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## FACTORS INFLUENCING THE ESTABLISHMENT OF WIGEONGRASS STANDS IN LOUISIANA

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### INTRODUCTION

Louisiana is fortunate in having one of the largest wintering areas for waterfowl in the United States. According to Hoffpauer (1965) the state's mid-winter waterfowl population was about five million birds. Most of these birds wintered in the southern portion of the state in the coastal marshes which comprise approximately 4,000,000 acres.

The Louisiana Wildlife and Fisheries Commission began an intensive waterfowl management program in the coastal area in 1954. As a part of this program, impoundments were constructed on certain marsh refuges. These impoundments were constructed with waterfowl management as the primary interest (Jemison, 1961). Management of these impoundments has been very successful. Chabreck (1960) found that 50% of the vegetation in the impounded areas on Rockefeller Refuge produced good duck food, and in adjacent coastal areas these same plants made up less than 5% of the vegetation. Aerial inventories in 1951-52 by Richard Yancey showed that Rockefeller Refuge wintered less than 75,000 ducks prior to the construction of the impoundments, but by 1958-59 the refuge was wintering 443,000 ducks, a 600% increase since the initiation of management. Of this number 80% were found in the impoundments.

Among the more important aquatic food-producing plants on the

refuge is wigeongrass (*Ruppia maritima*). All parts of the plant, the seeds, leaves, branches, stems, and roots, are consumed by waterfowl. Excellent growth of wigeongrass occurs in situations unfavorable to most aquatic plants, and it is widely distributed. The following authors report its importance to waterfowl; McAtee (1915), Setchell (1924), Metcalf (1931), Bourn (1932), Martin and Uhler (1939), Beter (1957), Kimble (1957) and Jemison (1961).

In an effort to learn more about the production of this aquatic plant, a study was initiated to investigate the factors that influence the establishment and growth of wigeongrass. The objectives of this study were as follows:

1. To study factors that influence natural and artificial establishment of wigeongrass.
2. To determine vegetative production of wigeongrass.
3. To measure waterfowl utilization of wigeongrass.

#### DESCRIPTION OF AREA

This study was conducted on Rockefeller Refuge at Grand Chenier, Louisiana. The refuge, which is owned and maintained by the Louisiana Wild Life and Fisheries Commission, is located in southwestern Louisiana in Cameron and Vermilion Parishes and consists of 85,000 acres of marshland. It is bounded on the south by the Gulf of Mexico and on the north by the Grand Chenier—Pecan Island stranded beach ridge complex.

Rockefeller Refuge as a whole, excluding the impounded areas, is a wire grass (*Spartina patens*) marsh.

Marsh elevations average 1.1 feet above mean sea level. Tide-water enters the refuge from the Gulf of Mexico through five separate channels, then spreads to all parts of the refuge outside the impounded areas. The average tidal variation is one foot; however, high tides frequently inundate the marshes with salt water.

The fresh marsh, a narrow belt adjacent to the Chenier, possesses the maximum water depth. Removal of water on the fresh marsh during the summer permits the germination of annual grasses. As a result, large stands of *Echinochloa walteri*, *Leptochloa fascicularis*, and *Panicum dichotomiflorum* frequently grow on exposed or shallow mudflats of the fresh marsh and produce seed which are eaten in quantity by waterfowl.

More than 75% of the vegetation of the refuge is growing on brackish sites. This brackish area is dominated by wire grass but contains some *Distichlis spicata*. The subclimax species, leafy three-cornered grass (*Scirpus robustus*) and three-cornered grass (*Scirpus olneyi*) potentially are of great importance as food for muskrat and blue and snow geese. The total area covered by these species is very small and on some of the brackish areas of the refuge these plants are non-existent.

The aquatic communities are composed chiefly of wigeongrass and dwarf spike rush (*Eleocharis parvula*). Both of these plants are excellent waterfowl foods. Wigeongrass is the only aquatic found in the salt ponds. Some moist sites are dominated by sea purslane (*Sesuvium portulacastrum*), an important teal food.

#### STUDY PROCEDURE

##### Tank Studies

Fourteen 12-gauge plastic pools, 9 feet in diameter and 2.5 feet high, were erected on Rockefeller Refuge. A series of 10 wooden boxes 1-foot square by 4 inches high were placed in each tank. Fifty boxes were filled with soil from stands of wigeongrass and 60 boxes were filled with soil taken outside stands of wigeongrass (Table 1). This soil was collected from salt marsh ponds that were dry. In order to disturb the soil as little as possible, a shovel with a square blade was used to cut the soil and arrange it in the boxes. These boxes were placed in tanks having different water levels and salinities. Water for the pools was obtained from a nearby canal.

A constant water level was maintained in all tanks throughout the study.

Wigeongrass for the tanks was collected from an experimental shrimp pond located near the refuge headquarters. Five stems, 9 inches in length, were planted in each box. Three samples of 15 plants each, 9 inches long, were selected at random, and measured by volumetric displacement of water. An average volume for the three samples was obtained to use as a base from which to determine growth.

Table 1. — Tank Number, Water Depth, And Collection Site Of Soil For Experimental Tanks.

Tank Number	Water Depth In Inches	Soil Collected in Wigeongrass Stand
4	6	Yes
5	8	Yes
6	10	Yes
7	12	Yes
8	14	Yes
9	6	No
10	8	No
11	10	No
12	12	No
13	14	No
14	16	No

Water and soil were analyzed chemically before being placed in the tanks.

*Germination Studies in Tanks.* Three thousand wigeongrass seeds were tested for germination in tanks one, two and three. The soil for this test was collected outside stands of wigeongrass from a salt marsh area. In tank one, 10 boxes were filled with soil collected from the top one-inch of surface soil. The boxes in the second tank were filled with soil collected from 1 to 2 inches deep and boxes in the third tank with soil from 3 to 4 inches deep. The seed were collected from plants grown in ponds located near the refuge headquarters, sun dried for two days, separated with the aid of a seed blower and stored in a refrigerator until planted. One hundred seeds were placed in each of the 30 boxes and the tanks were filled with water to a depth of three inches. The germination study, which began on August 15, was terminated on September 18, 1962.

*Growth Studies.* Plants were clipped at the ground surface and submerged in water to determine growth. Growth measurement for plants in tanks 1, 2, 3, 7, 8, 12, and 13 were made in February 1963. Boxes containing the undisturbed rootstocks of these plants were replaced in the tank for mullet studies. Growth for plants in tanks 4, 5, 6, 9, 10, 11, and 14 were made in May 1963. This portion of the growth study was terminated as of this date.

*Turbidity Studies.* Striped mullet (*Mugil cephalus*) were stocked at different rates in seven tanks in order to evaluate their influence on turbidity (Table 2). These tanks as well as several study ponds were invaded by branching filamentous algae (*Cladophora*). According to Neely (1962), growth of this algae may become so dense as to smother the wigeongrass. He also states that it may be objectionable to ducks, as evidenced by their decreased use of ponds containing algae. Mullet were also stocked to determine whether they could effectively control this algae.

Turbidity was measured every two weeks with a Jackson Turbidimeter.

#### *Pond Studies.*

*Location and Description.* Seven ponds located on the refuge and two ponds off the refuge were selected for observation. Ponds were chosen because of their location and water level or they showed

unusual conditions which were pertinent to this study. Most of the ponds, at one time during the study, supported stands of wigeongrass in varying degrees of size and density, and were located in the fresh, brackish, and salt marsh areas.

Table 2. — Bi-Weekly Reading Of Turbidity, Expressed In PPM And Stocking Rate Of Mullet In 8 Experimental Tanks.

Tank Number	No. Fish	Reading		
		1	2	3
1	2	29	25	30
2	4	50	40	35
3	6	100	25	25
4	8	25	25	30
5 (Control)	0	25	25	25
6 (Control)	0	25	25	25
7	10	25	25	30
8	20	45	35	95

*Water Chemistry.* Water samples were taken in the study ponds every two weeks. Factors investigated were water depth, turbidity, salinity expressed in chlorides (ppm), pH, alkalinity (ppm) as CaCO<sub>3</sub>, hardness (ppm) as CaCO<sub>3</sub>, sulfates, color, potassium (ppm), sodium (ppm), calcium (ppm), biological oxygen demand or B.O.D. (ppm) five days at 20°C., water temperature, and dissolved oxygen. The majority of these tests were made by the Louisiana Wildlife and Fisheries Water Pollution Laboratory in Baton Rouge. Two water samples were collected from each pond, one in stands of wigeongrass (if present) the other outside stands of wigeongrass.

*Soil Analysis.* Soil samples were tested for available phosphorous (ppm), available calcium (ppm), available magnesium (ppm), pH type, and soluble salts. These soil samples were taken monthly and sent to the Soil Testing Laboratory at Louisiana State University for analysis. Soil samples, taken to a depth of 6 inches, were collected on the same day and at the same site as the water samples.

*Growth Measurement.* Three samples of wigeongrass, each 1 square foot in size, were collected monthly for growth studies from each pond. The vegetation was cut at ground level and measured by water displacement.

*Utilization Enclosures.* Wire enclosures, used in determining waterfowl utilization, were placed in suitable areas on and off the refuge. These wire enclosures were constructed to provide a means of making a comparison between the wire-covered areas, on which the waterfowl could not feed and on the areas exposed to feeding waterfowl. The sides of the enclosures were constructed of welded wire and the tops of poultry netting.

*Growth Measurement.* Growth under natural conditions was determined from 1 square foot samples of wigeongrass collected monthly in each of 4 separate ponds. Line transects were established in the ponds and the sampling areas were selected at random along these lines. Growth measurements in the tanks were completed in the same manner. These samples were placed in plastic bags, labeled, sealed, and returned to the laboratory. All of the soil, debris, and free water were removed from them. Plant growth was then measured by water displacement.

## DISCUSSION OF RESULTS

### *Germination of Wigeongrass Seed in Tanks*

The results of the seed germination study in the tanks are expressed in per cent germination. The influence of salinity was seen in the tanks when the soil was sectioned and the seeds allowed to germinate. Seeds that germinate on the top 1-inch of soil (2.5% germination) produced very small plants with small root systems. Plants in tank number 2 which contained the second inch of soil, showed an

increase in per cent of germination (35.2%) over the top 1-inch of soil, and soil from the 3-inch level showed the greatest per cent of germination (61.9%). This probably indicates that the high amount of salt in the top layer of soil had a definite limiting effect on the germination of wigeongrass.

The per cent of soluble salts in the three tanks ranged from .89 to 1.12.

### Growth

The best growth of wigeongrass was obtained in the study ponds having a water level of approximately 24 inches and in the experimental tanks with a water level of approximately 16 inches. The greatest mass of aquatic vegetation (236 ml/sq. ft.) was collected from a site with a small amount of suspended matter present. The salinity at this site ranged from a low of 2,075 to a high of 18,500 ppm. The lowest production of vegetation (3 ml/sq. ft.) was collected from water containing a large amount of suspended matter. The salinity in this pond ranged from a low of 3,420 to a high of 18,500 ppm.

Plant growth in the experimental tanks was terminated in February of 1963. The best growth occurred in the tanks having a 12 to 16-inch water level. These plants were grown under optimum conditions of reduced turbidity, little wave action, and stable water levels. Salinity varied with the increase in winter rains, evaporation, and the draining that was required to prevent overflowing of the tanks. The salinity dropped from a high of 19,000 ppm to a low of 1,160 ppm (Table 3).

Table 3. Salinity, Water Depth, And Growth Of Wigeongrass In Experimental Tanks, Rockefeller Refuge, 1962-63.

Tank Number	Range of Salinity (ppm)	Water Depth (Inches)	Wigeongrass (ml)
1	1,160- 7,600	6	130*
2	1,290- 6,900	8	120*
3	1,475- 7,250	10	142*
4	2,450-13,800	6	230*
5	2,970-14,000	8	500
6	2,520-14,500	10	450
7	1,125-19,000	12	145*
8	3,985-15,000	14	295*
9	2,875-14,000	6	0
10	1,190-14,600	8	592
11	2,620-14,000	10	700
12	3,150-13,500	12	395*
13	3,350-15,000	14	307*
14	2,625-12,500	16	790

\* The wigeongrass in these tanks was removed in February, the remaining tanks were pulled in May, 1963.

As previously stated, soil for these tanks was collected in and out of wigeongrass stands. No correlations could be made with growth of the plants and the soil collecting areas. Soil from both areas, while in the tanks, produced maximum stands of wigeongrass.

Singleton (1951) found that wigeongrass produced 1,757.2 pounds per acre (air dried yield of stems and leaves) at a semi-established water depth of 11 to 19 inches.

Jemison (1961) states that wigeongrass in October produced 4.73 pounds, December 6.59 pounds, and March 2.40 pounds of seeds per acre in Lake "3," Rockefeller Refuge.

Growth of wigeongrass was first noticed in September, but it stopped in November, began again in February and tapered off in the summer. It appears that wigeongrass has two growing seasons which

occur within the temperature range of 18°C to 30°C. When water temperature goes above 30°C or below 18°C growth apparently ceased.

Wigeongrass, according to Setchell (1924), requires a temperature range between 15°C to 20°C for germination and seedling development and 20°C to 25°C for vegetative growth and reproductive activity.

The writers recorded temperature ranges of 18 to 19°C for seedling development and up to 30°C for vegetation growth. Flowering and fruiting were observed to continue under a higher temperature than growth of the vegetative portion of the plant. Flowering and fruiting of wigeongrass were first noticed in May when the water temperature was 29°C to 30°C.

It was noticed in all the study ponds and experimental tanks with a water depth below 10 inches that seed production was greatly reduced or did not occur. The maximum seed production was obtained at the 16-inch water level in the experimental tanks and at the 24-inch water level in the study ponds.

Low and Bellrose (1944) found long leaf pond weed (*Potamogeton sp.*) to have optimum seed production at the 20 to 24-inch water level.

### Turbidity

Turbidity according to Martin and Uhler (1939), Chamberlain (1948), Robel (1961), Chabreck and Hoffpauer (1962) is one of the major physical factors responsible for the scarcity or total absence of duck food plants in many areas.

Growth was retarded to such an extent that this plant was almost non-existent in two of the study ponds (Table 4). Turbidity reached highs of 70 ppm in the Experimental Shrimp Pond and 275 ppm in the study pond on the western boundary of the refuge.

The turbidity (70 ppm) was not exceedingly high but because of a water depth of 24 inches in the North Center Shrimp Pond, light was scattered and absorbed rather than transmitted through the water. Therefore, insufficient light reached the pond bottom to support plant growth. In the pond near the refuge boundary, turbidity reached a high of 275 ppm. This high reading was believed to be due to rough fish and to wave action which kept the shallow marsh pond in a constant state of turbulence. The fish did not uproot or eat the plants, but they created such high turbidity that the necessary light for plant growth was eliminated.

Correlations were found between water depth, turbidity and vegetative production (Table 5). The greatest production was obtained at the 24-inch water level. The turbidity in this pond ranged from 25 to 55 ppm. The smallest production of wigeongrass was obtained in a study pond near the western edge of the refuge. The

Table 4. Comparison Of Turbidity And Growth Of Wigeongrass In Study Ponds, Rockefeller Refuge, 1962-63.

	Turbidity (ppm)		Water Depth (inches)		Growth (ml)	
	*A	**B	A	B	A	B
July	55	0	24	0	0	0
August	70	0	24	0	15	0
September	56	0	24	0	38	0
October	60	0	24	3-4	22	0
November	65	275	24	3-5	25	0
December	50	135	24	4-6	23	0
January	32	65	24	5-7	11	0
February	62	125	24	4-6	20	0
March	0	0	6-8	3-4	122	***
April	0	0	6-8	4-0	200	***

\*North-Center Shrimp Pond.

\*\*Highway Pond on Western Boundary of refuge.

\*\*\*A stand of wigeongrass was established at this time but growth was not measured.

Table 5. Relationship Between Water Depth, Turbidity, and Wigeongrass Production in Study Ponds, Rockefeller Refuge, 1962-63

	Turbidity (ppm)		Water Depth (inches)		Production (ml)	
	*A	**B	A	B	A	B
August	55	0	24	0	67	0
September	49	0	24	0	182	0
October	25	0	24	3-4	116	169
November	25	25	24	3-5	112	132
December	50	50	24	4-6	136	66
January	32	32	24	5-7	112	12
February	30	42	24	4-6	236	25
March	0	0	24	3-5	200	38
April	0	0	24	2-0	0	42

\*A—Northeast Shrimp Pond

\*\*B—Highway Pond

water depth ranged from 0 to 7 inches. Turbidity was very low (25 to 50 ppm) due to the fact that this area had been dry during the summer. This eliminated the fish population and allowed the bottom to oxidize and cement together. A dense stand of wigeongrass appeared in this pond when it was filled by rains in September and October. The correlation between water depth and production is clearly shown by comparing the amount produced in this pond with production in the shrimp pond held at the 24-inch water level.

Turbidity was important in retarding growth in Impoundment "15." Growth was retarded considerably during the month of August when the water depth was 2-4 inches. Turbidity was extremely high (100 ppm to 300 ppm. This was caused by the fish being trapped in the low areas of the pond and not being able to move into the canal.

Turbidity was found to be most harmful to young plants before the stems reached the surface of the water. This was observed with the drawdown of the North Center Shrimp Pond. The water level dropped from 24 inches to 6 inches and turbidity dropped from 70 ppm to 35 ppm. This pond had several deep areas near the north levee. All the marine life was forced into these holes for a period of two weeks. The water was raised to the original level after young plants were seen forming mats on the surface of the pond.

No harm was observed after the fish were allowed to use the entire pond and growth increased normally as compared to the North East Shrimp Pond. After the plants reached the surface of the water the influence of turbidity was almost completely eliminated.

Ponds with high turbidity readings such as pond number one in the Old Humble Canal Study Area (average 100 ppm during study) and pond number two in Impoundment "15" (average 108 ppm during the study) did not support wigeongrass as long as these high readings persisted.

A generalized range of turbidity which allowed wigeongrass growth in ponds with water depths less than 24 inches as found in this study, was 25 to 55 ppm.

#### *Wave Action*

Wave action in large open ponds limits the growth of wigeongrass either through mechanical injury or by causing high turbidity in ponds with soft bottoms and in those containing large amounts of vegetative debris. It was noticed in all situations that turbidity caused either by wave action or by fish had the same influence in retarding plant growth.

#### *Water Fluctuations*

No single factor was found to be more detrimental in the establishment or elimination of stands of wigeongrass than excessive or irregular water fluctuations. When water fluctuations were held at a minimum and plants were not completely exposed on the pond bottom,

damage to growth was very slight. Several ponds were observed which had extensive stands of wigeongrass. But due to extreme water fluctuations and long periods of exposure of the plants, these wigeongrass stands were eliminated.

Low and Bellrose (1944) found that a sudden rise in water levels inundated and killed large beds of sago pond weeds (*Potamogeton pectinatus*). They also found that seasonal fluctuations greatly reduced the seed production on the area. Water fluctuations change the amount of sunlight reaching the plants.

#### *Ice Cover*

Several times during the winter ice completely covered ponds on the Rockefeller Refuge, but did not persist for more than two-day period of time. Some plants were noticed uprooted in the study ponds after the ice had melted. This could be attributed to heavy duck utilization during this period of melting. Large concentrations of waterfowl were seen using these ponds at this time. No plants were uprooted in the experimental tanks during the period of melting.

#### *Algae*

During this study several ponds were covered with filamentous algae. It was observed that waterfowl utilization was reduced in these areas, also plant growth was greatly reduced. Neely (1962) also noticed a reduction in waterfowl utilization in ponds with heavy algae cover. This algae at times became very destructive to wigeongrass by forming dense floating mats or by blanketing submerged plants. These mats became so thick that sunlight was totally excluded and plants were weakened.

Algae was observed in all of the experimental tanks, but in varying degrees of abundance. It had completely covered the tanks with low water levels of 2 to 8 inches above the boxes. As the salinity decreased with the winter rains, this problem increased.

Algae completely covered the tanks when the salinity dropped to less than 1,500 ppm. Tanks with salinities of less than 1,500 ppm produced less than half as much wigeongrass as tanks of the same water level, but of higher salinities. Tanks 8 and 13 which had the same water depth and same salinity produced almost equal amounts of wigeongrass and were almost free of algae infestations. Therefore, it is believed that dilution by the winter rains to less than 1,500 ppm chlorides would induce algae growth in wigeongrass ponds.

Mullet were stocked at different rates in tanks to see if these algae-eating fish would control the algae. Due to the low water in some tanks and heavy algae problem, the fish could not maintain themselves under existing conditions and fish in tanks 1 to 4 died. Algae control and the production of a good stand of wigeongrass were obtained in only one tank. After the introduction of mullet, turbidity in this tank increased from 25 ppm to a high of 90 ppm, but this had little or no effect on plant growth. Plants were clipped and the boxes were returned to the tanks when the mullet were stocked. This tank produced 250 ml of wigeongrass for a two-month period.

#### *Enclosures*

The utilization enclosures were removed in April of 1963. The results are clearly seen when comparing the enclosed 4-foot area with the exposed area. The enclosed area produced 2000 ml of wigeongrass whereas the exposed area produced only 300 ml. This 1700-ml difference clearly shows the desirability of this species as a waterfowl food.

The second enclosure did not show as wide a margin as the first enclosure. This enclosed area produced 1,300 ml of wigeongrass whereas the control area or exposed area produced 925 ml. This was a 375-ml difference between the covered area and the exposed area.

#### *Salinity of Water*

According to Osterhaut (1906), Setchell (1928), Martin and Uhler (1939), and Neely (1962) wigeongrass has a wide range of salinity

tolerance and has been observed in ponds with salinity greater than sea strength. Metcalf (1931) reported finding wigeongrass in an alkali lake in North Dakota that had a total salt content of 77,386 ppm, or more than twice that found in normal sea water. Osterhaut (1906) found experimentally that wigeongrass will grow in distilled water with pure white sand. This plant was seen growing in a salinity range from 2,075 ppm to 18,500. The salinity range in the experimental tanks was 1,160 ppm to 19,000 ppm. There was no correlation between chlorides and growth of wigeongrass. All ponds attained maximum growth in a salinity range of 4,200 to 18,500 ppm.

When comparing the salinities in ponds that had good stands of wigeongrass with ponds that did not produce wigeongrass, very little difference, if any, could be seen. All ponds which produced wigeongrass had a salinity range from 2,075 to 18,500. The pond which produced the most wigeongrass had a salinity range of 2,075 ppm to 18,500 ppm. The pond which produced the smallest amount of plants had a range of 4,025 ppm to 14,750 ppm. One pond which produced no wigeongrass at all had a range from 4,100 ppm to 17,000 ppm (Table 6).

In the experimental tanks, chlorides ranged slightly below those of the study ponds. Growth might have been affected in the tanks by an extreme lowering of chlorides below 1,500 ppm. It was interesting to note that these same tanks with salinities below 1,500 ppm were the tanks most heavily covered with algae. This algae could have also contributed to the reduced yield in these tanks in addition to low salinity.

### *Alkalinity*

Each species of aquatic plant has its own range of chemical tolerance and set of chemical conditions within which it makes its best growth. Within the range of chemical tolerance, the local distribution of aquatic plants is greatly influenced by the type of bottom soil and the physical nature of the body of water.

Alkalinity followed much the same pattern throughout each pond. The range of total alkalinity observed was 36 ppm to 740 ppm. The December samples showed the highest increase in all study ponds. This was followed by a drop below the average for the previous months.

For a group of brackish aquatic plants, Moyle (1945) reported that their best growth was made at a total alkalinity range of 146.8 to 376.0 ppm with a median of 252.8 ppm.

Due to the fact that alkalinity followed much the same pattern in all of the study ponds with stands of wigeongrass and without stands of wigeongrass, the writers can find no data which would indicate that alkalinity would be a limiting factor on wigeongrass growth.

The median range of alkalinity found in all study ponds was 121 to 284 ppm. This would fall within the desired range as stated by Moyle (1945).

### *Dissolved Oxygen*

Dissolved oxygen concentrations were determined at the start of the study, but because of extreme diurnal variation in the amount of oxygen present in shallow marsh waters measurements of this factor were abandoned.

### *pH*

Under ordinary conditions the hydrogen ions themselves probably have little effect upon plants, but degrees of acidity of the soil may have a regulatory effect upon chemical processes that do influence growth. Increased acidity may reduce availability of nutrients. High acidity may produce toxic effects, but these are not caused by hydrogen ions.

There is no simple relationship between pH and plant response. In the environment where favorable and necessary nutrients are available, most species can tolerate a rather wide range of pH (Oosting, 1948).

The writers did not find any extreme fluctuation in pH throughout the study. The range of pH for this study was from six to 9.2. PH is a retarding factor only under extreme conditions. This may have

Table 6. Water Salinity (Chlorides PPM) and Growth of Wigeongrass  
In Study Ponds, Rockefeller Refuge, 1962-63

	Northeast Shrimp Pond		North-Center Shrimp Pond		Pond One Impoundment "15"		Highway Pond	
	Range of Chlorides	Growth (ml)	Range of Chlorides	Growth (ml)	Range of Chlorides	Growth (ml)	Range of Chlorides	Growth (ml)
July	7,461 - 9,675	0	7,203 - 8,600	0	6,106 - 8,331	0	0 - 0	0
August	8,500-13,500	67	8,280-14,500	15	8,480 - 12,900	3	0 - 0	0
September	18,500-12,250	182	10,300-12,750	38	6,700 - 8,750	167	0 - 0	169
October	15,250-0	116	14,750-0	22	18,500 - 0	184	0 - 0	132
November	7,779 - 5,564	112	8,477 - 6,948	25	7,512 - 7,925	22	6,274-5,504	66
December	5,790-0	136	4,030-0	23	6,760 - 0	21	4,140 - 0	12
January	2,880 - 2,580	112	4,860 - 4,540	11	4,440 - 3,420	7	2,520-2,920	25
February	2,750 - 2,075	236	4,675 - 4,025	20	4,200 - 3,700	35	2,825-2,100	38
March	0 - 0	200	0 - 0	122	0 - 0	42	0 - 0	42
April	0 - 0	0	0 - 0	200	0 - 0	32	0 - 0	0
May	0 - 0	0	0 - 0	0	0 - 0	0	0 - 0	0

been caused by the presence of excess bases in sea water which would serve to buffer the water against any great change in pH.

Setchell (1924) found an increase in pH from 7.4 to 9.6 as the season of growth and reproduction advanced.

A slight increase was noted in this study. The median range was found to be 6.2 to 8.2.

Moyle (1945) gave the pH range in which aquatic plants made their best growth, to be between 8.1 and 9.0 with a median of 8.5.

### *Soil Salinity*

The importance of soluble salts as a limiting agent in the plant environment has long been recognized. Pendfound and Hathaway (1938) stated that salinity of soil water (not surface water) and water level appear to be the most important habitat factors. In coastal marshes the salt concentration in the aquatic environment and the underlying substrate is an important factor governing marsh plant distribution.

It was found that the amount of soluble salts in the soil which exceed 1.12 per cent was extremely harmful to germination of wigeongrass. Germination tests were run using soil containing varying per cents of soluble salts. The results of these tests clearly show the importance of soluble salts present to be a limiting factor in wigeongrass growth.

This salt build-up was caused by evaporation of water under high temperature leaving behind salt it had carried from the soil. If precipitation is seasonal and alternates with extreme drought, there is insufficient leaching to prevent accumulation of these soluble salts. Low lands bordering the Gulf of Mexico were subject to periodic inundation with sea water followed by evaporation and consequently contains relatively high concentration of salts.

Wigeongrass was observed growing in soil with a per cent of soluble salts as high as 2.99 and as low as .89. It is doubtful that germination took place at these upper limits of salinity. The fact that wigeongrass spreads rapidly from rhizomes, may account for the large stands appearing in these areas of high soil salinity. Wigeongrass belongs to a peculiar group of marsh plants called halophytes that possess the ability to utilize different concentrations of salt water due to an osmotic regulation process of the cell walls. Because of this, it can tolerate rapid changes of salinity without being dehydrated or hydrolyzed due to difference in osmotic pressure between the plant and the concentration of salt in tidal water around it (Hoffpauer 1961).

Halophytes store large quantities of water in their tissues, with high osmotic pressure and reduced rates of transportation. These plants are capable of a high degree of chlorophyll assimilation despite the presence of salt in the tissues.

Resistance to salinity increases with the age of the plant. On passing from the vegetative to the reproductive stage, there is a marked and probably sudden increase in its salt resistance.

In this study, maximum growth was obtained within the soil salinity range of .89 to 1.72 per cent.

The soluble salt content of the soil from the sampling stations varied during the season because of climatic conditions. There was an over-all drop in soil salinity from summer to mid-winter and early spring, then a slight increase in April as these study ponds again dried up.

It was evident that the more productive study ponds were the ones with the low amount of soluble salts. The 10-month average range for ponds which produced stands of wigeongrass was between .96 and 2.16. It was noted that during February when wigeongrass started to form new growth, the soluble salt range in wigeongrass ponds was .95 to 1.85 per cent.

### *Phosphorous*

The availability of phosphorous in the surface soil was roughly inversely proportional to the plant productivity.

The more productive ponds were lower in available phosphorous than the lower yielding ponds. Pond two which produced little or no

wigeongrass had an average of 177 ppm for the 10-month study period, while Pond one which produced a sizeable stand of wigeongrass had an average of 120 ppm.

In the four ponds in which wigeongrass growth was measured, the phosphorous was higher outside stands of wigeongrass and lower in the stands. The seasonal trends showed a general increase coinciding with the period of low water. This was probably due to a concentrating effect produced by excessive summer evaporation.

Excessive amounts of phosphorous are known to limit growth of plants. However, little or no work with aquatic plants has been done along these lines. It may well be that increased concentrations of phosphorous and other elements are not toxic to aquatic plants and that aquatic plants are therefore capable of withstanding greater concentrations of each substance (Jensen, 1940). It seems probable that the productivity differences are due to other soil conditions.

#### *Potassium, Magnesium and Calcium*

Potassium and magnesium did not show an increase or decrease throughout the entire study. The amount present represents the optimum levels of the substance as recommended for agricultural soils. Under normal conditions, measurements are not made above this level. Potassium and magnesium maintained constant levels of 453+ ppm and 450+ ppm, respectively, throughout the study.

Hayward (1954) states that excess amounts of magnesium and potassium when present separately are toxic to plants. When these elements are in excess, no specific inhibitive effect on plant response is likely to be noticed if this accumulation is partially balanced by calcium.

In this study, calcium showed very little variation in all ponds sampled. The range in an unproductive pond showed much the same picture as a highly productive area. These writers found no correlation between plant growth and calcium or that this element at any time inhibited plant growth.

#### *Soil pH*

The hydrogen ion concentration of the soil did not show as wide a spread as the hydrogen ion concentration of the water. General monthly pH values fluctuated inversely with water level. These conditions would not necessarily be due to concentration of water during the summer, but rather to increased photosynthetic activity. This condition was due to increased alkalinity resulting from the precipitation of calcium carbonate by the plants (Jensen, 1940).

The soil pH had the lowest reading of 5.3 when compared to the water pH reading of 6.0. It also did not exceed 7.9 as compared to the water pH high of 9.2. The range of pH in the soil which supported good stands of wigeongrass was found to be 5.8 to 7.0. Study ponds which produced no wigeongrass at all had a range of 5.9 to 7.3.

Wigeongrass made vigorous growth in both the high and low areas of soil pH.

From the above information it would seem that the pH of the surface soil would have little or no effect upon the production and distribution of wigeongrass on the refuge.

#### MANAGEMENT FOR WIGEONGRASS

Results from this study show that wigeongrass was definitely affected by turbidity, soluble salts, and water fluctuations. Control or elimination of the retarding factors would greatly benefit propagation of this plant.

A stable water depth of two feet with a turbidity range not to exceed 25 ppm to 35 ppm was found to produce the highest yield of wigeongrass in small ponds. The ponds found in the southern portion of Louisiana are typically small and shallow, with soft bottoms. The majority of the ponds investigated in this study were of this nature and had a turbidity range too high to support maximum stands of wigeongrass. It is recommended that these ponds be drained during the summer months to eliminate fish populations and to let the pond

bottoms oxidize and cement together. Reflooding should be completed prior to the fall growing season. If complete draining is impractical, a partial draw-down of the water level and reflooding has proven successful in producing dense stands of wigeongrass. This practice should be carried out either in early spring or fall prior to the growing seasons. Once a stand has become established or when the young plants form mats on the surface of the water, the water level should be raised to the desired depth. Although this will allow fish to re-enter the ponds, damage from turbidity caused by fish is slight once a stand has become established. The above management practices should be followed to establish stands of wigeongrass in areas in which it is absent.

If complete or partial draw-down is not economically feasible, artificial planting could provide a stand in areas which are suitable for wigeongrass. Artificial planting of stems, handling methods, etc., as described by Neely (1962) and Martin and Uhler (1939) should be followed. Propagation by seed as described by McAtee (1951) should also produce favorable results in areas that are capable of supporting wigeongrass. However, most ponds with suitable conditions are undoubtedly stocked naturally.

The percent of soluble salts in the soil which exceed 1.12 per cent were found to be harmful to wigeongrass germination. The increase in soluble salts was caused by periodic drying of impoundments. If this problem exists, flushing water of low salinity over the area will reduce the salt content of the soil. This should be done when the canals or bayous surrounding the area are lower in salinity than the marsh itself, or just before the "dry-up" period when one still has control over the water in the marsh. Sufficient water should flow out of the marsh of its own accord before evaporation permits an accumulation of salt on the surface of the soil. This build-up of soluble salts in the soil is cumulative over a number of dry years. If the marsh manager is aware of this build-up on his area he can better choose the time for flushing the marsh.

The problem of extreme or irregular water fluctuations during the growing season can change productive areas into biological deserts so far as the production of waterfowl food plants is concerned. In order to maintain productive ponds, water levels should be held at a constant level. This can be accomplished by installation of low level weirs as suggested by Chabreck and Hoffpauer (1962), or by the construction of impoundments. The installation of Wakefield-type weirs in the drainage systems, although installed at a high initial cost, has proven to be very successful in stabilizing water levels. The use of impoundments has also been very successful in southwestern Louisiana for waterfowl management (Chabreck, 1960). However, most areas in the Delta and Sub-delta of Louisiana will not support continuous levees, therefore impoundments in these areas could not be constructed (O'Neil, 1949).

Undesirable species of algae at times become very destructive to submerged aquatic plants. Control of this undesirable species has been accomplished in this study only on a limited scale. This was done by stocking mullet in areas with small infestations. If this method is expected to control algae, it should be done at the first appearance of algae in the ponds. Neely (1962) also suggests mullet as a means of algae control. He suggested these algae-eating fish be stocked in ponds in the spring of the year when fingerling mullet are in estuarine creeks. Martin and Uhler (1939) give a complete breakdown on the different means of control for these plants.

It was noticed several times during this study that waterfowl utilization was so heavy in some areas that entire stands of wigeongrass were completely eaten. After this, waterfowl no longer used the areas. It is suggested that in these "eaten out" areas that the water be drawn down to a few inches in depth over the marsh floor. This will allow a new stand to become established. If this is done toward the end of February or when the water temperature is 18.5°C to 30.0°C, a new stand will appear in a matter of several weeks. This will provide an additional food source for the returning flights of ducks from the South.

The management practices described above were directed toward the elimination or in some cases the control of the factors which inhibit wigeongrass growth. Almost all of the physical, chemical and biotic factors as stated by Martin and Uhler (1939), although not discussed here, were investigated in the study. From the results obtained, the remaining components did not prohibit the establishment of new stands of plant growth.

#### SUMMARY

A study of the factors that influence the establishment of natural and artificial stands of wigeongrass (*Ruppia maritima*), was conducted on Rockefeller Refuge during 1962-63. Physical, chemical and biotic factors were investigated; growth was measured monthly and germination tests of wigeongrass seed were carried out.

Physical factors such as turbidity, fluctuating water levels, and water depth were found to be controlling factors in the establishment of new stands and also to the development and production of mature stands of wigeongrass. Correlations were found between water depth, turbidity, and vegetative production. The greatest production was obtained at the 24-inch water level. A generalized range of turbidity which will allow wigeongrass growth in ponds with water depths less than 24 inches, as found in this study, is from 25 ppm to 54 ppm.

Chemical factors, such as per cent of soluble salts, inhibited seed germination probably by increasing the osmotic pressure of the soil solution so that the plants had difficulty in getting water. Salinity in the soil surface zones was most important because germination and establishment of seedlings were critical stages which had to take place on the soil surface. Soluble salts present in the soil which exceed 1.12 per cent are extremely harmful to germination of wigeongrass seeds.

The most important biotic factor affecting plant growth was algae cover. Algae overshadowed and crowded out wigeongrass by reducing the light. It was also observed that waterfowl utilization was reduced in these areas. Control of this undesirable plant was tried by stocking mullet at different stocking rates to see if these algae-eating fish could serve as a means of natural control. Control was successful in only one tank in which a desirable stand of wigeongrass was produced.

Wigeongrass was observed growing in a wide range of salinities from 2,075 ppm to 18,500 ppm in the study ponds and 1,160 ppm to 19,000 ppm in the experimental tanks. There was no correlation between chlorides and growth of wigeongrass. Wigeongrass was found to have two growing seasons that are controlled by a temperature range of 18.5°C to 30°C. When the temperature was above or below these figures, growth apparently ceased.

Water quality and soil chemistry, other than the factors mentioned above, proved to be of little significance in influencing the growth of wigeongrass.

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