Stieglitz, W. O. and C. T. Wilson 1968. Breeding biology of the Florida Duck. J. Wildl. Mgmt. 32(4): 921-934.
Wright, B. 1954. High tide and east wind: the story of the Black Duck. Stackpole Co., Harrisburg, Pa. 162pp.
Yocum, C. F. and H. A. Hanses 1960. Population studies of waterfowl in eastern Washington. J. Wildl. Mgmt. 24(3) :237-250.

SOME ECOLOGICAL CONDITIONS UNDER WHICH SELECTED WATERFOWL FOOD PLANTS GROW IN SOUTH CAROLINA[1]

Percival, H. Franklin[2], Lloyd G. Webb[3], and Norwood R. Page[4]

There are approximately one-half million acres of marshland in South Carolina and a total of almost seven million acres of coastal marshes in the Gulf and South Atlantic coasts (Wilson, 1967). These figures do not include the vast acreage of upland wetland areas suitable for waterfowl habitat. The importance of these vast areas has to be recognized as an important resource or potential resource in the Southeastern United States.

The South Carolina Wildlife Resources, United States Fish and Wildlife Service, and many private landowners are developing some of these wetland areas for wildlife habitat. Often the private landowner looses in his attempts due largely to lack of technical assistance. The Belle W. Baruch Foundation, The South Carolina Wildlife Resources Department and the South Carolina Agricultural Experiment Station initiated a joint study directed toward determining the food habits of waterfowl wintering in the coastal areas and defining some ecological conditions of some of the more important waterfowl food plants in that area.

The first step to accomplishing this goal was to conduct a food habit study to determine the more important food plants of waterfowl wintering in the state. James A. Kerwin, working under a grant from the South Carolina Agricultural Experiment Station, completed these analyses in 1967.

This paper is a result of a second task to determine some of the factors surrounding the growth of some of the plants selected from Kerwin's (1967) data and Conrad's (1965) food habit study of waterfowl collected on the Pee Dee and Waccamaw Rivers.

METHODS AND TECHNIQUES

The plants considered in this study were selected because of their importance to waterfowl as food plants as indicated by food habit studies by Kerwin (1967) and Conrad (1965). Sampling sites were determined on the basis of the presence of a "historically pure stand" of a selected plant. A historically pure stand was defined as a local condition wherein a specific plant, whether under the same management practices or by natural phenomena, had been maintained for more than one growing season. If a plant maintained itself year after year in the same location, those factors surrounding the growth of that plant were conducive to the survival of that species.

South Carolina Wildlife Resources Department biologists and/or area managers familiar with the vegetation in their respective areas aided in the selection of the historically pure stands of these plants.

[1]This study was supported by The Belle W. Baruch Foundation, South Carolina Wildlife Resources Department, and the South Carolina Agricultural Experiment Station.
[2]Belle W. Baruch Fellow, Department of Entomology and Economic Zoology, Clemson University.
[3]Research Project Leader, South Carolina Wildlife Resources Department, Clemson University.
[4]Head, Department of Agricultural Chemical Services, Clemson University.

Each stand of plants selected for study was visited biweekly and water samples were taken if water was present at that time. Soil samples were taken monthly. The study period was from May-October, 1967.

An estimation of soluble salt concentration of water samples was made by combining sulfate content and chloride content. Sulfates were determined by the Hach Procedures for Water and Sewage Analysis using Baush and Lomb Spectronic 20 Colorimeter. Chloride content was determined by the argentometric method as described in Standard Methods (1965. pH was determined with a pH meter equipped with glass and reference electrodes.

Soil samples were analyzed for soluble salts, pH, phosphorous, potassium, calcium, and magnesium. pH was determined with a glass electrode on one part soil to two parts water. Soluble salt content was determined with a wheatstone bridge. Five to ten grams of soil were shaken with 100 ml. water for 30 minutes and allowed to sit overnight before washing up to 250 ml. with water. This solution was diluted again if concentrations were too high to be read on the wheatstone bridge. Exchangeable phosphorous was determined colorimetrically by the vanadate procedure. Potassium concentration was determined by flame emission. Calcium and magnesium concentrations were measured by atomic absorption procedures.

RESULTS

Nine waterfowl food plants important to ducks in the coastal plain area of South Carolina were studied in relation to certain chemical and physical properties of soil and water present where these plants were found growing.

Aneilema keisak Hassk. (Aneilema)

Stands of aneilema studies were located in a diked impoundment (Site 1) and an abandoned ricefield (Site 2), both of which were near the Big Pee Dee River. These stands were flooded only rarely during the study period and then only after heavy rains or extremely high tides. The soil, however, was saturated. The diked impoundment was managed with flash board risers set at bed level thus removing excess water, while the rice field was flooded by extremely high tides.

Both stands were located in what is commonly termed fresh water marshes. Soluble salt concentrations of water collected in the stands averaged 383 ppm in the diked field and 97 ppm in the tidal field (Table 1), while the soluble salts in soil samples averaged 3350 ppm and 1090 ppm respectively (Table 2). The soils were characteristically acidic with high nutrient levels. The pH of soils taken from the sites averaged 4.6 and 4.8 in the impoundment and tidal field respectively. Exchangeable phosphorous, calcium, potassium, and magnesium were in high concentrations.

Brasenia schreberi Gmel. (watershield)

Two sites were selected that produced *B. schreberi* — an upland pond on Medway Plantation (Site 3) that was literally covered with the plant and the Hatchery Pool area of Lake Marion (Site 4) which also produced dense stands of this plant. Both sites were characterized by acidic soils with low mineral nutrient concentrations (Table 2).

Watershield is a floating-leaf plant requiring standing water which, of course, was true of both sites. The depth of water in which the plant grew in both sites varied from several inches to greater than three feet. The water in the hatchery pool was slightly acidic to basic averaging 7.9 during the growing season whereas the Medway Pond had an average pH of 5.0 (Table 1). Both sites had characteristically fresh water in terms of soluble salt content.

The Medway Pond supported a much denser growth of watershield than did the Hatchery Pool. The former was generally shallower and less subject to

Table 1. pH and soluble salt content of water collected from historically pure stands of selected waterfowl food plants.

Plant	Sampling Site	pH	Soluble Salts (ppm)
aneilema	1	6.5	383
	2	6.1	97
watershield	3	5.0	135
	4	7.9	77
jointed spikerush	5	5.0	77
	6	5.9	69
squarestem spikerush	7	5.5	506
	8	5.4	673
swamp smartweed	9	6.5	383
	10	5.5	118
	11	6.2	1,528
	12	6.0	1,797
widgeongrass	13	9.0	12,298
	14	8.2	11,357
saltmarsh bulrush	15	4.3	4,040
softstem bulrush	16	6.4	2,472
	23	6.5	169

winds and resulting wave action because of its smaller surface area and protection afforded by a surrounding pine-hardwood forest.

Eleocharis equisetoides (Ell.) Torr. (jointed spikerush)

E. equisetoides thrives in fresh water habitats. The Medway pond (Site 5) in addition to supporting a dense stand of watershield, produced a stand of jointed spikerush around the shallow edges of the pond. Another site producing dense stands of jointed spikerush was located in one of the borrow pits near Bonneau, South Carolina (Site 6). The borrow pits were formed when material was "borrowed" to build extensive dikes retaining the waters of Lake Moultrie. These areas are dependent on rain and the soil water table as a source of water.

Both sampling sites were characteristically fresh water areas with low pH and low soluble salt concentration (Table 1), and supported plants that are capable of existing on soils of low nutritional levels as the top soil had been removed from both areas. Table 2 shows that nutrient concentrations were much lower in these areas than that found in the marsh soils.

Eleocharis quadrangulata (squarestem spikerush)

Two squarestem spikerush stands (Sites 7 and 8) in Big Pee Dee River marshes were studies. Both marshes were diked and the water manipulated so that water was standing in shallow depths during most of the growing season. Both fields supported dense stands of this plant.

The pH of water (Table 1) and soil (Table 2) sampled from these stands was acidic. Soluble salt concentrations were higher than in the aneilema sampling sites which were situated several miles upstream. Although soil nutrient concentration were much higher in these areas than in the Hatchery pool or Bonneau borrow pits, squarestem spikerush grew prolifically along the shallow edges in both of the latter areas. Contrastingly the jointed-stem spikerush did not appear in the most saline, nutrient-rich, marshes.

Table 2. Results of analyses of soil collected from historically pure stands of selected waterfowl food plants.

Plant	Sampling Site	pH	Expressed in ppm				
			Soluble Salts	P	K	Ca	Mg
aneilema	1	4.6	3,350	8.7	86	1391	60
	2	4.8	1,090	9.4	55	1060	39
watershield	3	5.0	470	7.5	31	336	15
	4	5.4	488	7.5	25	650	14
jointed spikerush	5	5.4	812	5.8	20	330	18
	6	5.0	790	7.6	29	364	21
squarestem spikerush	7	4.4	8,033	9.7	74	787	90
	8	4.4	5,300	12.3	76	513	64
big leaf tearthumb	9	4.3	958	13.0	50	332	107
	10	4.7	1,280	14.6	106	532	94
swamp smartweed	11	4.6	2,392	9.2	80	1167	52
	12	4.6	1,908	10.2	58	1220	50
	13	4.6	6,780	15.2	146	498	145
	14	4.7	4,740	12.4	133	444	148
widgeongrass	15	6.3	60,800	15.4	124	3348	146
	16	4.2	72,000	7.0	69	2375	98
saltmarsh bulrush	17	5.0	11,000	14.0	110	870	142
	18	4.2	22,000	9.8	132	660	129
softstem bulrush	19	3.8	19,500	9.8	112	700	96
	20	4.0	5,362	8.5	40	580	26
	21	3.7	12,000	10.5	63	730	64
	22	4.2	9,250	11.8	61	1095	78
	23	4.6	1,770	9.8	75	1357	47

Polygonum arifolium (big leaf tearthumb)

Two sites on the Big Pee Dee River were utilized as sampling sites for big leaf tearthumb growing conditions. Both sites were located on the berm of the dikes within impoundments. Because both fields were being managed for plants requiring wet soil or shallow water during the growing season, the berm was rarely flooded. Site 9, much higher in elevation, was never flooded during the study period and supported the tearthumb and a variety of undesirable plants such as thistle and reed *(Phragmites communis* Trin.). Site 10 was maintained in a wet soil condition and produced an almost exclusive stand of big leaf tearthumb.

Sampling Site 9 was located on the berm of the same field in which Site 8 of squarestem spikerush was located as sampling Site 10 was to Site 12 for swamp smartweed (*Polygonum hydropiperoides* Michz.). The data in Table 2 shows that, although originally the same soil, the berm was lower in soluble salt concentration than was found in the field. This was probably due to the fact that they are not exposed to river water except during the winter, and the rain had a leaching effect on these soils during the summer drawdown period. However, the rich nutrient levels were maintained.

Polygonum hydropiperoides Michx. (swamp smartweed)

Sampling sites 11 and 12 were located within impoundments along the Big Pee Dee River whereas sites 13 and 14 were located within impoundments on Bear Island Management Area which is between the Edisto and Ashepoo Rivers. *P. hydropiperoides* grew in abundance in sampling sites 11 and 12 but there was no evidence of that plant in sampling sites 13 and 14 which had once supported its growth. The soluble salt content of water (Table 1 and soil (Table 2) from sites 3 and 4 was much greater than that of sites 1 and 2 due to changed management practices. The major changes in management involved the greater use of brackish instead of fresh water. Also, this and other changes in management techniques could have eliminated the swamp smartweed in areas that heretofore were noted for smartweed production. Dwarf spikerush (*Eleocharis parvula* (R. & S.) Link.) was the dominant species in the Bear Island sites during the study period when more saline conditions existed.

Manipulation of water was different on Bear Island in that water was standing on the field most of the time whereas the Pee Dee fields were maintained in a wet soil state. In most situations observed flooded fields, where swamp smartweed could have been produced, did not support that plant.

The nutrient laden marsh soils were another factor enhancing the optimum growth of swamp smartweed. Absence or only sparse stands of this plant was observed in soils of less nutrient levels as was the conditions in the Medway, Hatchery pool, or borrow pit sites.

Ruppia maritima L. (widgeongrass)

Widgeongrass is a submergent waterfowl food plant that was found growing in salt water habitat. Both sampling sites (Sites 15 and 16) described by data in Table 1 and 2 were located in ponds on South Island Plantation which is bordered by the Intracoastal Waterway, the Santee River, Winyah Bay, and the Atlantic Ocean. Tables 1 and 2 show that salinity of water and soil were much greater than in any of the areas previously described. Mineral nutrients particularly calcium, were in higher concentrations that most of the other sites.

There was a dense growth of widgeongrass in both ponds but an almost complete die-off occurred in August of 1967. There was a slight decrease in soil pH and available soil nutrients at that time but no explanation for the die-off can be advanced with data taken in this study.

Scirpus robustus Pursh. (saltmarsh bulrush)

Two sampling sites were chosen to study *S. robustus*. Both sites were on Bear Island Waterfowl Management Area. Site 17 was in a diked impoundment supporting an almost pure stand of saltmarsh bulrush and Site 18 was in an Ashepoo River tidal marsh.

The soil from both sites were high in nutrient content (Table 2). Water flooded the impounded site 17 only rarely during the growing season and as a result only two water samples were taken. Site 18, within the tidal marsh, was not flooded at any time during the study period. The latter site because it was not maintained in a wet soil condition supported a variety of upland plant species competing with saltmarsh bulrush thus reducing the density of saltmarsh bulrush.

Both water and soil from both sites (Tables 1 and 2) had an intermediate soluble salt concentration as compared to the fresh water areas sampled and the South Island widgeongrass ponds.

Scirpus validus Vahl. (softstem bulrush)

Five sampling sites were chosen for the study of *S. validus*. Site 19 was located in an Ashepoo River tidal marsh which was flooded only three times during visits made to that site. Sites 20, 21, and 22 were located in a Black River tidal marsh, an Edisto River tidal marsh, and the Santee Delta, respectively.

The latter 3 sites were never flooded above soil level during visits made to the sites. Site 23 was in an abandoned rice field on Schooner Creek, a tributary of the Big Pee Dee River. This field was subject to tidal action but the sampling site was flooded only once during the visits made to the site. It is important to note that, although not flooded with standing water often, these sites maintained a wet soil condition throughout the growing season.

Phosphorous, potassium, calcium, and magnesium concentrations in the soil (Table 2) were high as they have been found to be in other marsh soils. Soluble salt concentrations of water and soil samples (Table 1 and 2) varied considerably between sites. The sampling sites ranged from fresh to brackish marshes indicating a rather wide range of salt tolerance for the species. No *Scirpus validus* was observed in salt marshes.

DISCUSSION

The results indicate three primary factors in control of the growth of selected waterfowl food plants — soil nutrition, soluble salt concentration, and water level. Watershield, jointed spikerush, squarestem spikerush, and widgeongrass were found growing only where standing water was above soil level during the growing season. Salinity and soil nutrition determined to a great extent their distribution. Watershield and jointed spikerush grew in dense stands in fresh water upland sites but in low densities in fresh water marshes. Squarestem spikerush grew in dense stands in both the fresh water marshes and upland sites. Widgeongrass was found to exist in salt water ponds but not in the fresh water sites.

Aneilema, swamp smartweed, saltmarsh bulrush, and softstem bulrush were found growing in dense stands in rich marsh soils which were rarely flooded above soil level during the growing season. However, those areas are maintained in a wet soil condition which reduces competition from other plants. Again salinity determines distribution as the saltmarsh bulrush exists in more saline marshes than either aneilema and swamp smartweed. In one site where swamp smartweed had existed, changed management toward saline habitat eliminated that plant and favored the more salt tolerant dwarf spikerush (*Eleocharis parvula* (R. & S.) Link).

Bigleaf tearthumb was found most productive on the berm of fresh water impoundments. This plant requires the nutrient rich marsh soils but drier than is required for the production of the freshwater marsh plants such as aneilema or swamp smartweed. It would probably be difficult to manage exclusively for this plant without competition from undesirable plants.

Thus, in the management of a wetland area these three factors must be considered in deciding upon the plants to be encouraged. More often than not, man has very little control over soil types, nutrition, or salinity; but water level manipulation can well decide the vegetative capabilities of area.

LITERATURE CITED

Conrad, Wriston Brock, Jr. 1965. A study of the food habits of ducks wintering on the lower Pee Dee and Waccamaw Rivers, Georgetown, South Carolina. M.S. Thesis. Auburn University. Auburn, Alabama.

Anonymous. No date. Hach procedures for water and sewage analysis using B & L spectronic 20 colorimeter. Hach Chemical Co. Ames, Iowa. 115 pp.

Kerwin, James A. 1967. Unpublished data.

American Public Health Association, American Water Works Association, Water Pollution Control Federation. 1965. Standard methods for the examination of water and wastewater. American Public Health Association. XXIX & 769 pp.

Wilson, Kenneth A. 1967. Fur production on southeastern coastal states. Proc. Marsh and Estuary Management Symposium. pp. 149-162.

ABSTRACT

Nine waterfowl food plants were selected from food habit studies conducted on waterfowl wintering in South Carolina coastal areas. These plants *(Aneilema keisak, Brasenia schreberi, Eleocharis equisetoides, Eleocharis quadrangulata, Polygonum arifolium, Polygonum hydropiperoides, Ruppia maritima, Scirpus robustus,* and *Scirpus validus)* were studied in relation to certain chemical and physical properties of soil and water collected from sites producing stands of these plants. It was found that soil nutrition, salinity, and water level are in primary control of the plant growth and distribution in these wetland areas.

EXPERIMENTAL TREATMENTS FOR THE CONTROL OF WIREGRASS AND SALTMARSH GRASS IN A BRACKISH MARSH

by

Larry L. McNease
Louisiana Wild Life and Fisheries Commission
Grand Chenier, Louisiana

and

Dr. Leslie L. Glasgow
Assistant Secretary for Fish and Wildlife and Parks
U. S. Department of the Interior
Washington, D. C.

ABSTRACT

During the period from January, 1965 to June 1970 a study was conducted in the Price Lake area of Rockefeller Refuge, Grand Chenier, Louisiana. The objectives were to measure and evaluate the results from a series of treatments designed to alter natural plant succession and improve the vegetative composition for wildlife. Experimental plots were treated in the spring and late fall, 1965. Treatments included burning, tilling, chemicals and combinations of burning, tilling, and chemicals.

Sampling data for 1970 (five years following initial treatment) showed that (a) tilling, (b) burning and tilling, and (c) burning, tilling, and chemicals were most effective in reducing the growth of undesirable vegetation and promoting the growth of a more desirable species, widgeongrass *(Ruppia maritima).* Reinvasion by widgeongrass varied from a high of 48 percent coverage to a low of three percent for the plots which received one of the three treatments named above. Reinvasion by desirable species of *Scirpus* was nil after a five-year period.

Chemicals and combinations of burning and chemicals gave good short term kills; however, after a one-year period the percent kill dropped off appreciably.

Fire breaks constructed by the rotary tiller were sufficient in containing all seven of the fires tested in this investigation.

Water level fluctuations and water salinities were determined periodically from wells established in the study area.