WATER DEPTH AND TURBIDITY IN RELATION TO GROWTH OF SAGO PONDWEED

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The amount of waterfowl food produced by a marsh is often closely associated with the waterfowl carrying capacity of that marsh. A better understanding of the growth of some important waterfowl food plants and a knowledge of their environment are necessary to manage a marsh for optimum propagation of waterfowl food.

This study presents the relationships of water depth and water turbidity to aquatic plant production. This study was not designed to explore the reasons behind the relationships, but rather to show the existence of such relationships.

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Study Area

This investigation was conducted on the marsh of the Bear River Club Company, located on the delta of the Bear River, about 15 mi. west of Brigham City, Utah. The marsh consists of several thousand acres of superb waterfowl habitat. A simple dike system regulates the water depth which reaches a maximum of 2 ft. except in the canals where it may be deeper.

Submersed vegetation consists mainly of sago pondweed (*Potamogeton pectinatus*), horned pondweed (*Zannichellia palustris*), and muskgrass (*Chara* spp.). The emergent vegetation is composed primarily of cattail (*Typha angustifolia* and *T. latifolia*), alkali bulrush (*Scirpus paludosus*), hardstem bulrush (*Scirpus acutus*), and reed grass (*Phragmites communis*).

Soils of the Bear River delta are predominantly clays and sandy clays (Jensen, 1940). Observations indicated soil types and fertility varied somewhat throughout the study area, but no intensive study of soils was incorporated in this investigation.

Methods

Vegetation sampling techniques were similar to those of Rickett (1921, 1924) and Low and Bellrose (1944). A square frame, measuring 12 in. per side, was lowered into the water, and the vegetation confined within it was collected.

Forty-two sampling sites were selected, with the aid of a table of random numbers, from aerial photographs of the western portion of the Bear River Club marsh. The sampling sites were located in water depths ranging from 3 to 20 in. At each site, four vegetation samples were taken systematically. The center of the sampling site was marked with a 4-ft. metal rod. A square foot vegetation sample was taken 4 ft. distant from the rod at each of the four points of the compass. Each of the four samples was placed in a separate container and marked by site number and compass reading.

The amount of vegetation, composed of approximately 95 percent sago pondweed, was determined on a dry-weight basis. Each sample was dried for 48 hr. at 90°C.

At each sampling site, one water sample was collected midway between the water surface and the marsh bottom; i.e., at a sampling site in water 10 in. deep, the water sample was taken 5 in. below the water surface. A Klett-Summerson photoelectric colorimeter with a No. 42 (blue) filter was used to measure the turbidity of the water by determining the amount of light penetration through a given sample of water.

Results

The mean weights of 168 samples of vegetation obtained from 42 sites during the period from July 30 to August 6, 1959 were correlated with water depth (Table 1). The calculated correlation coefficient, $r = 0.80$, is highly significant at the 95-percent level. A maximum sago pondweed production of 152.7 g. was obtained from a sample site in

Table 1.—Mean Weights of 168 Vegetation Samples and Estimated Production from Different Water Depths in 1959

No. of Samples	Water Depth (in.)	Plant Production (mean g. / sampling unit)	Approximate Pounds per Acre
8	3	2.4± 0.7[1]	60
8	3	2.4± 0.7[1]	60
8	5	3.9± 0.7	95
16	6	5.7± 3.9	150
8	7	13.6± 6.2	385
24	8	3.7± 0.9	90
20	10	9.0± 2.8	225
4	11	6.0± 0.5	150
4	12	42.6± 5.1	1,000
8	13	61.7± 9.5	1,500
20	14	75.6± 8.0	1,800
16	15	119.6±14.1	2,850
4	16	117.3± 7.3	2,800
12	18	101.7± .50	2,400
4	19	97.3±15.4	2,350
4	20	113.3±15.6	2,700

[1] Standard error of the mean.

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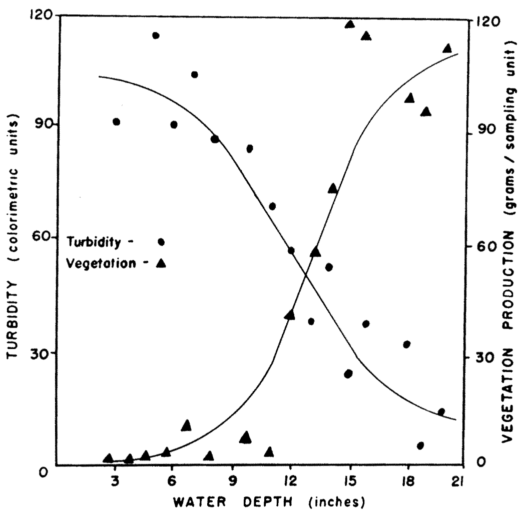

FIG. 1. Relationship between water depth, mean weight of plant mass, and mean turbidity as obtained from 168 aquatic vegetation samples. Vegetation weights and turbidity measurements were stratified as to water depth and then a mean calculated.

water 15 in. deep. The minimum production, 0.2 g., was collected from a sample site in 6 in. of water. Those vegetation samples taken from the same water depths, at gradations of 1 in., were averaged and then plotted (Fig. 1).

A negative correlation exists between water depth and turbidity, deeper water being considerably less turbid than more shallow areas (Fig. 1). The calculated correlation coefficient, $r = -0.91$, is highly significant at the 95-percent level.

The relationship between water turbidity and vegetation production is marked (Fig. 2). A negative correlation, $r = -0.61$, existed between water turbidity and the amount of aquatic vegetation present. This correlation coefficient is highly significant at the 95-percent level. The weights of vegetation samples collected from water with the same turbidity level, within 10 colorimetric units, were combined and averaged (Table 2) and then plotted (Fig. 1). The greatest mass of aquatic vegetation, 152.7 g., was collected from a sample site in water with a small amount of suspended matter present. The lowest production of vegetation, 0.2 g., was found in water with a large amount of suspended matter present.

DISCUSSION AND CONCLUSIONS

A complex relationship exists between vegetation production, water depth, and water turbidity. A cause-and-effect relationship undoubtedly exists between these variables; however, the identity or degree of the cause and effect was not determined in this study.

Turbidity and plant production were closely associated. This study shows a relationship between turbidity and the amount of aquatic vegetation present, a relationship stronger in the 6- to 18-in. depth than in the shallower or deeper areas. Other observers have suggested a relationship between vegetation production and water turbidity (Martin and Uhler, 1939; Low and Bellrose, 1944; Chamberlain, 1948; Nelson, 1954). Chamberlain (1948), reporting on a study conducted on the Back Bay National Wildlife Refuge in Virginia, states: "Turbidity, however, was found to be correlated with the quantity of aquatic growth, the better areas being less turbid." He found that turbidity was the chief limiting factor in aquatic plant growth. However, the report did not include statistically sound quantitative studies to determine the extent of this relationship.

I also found water depth to be closely associated with aquatic plant production; the most striking relationship was in the water depth zone of 9 to 15 in. Other observations have also shown a relationship between water depth and aquatic plant mass (Martin and Uhler, 1939; Low and Bellrose, 1944; Hall, *et al.*, 1946; Singleton, 1951; Anonymous, 1958). However, again as with turbidity relationships, no intensive study was conducted to show the extent of this relationship.

In shallow water the amount of submersed vegetation is low and the turbidity is high. Where water depth exceeds 6 in., turbidity decreases rapidly, but vegetation production increases abrupt-

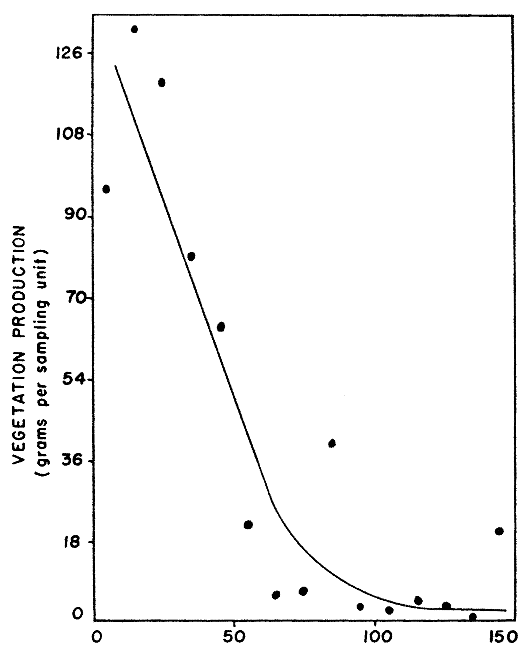

FIG. 2. Relationship between water turbidity and the mean weights of vegetation samples collected at 42 sampling sites. Vegetation samples were stratified into turbidity classes and a mean weight calculated.

TABLE 2.—MEAN WEIGHTS OF 168 VEGETATION SAMPLES AND ESTIMATED PRODUCTION FROM WATER OF DIFFERENT TURBIDITIES IN 1959

Relative Turbidity Rating	No. of Samples	Water Turbidity[1]	Plant Production (mean g. / sampling unit)	Approximate Pounds per Acre	Mean Pounds per Acre
	4	0– 10	97.3± 4.0[2]	2,350	
	8	11– 20	133.0±14.1	3,200	
Low	8	21– 30	120.8±11.3	2,800	2,050
	24	31– 40	81.5±20.8	1,950	
	24	41– 50	65.7±16.9	1,500	
	8	51– 60	22.1±14.1	550	
	4	61– 70	6.6± 1.7	150	
Medium	16	71– 80	7.1± 3.3	175	400
	16	81– 90	39.9±18.2	950	
	20	91–100	4.3± 1.9	100	
	12	101–110	2.3± 1.5	55	
	8	111–120	5.2± 1.4	125	
High	4	121–130	4.6± 0.7	100	125
	4	131–140	0.2± 0.2	5	
	4	141–150	20.7± 9.9	500	

[1] Units on a Klett-Summerson photoelectric colorimeter.
[2] Standard error of the mean.

ly as water depth exceeds 9 in. It seems therefore that by inundating the majority of the Bear River Club marsh or similar western marshes to a depth exceeding 9 in. the greatest amount of submersed waterfowl food could be produced (if all other factors remained constant). Since no sample was collected from water more than 20 in. deep, management information cannot be projected to the deeper waters. It is suspected, however, that water depth–vegetation relationships will remain until there is reached a water depth through which light rays can no longer pass in quantity or a depth which exceeds the optimum requirements of the plant in question.

Water depth and turbidity are not the only factors that affect growth and production of waterfowl food plants. Soil type, soil fertility, water chemistry, wave action, and countless other factors play important roles in determining plant growth.

SUMMARY

To better understand the complex ecological relationships within waterfowl marshes, a vegetation production study was initiated in the Bear River marshes during the summer of 1959. Vegetation and water samples were collected from 42 sampling sites.

Strong correlations were found between vegetation production and water depth, water depth and turbidity, and turbidity and vegetation production. Deeper waters were observed to support larger crops of aquatic vegetation. These deeper waters also contained less suspended matter.

Water depth at the delta of the Bear River is a significant factor to be considered in the management of the local marshes for the production of the greatest amount of aquatic waterfowl food.

REFERENCES CITED

ANONYMOUS. 1958. Water plants and wildlife. Minn. Dept. Cons. Div. Game and Fish, Sec. Res. and Planning, St. Paul. 11pp. (processed).

CHAMBERLAIN, E. B., JR. 1948. Ecological factors influencing the growth and management of certain waterfowl food plants on Back Bay National Wildlife Refuge. Trans. N. Amer. Wildl. Conf., 13:347–355.

HALL, T. F., W. T. PENFOUND, AND A. D. HESS. 1946. Water level relationships of plants in the Tennessee Valley with particular reference to malaria control. J. Tenn. Acad. Sci., 21(1):18–59.

JENSEN, G. H. 1940. The relationship of some physical and chemical factors of the soil to the productivity and distribution of certain waterfowl food plants at the Bear River Migratory Waterfowl Refuge. Unpub. master's thesis, Utah State Univ., Logan, Utah. 34pp.

LOW, J. B. AND F. C. BELLROSE, JR. 1944. The seed and vegetative yield of waterfowl food plants in the Illinois River Valley. J. Wildl. Mgmt., 8(1):7–22.

MARTIN, A. C. AND F. M. UHLER. 1939. Food of game ducks in the United States and Canada. Tech. Bull. 634. U.S.D.A. 157pp.

NELSON, N. F. 1954. Factors in the development and restoration of waterfowl habitat at Ogden Bay Refuge, Weber County, Utah. Utah State Dept. Fish and Game, Publ. 6. 87pp.

RICKETT, H. W. 1921. A quantitative study of the larger aquatic plants of Lake Mendota. Trans. Wis. Acad. Sci., Arts, and Let., 20:501–527.

———. 1924. A quantitative study of the flora of Green Lake, Wisconsin. Trans. Wis. Acad. Sci., Arts, and Let., 21:381–414.

SINGLETON, J. R. 1951. Production and utilization of waterfowl food plants on the east Texas Gulf Coast. J. Wildl. Mgmt., 15(1):46–56.

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