measuring the heights of randomly chosen plants, the production of a marsh may be estimated avoiding the harvesting method.

The data from our study were graphed (Fig. 6) and a test performed to see if the relationship could correctly predict production. Areal and individual plant samples were taken as described above. An estimate of plant density was made by measuring and counting plants over 20 cm tall within each quadrant. The results are shown in Table 3. Values predicted using density as a factor were closer to the true value in 5 out of 8 cases. Linear regressions were run on the true data using actual dry weights and density multiplied by dry weights/100. Those using density as a factor had a correlation coefficient of .89,while those without had a correlation coefficient of .80.

We will continue efforts to find a simple method of indexing and appraising marshes. Variations in local production preclude assuming standard production levels based on existing data. Statistically valid surveys are too expensive and time consuming for rapid marsh appraisal required by government or industry. Individual random plant samples illustrate physiological differences and perhaps allow rapid measurements of production from height-production relationships. In this direction, we have also measured some chemical characteristics of *Spartina*. We are hopeful that measurements associated with production estimates will provide a much needed index of marsh condition.

Acknowledgements

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References

Black, C.C. 1971. Ecological implications of dividing plants into groups with distinct photosynthetic production capacities. *Advances in Ecological Research.* 7:87-114.

Gallagher, J.L., Reimold, R.J. and Thompson, D.E. 1972. Remote sensing and salt marsh productivity. *Proceedings 38th Annual Meeting, American Society of Photogrammetry,* Washington, D.C., 1972, pp. 338-348.

Good, R.E. 1965. Salt marsh vegetation, Cape May, New Jersey. *Bull. New Jersey Acad. Sci.* 10(1):1-11.

Keefe, C.W. 1972. Marsh production: A summary of the literature. *Marine Science.* 16:163-181.

Morgan, M.H. 1961. Annual angiosperm production on a salt marsh. M.S. Thesis Univ. Dela. 34pp.

Nixon, S.W. and Oviatt, C.A. 1973. Analysis of local variation in the standing crop of *Spartina alterniflora. Botanica Marina.* 16:103-109.

Odum, E.P. 1959. Fundamentals of Ecology. W.B. Saunders Co., Phila. 546 pp.

____. 1961. The role of tidal marshes in estuarine production. *N.Y. State Cons.* 15(6):12-15, 35.

Phleger, C.F. 1971. Effect of salinity on growth of a salt marsh grass. *Ecology.* 52:908-911.

Smalley, A.E. 1959. The growth cycle of *Spartina* and its relation to the insect populations in the marsh. *Proceedings Salt Marsh Conf., Mar. Inst. Univ. of Ga., Sapelo Isl., Ga.* 96-100.

Wass, M.L. and Wright, T.D. 1969. Coastal wetlands of Virginia. Interim report to the Governor and General Assembly. *VIMS Spec. Rept. in Applied Mar. Sci. and Ocean Eng. #10.*

Williams, R.B. and Murdoch, M.B. 1969. The potential importance of *Spartina alterniflora* in conveying zinc, manganese, and iron into estuarine food chains. *Proc. 2nd Natl. Symp. on Radioecol.* 431-439.

Windom, H.L., Dunstan, W.M., and Gardner, W.S. 1974. River input of inorganic phosphorous and nitrogen to the southeastern salt marsh estuarine environment. *Mineral Cycling in S.E. Ecosystems. A.E.C. Savannah River Ecological Laboratory Publication.*

Table 1

Measurements from 20 Randomly Selected Plants

	J	F	M	A	M	J	J	A	S	O
Mean Plant Dry Weight (gms)										
Savannah	5.4	7.5	.9	3.5	4.3	5.3	11.5	13.4	13.4	10.0
Wilmington	.3	.6	.5	1.1	1.3	2.2	2.1	2.7	2.6	1.8
Skidaway	.8	.7	.6	.6	1.5	1.3	2.3	2.9	3.2	2.0
Mean Plant Ash Free Dry Weight (gms)										
Savannah	4.9	6.9	.8	3.2	3.8	4.5	10.3	12.0	12.5	9.2
Wilmington	.2	.6	.5	.9	1.1	1.9	1.7	2.3	2.3	---
Skidaway	.7	.6	.6	.4	1.4	1.1	2.1	2.6	2.8	---
Mean Number Leaves/Plant (rounded to nearest whole number)										
Savannah	3	3	3	3	4	3	5	7	7	5
Wilmington	1	3	2	2	3	3	4	5	5	4
Skidaway	3	2	2	2	2	2	3	4	3	4
% Live Leaves/Plant (by weight)										
Savannah	11	21	29	44	26	40	41	41	38	31
Wilmington	11	43	67	36	36	29	48	32	42	40
Skidaway	25	28	27	30	29	25	41	30	22	28

Table 2

Location	Biomass g dry/m^2	Net Production g dry/m^2/yr	Source
Savannah River	1922	2162	This Study
Wilmington River	328	369	This Study
Skidaway River	275	309	This Study
Fall River	946	1064	Nixon and Oviatt (1973)
Narragansett Bay	887	998	Nixon and Oviatt (1973)
Block Island Sound	476	536	Nixon and Oviatt (1973)
New Jersey	300	338	Good (1965)
Delaware	413	445	Morgan (1961)
Virginia	1332	1499	Wass and Wright (1969)
North Carolina	545	650	Williams and Murdock (1969)
Georgia	1750-2888	2000-3300	Odum (1959-1961)
Georgia	1013	1158	Teal (1962)
Georgia	851	973	Smalley (1959)
Georgia	1665	1873	Gallagher, *et al.* (1972)

Table 3

Marsh	Height (cm)	Actual Wt. g/m^2	Predicted Wt. Height	Predicted Wt. Ht (.01)D$^+$
Wilmington River	56.0*	415	342	538
Random Plants	71.0†		430	728
Skidaway River	66.0	211	399	268
Random Plants	63.0		381	263
Savannah River	127.0	2530	1028	1483
Random Plants	136.0		1183	1729
Bethesda Marsh	98.0	1467	658	1656
Random Plants	116.0		876	2530

*Height values are averages from the plants within the quadrants.

†Values are from the twenty random plants outside of the quadrants.

$^+$Density values are in culms/m^2

Figure Captions

Fig. 1 Map of study region showing 3 sample site locations.

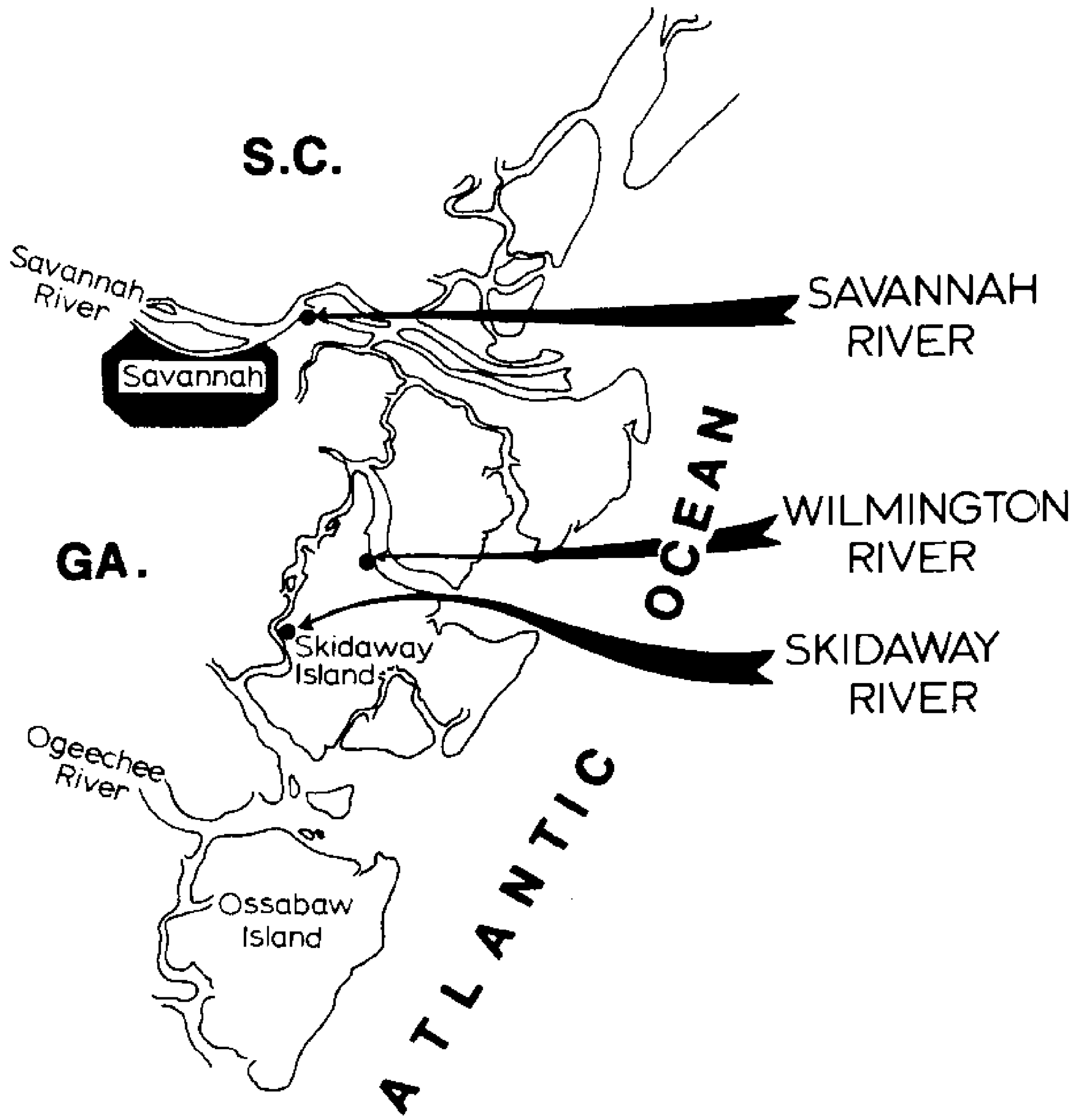
Fig. 2 Total dry weight, live dry weight, and dead dry weight/m^2 during the year.

Fig. 3 Average plant height at each marsh during the year.

Fig. 4 Percentage dead material during year.

Fig. 5 Ash free dry weight/m^2 at each marsh during the year.

Fig. 6 Standing crop (gms dry wt/m^2) vs height from three studies.



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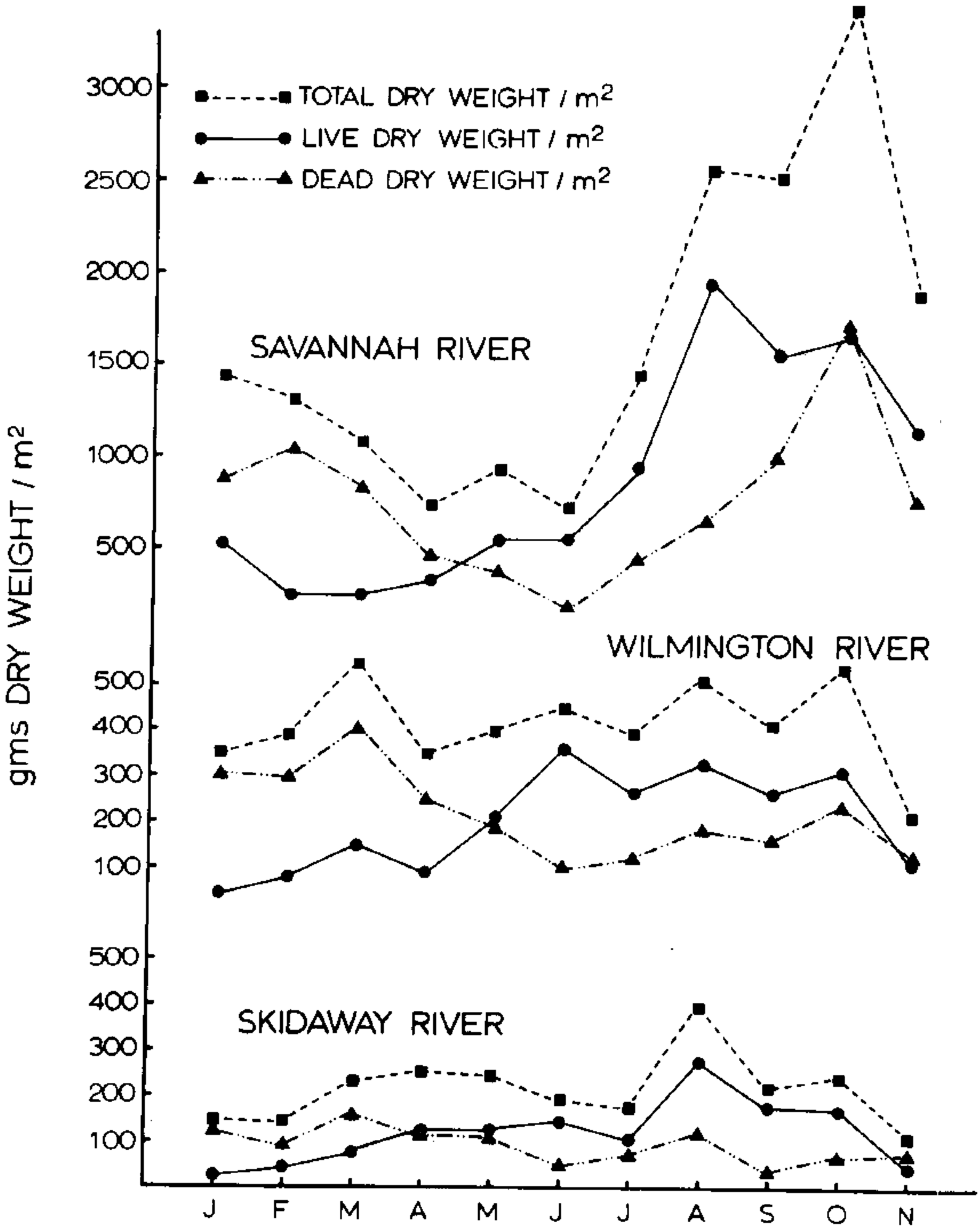

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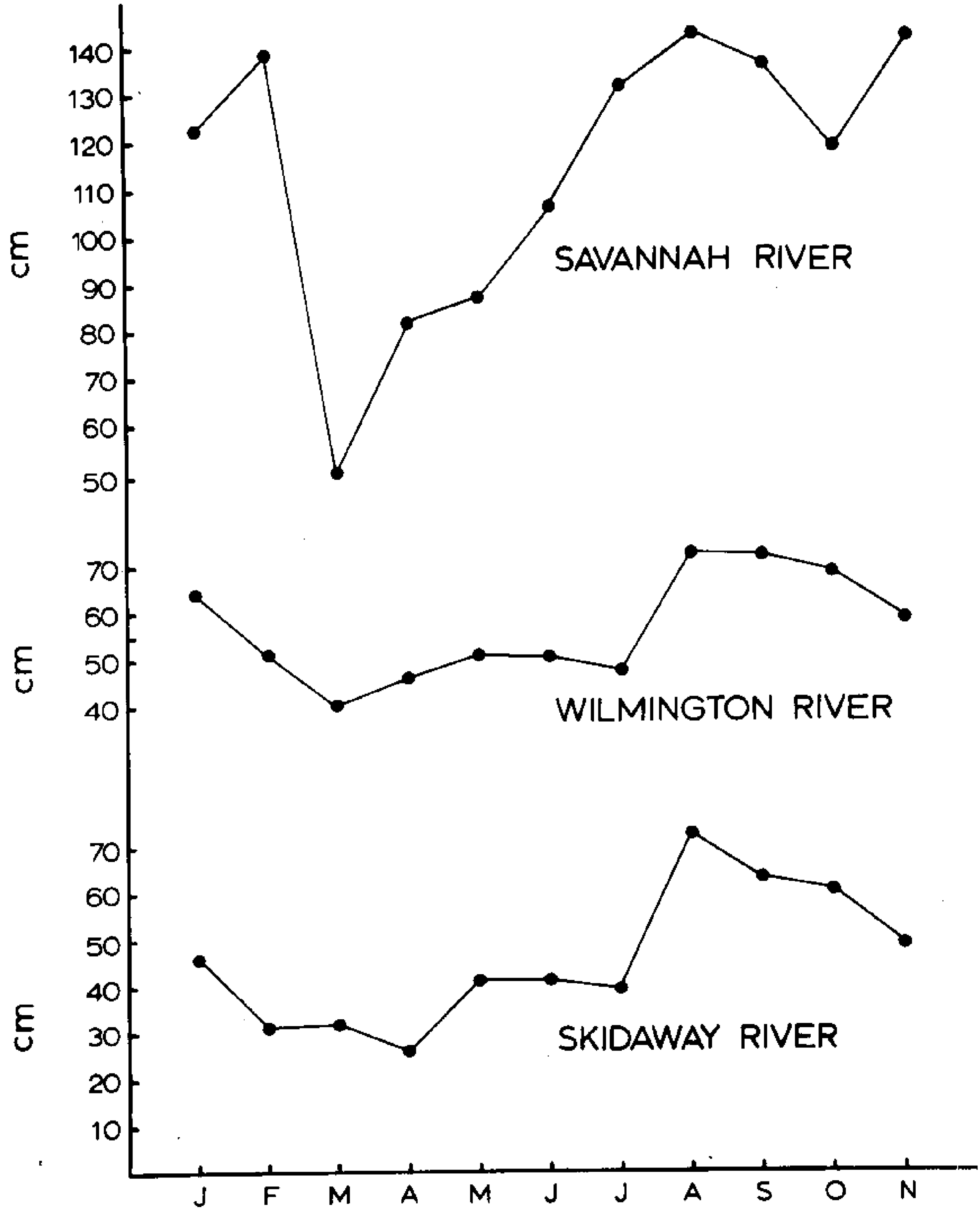

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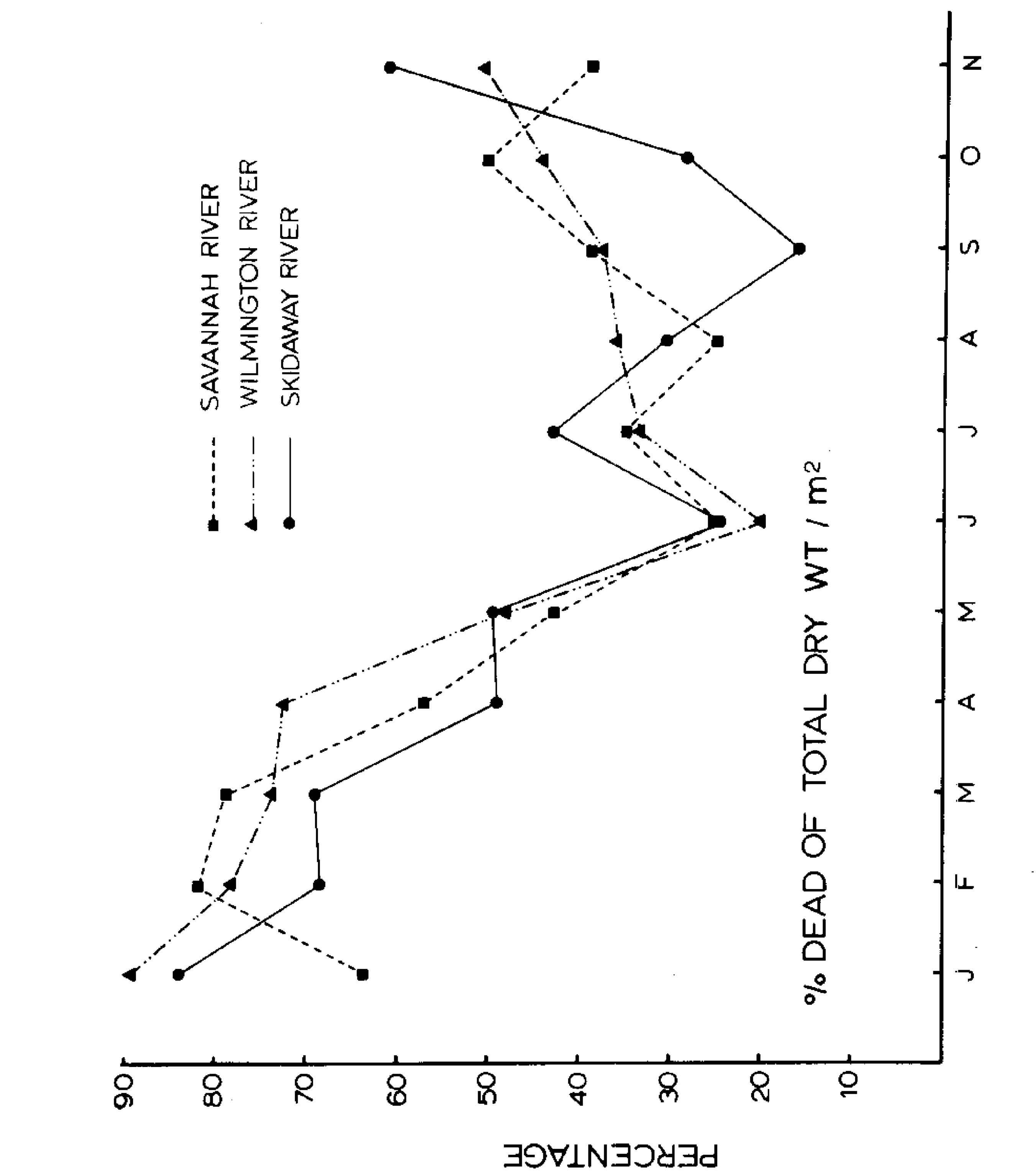

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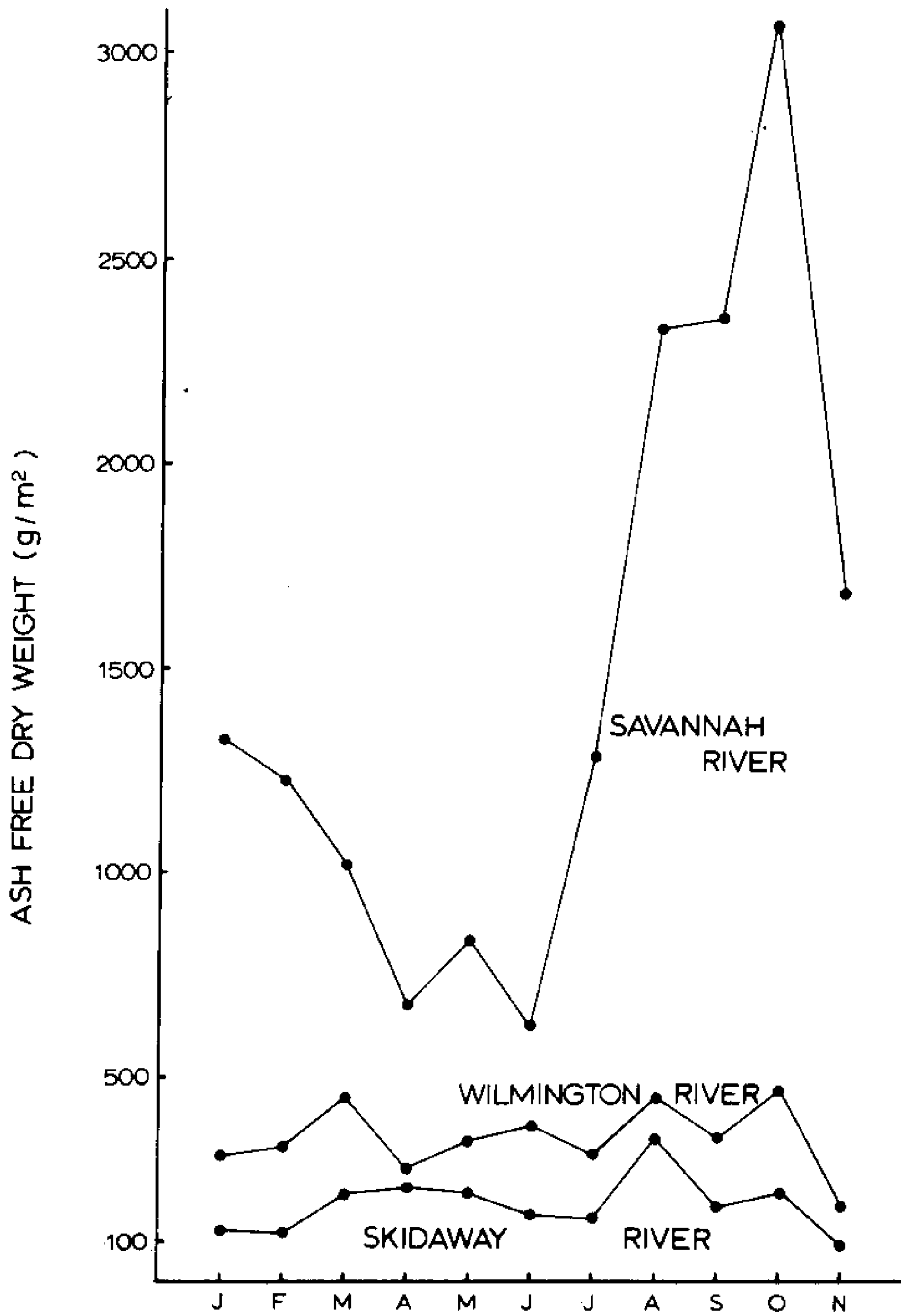
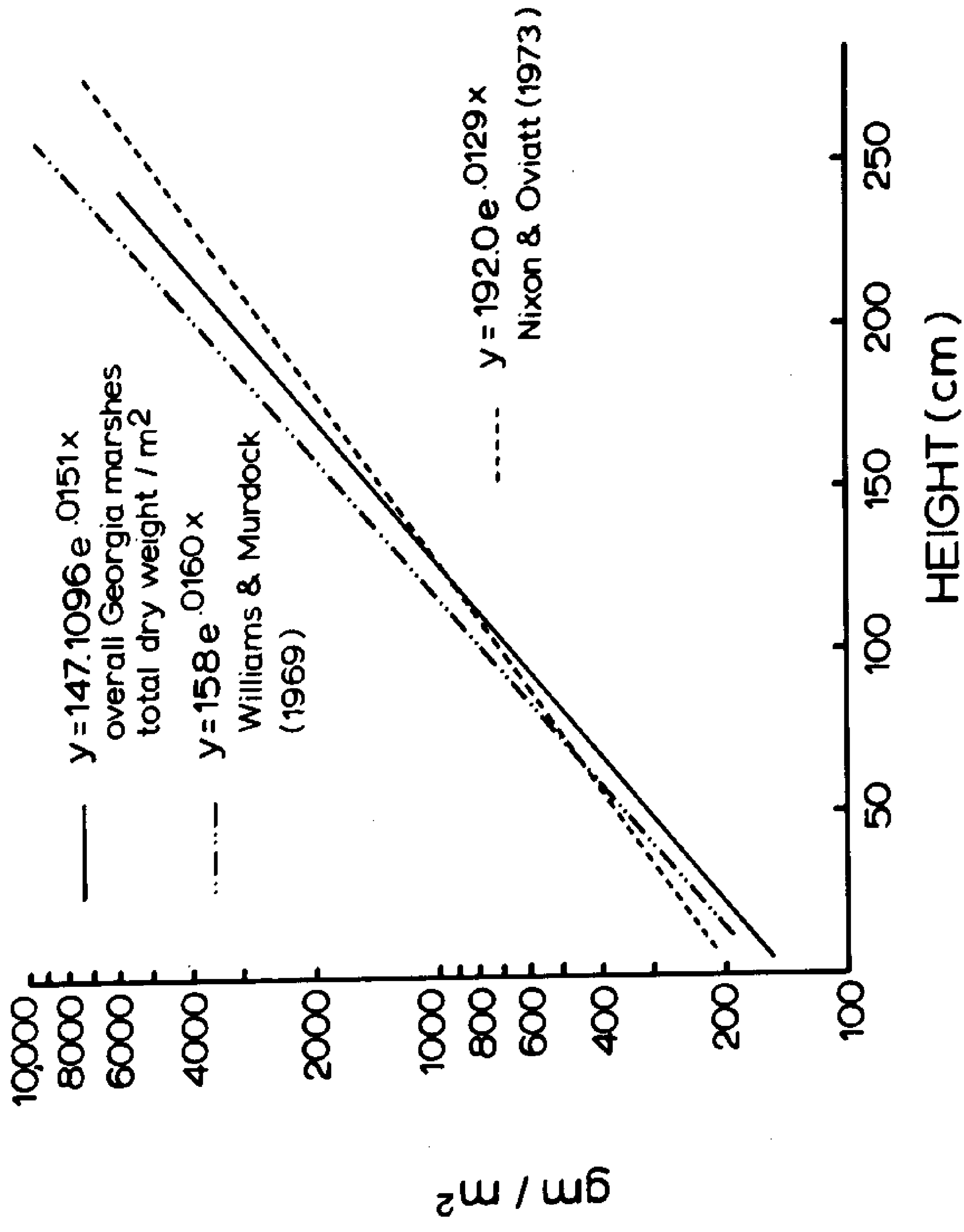


Fig. 5 Ash free dry weight/m^2 at each marsh during the year.



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