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

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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.

INTRODUCTION

Louisiana is fortunate in having 12.9 percent of the land area vested in marshland and waterways (St. Amant, 1959). This vast area of marshland, covering an estimated 4,000,000 acres (O'Neil, 1949), provides a livelihood for many people in south Louisiana through trapping, fishing, raising cattle, and the leasing of land for hunting. According to Hansen and Hudgins (1966), these large expanses of marsh winter almost one-fourth of the total waterfowl population of the United States. The Louisiana marshes lead the nation in fur-production, as well as supplying nursery grounds for the young of many commercial and sport marine fishes.

Chamberlain (1957) reported that more than 75 percent of the vegetated area on Rockefeller Refuge was brackish marsh. Wiregrass *(Spartina patens)* is the dominant plant species in much of this marsh, with saltmarsh grass *(Distichlis spicata)* more evident near the Gulf of Mexico.

Although wiregrass and saltmarsh grass are utilized by wildlife, pure stands are generally undesirable. These two plants tend to dominate sites and exclude more desirable food producing plants for wildlife. For fur animal or waterfowl management these plants should be reduced or eliminated and replaced with plants such as Olney's three-cornered grass *(Scirpus Olneyi)*, leafy three-cornered grass *(Scirpur robustus)*, millets *(Echinochloa sp.)*, paspalums *(Paspalum sp.)* or other more desirable food producing plants.

Glasgow (1964) related that the need for agricultural and industrial land by an expanding population has reduced not only the quantity but also the quality of marshland that was formerly excellent wildlife habitat. At the same time, the rapidly rising demand for outdoor recreation has made it evident that more consideration must be given to the productivity of marshlands. Increase in carrying capacity for waterfowl and fur animals in coastal Louisiana will depend to a large extent on increased production from existing marshes.

It is desirable to develop economical methods for establishing grasses and sedges that will increase the carrying capacity for wildlife. Techniques developed in this project will probably be applicable in other coastal states having similar problems.

The objectives of this study were to:

1. Test the effectiveness of the following treatments to reduce or eliminate wiregrass and saltmarsh grass:
   a. Tilling
   b. Burning
   c. Application of chemicals
   d. Combinations of burning, tilling and chemicals.
2. Test the effectiveness of a rotary tiller to construct fire breaks in the marsh.
3. Measure water fluctuation and determine water salinity.

DESCRIPTION OF AREA

Rockefeller Refuge

This study was conducted in the Price Lake area of Rockefeller Wildlife Refuge in Southwestern Louisiana. The refuge, consisting of 85,000 acres of coastal marshland, is owned and managed by the Louisiana Wild Life and Fisheries Commission.

The northern boundary of the refuge is a chenier, or old beach remnant, which extends in a WNW - ESE direction, and the southern limit is a paralleling beach rim bordering the Gulf of Mexico. The refuge is approximately 26 miles long and the distance between the chenier and beach is roughly seven miles. Marsh elevations average 1.1 feet above mean sea level. The average tidal variation is about one foot, but occasional high tides inundate the natural marshes with salt water. The refuge has 12 impoundments which range in size from 120 to 5,680 acres and total 23,600 acres (Chabreck, 1960).

The chenier, levees, beach rim, and marsh complexes are the four general vegetational associations which occur on the area (Chamberlain, 1957).

The marshlands of the refuge are arranged in belts and are of three types; the fresh marsh zone, brackish marsh zone, and salt marsh zone. The northern belt is the fresh marsh, the middle belt the brackish marsh and the southern belt is the salt marsh.

STUDY PROCEDURE

Soil Samples

Soil Depth-Rhizome Relationship. Before one phase of this study, involved with the control of marsh vegetation by mechanically reducing stands of undesirable vegetation, could be accomplished it was necessary to take soil samples to determine the depth of rhizomatous roots of wiregrass and leafy three-cornered grass. This information was needed in order to know if the depth of cut of the tiller could be regulated to favor Olney's and leafy three-square to the detriment of the less desirable species. It was hoped that the majority of the roots of leafy three-square were slightly deeper than those of competing plants.

Twenty-five soil samples were taken in the Price Lake area of Rockefeller Refuge and ten soil samples were taken as controls in a relatively high, firm, highly mineral marsh west of the refuge. These samples were taken to a depth of 10 inches with a 4-inch diameter stainless steel sampling tube. The soil core was pushed out of the sampling tube into a sectioning tool that was calibrated in one-inch intervals. This sectioning tool was simply a section from a 4-inch diameter pipe split in half along the median plane with a space the width of a saw blade cut at one-inch intervals in the cross sectional plane. Once the sample was placed in the sectioning tool, the core was divided into one-inch sections by cutting through it with a large kitchen knife. Each subsample was then tagged, labeled, and sealed in a plastic bag.

The one-inch subsamples were taken to the lab and washed through a series of screens, after which the roots were separated and weighed according to species. The total weight of each species was recorded as well as the weights of the rhizomatous roots. These weights were then used to project the percentage of roots of wiregrass, saltmarsh grass, and leafy three-cornered grass in intervals of one inch to a depth of 10 inches.

Soil Chemistry. Nine composite soil samples were taken from each of three sampling stations on the study area. These samples were taken in March prior to the beginning of the growing season. At least 12 one-inch diameter subsamples were taken to a depth of 6 inches and mixed well for each composite sample. The sample was then numbered and put into a cloth bag for drying. After drying, the samples were crumbled into small pieces and submitted to the Soils Testing Laboratory at Louisiana State University for soil analyses.

Soil sample analyses were conducted using the methods described by Brupbacker, Bonner, and Sedberry (1968).

Vegetation Control Studies

Location and Description. A dense stand of wiregrass and saltmarsh grass was selected at the end of the Price Lake road for the vegetative control study area. This area was laid out in the form of a rectangle with the long sides running in an east-west direction. This area encompasses 137,488 square feet of marsh.

The study area was selected because of the predominance of wiregrass over the entire area and also because there were no large depressions or ponds which would tend to drastically alter the vegetative composition. It is located in the brackish marsh zone and is subjected to tidal action during abnormally high tides and also to periodic flooding with fresh water during the rainy seasons.

Establishment of Boundaries and Neutral Areas Between Plots. One hundred and twelve plots were staked out. Each plot was 20 feet square with a 16-foot isolation strip around each plot. The central eight feet of the isolation strip was tilled, and an additional four feet on each side of the tilled strip was ridden down by the marsh buggy.

Nine strips (two passes with the tiller were required to complete one strip) were tilled in the east-west direction and 15 strips were tilled in the north-south direction in completing the boundaries for the study plots.

Methods of Control. Each study plot was treated using one of 19 possible control measures. These control measures included burning, tilling, four chemicals, and combinations of these treatments. The chemicals used were Dalapon, a contact type herbicide and three soil-sterilants; Fenuron, Bromacil, and Karmex. Spring and fall applications were made for each control measure.

The treatment type for each individual plot was randomly selected for both the spring and fall applications. Three replications for each treatment were included in both phases of the study.

The same rate of application for both spring and fall treatments was maintained for each chemical. The rate of application for each chemical was: Fenuron - 6 pounds per 1000 square feet, Dalapon - 25 pounds per acre, Karmex - 20 pounds per acre, and Bromacil - 25 pounds per acre.

Fenuron was applied in a pelleted form by hand sprinkling it evenly over each 400-square foot plot.

Dalapon, Bromacil, and Karmex were applied with a three-gallon, hand-type pressure sprayer. The required chemical for each plot was dissolved in one gallon of water with one teaspoon of liquid detergent added as a wetting agent. These constituents were mixed well and applied to the appropriate plot.

Dalapon, manufactured by the Dow Chemical Corporation, contained 74 percent active ingredients of Dalapon (2,2-Dichloropropionic acid). According to the manufacturer, this herbicide works best as a foliage spray, although it is absorbed to a limited degree through plant roots. Dalapon offers only a limited soil persistence.

Fenuron, sold under the Dupont trade name of Dybar, contained 25 percent active ingredients of Fenuron (3-phenyl-1, 1 dimethylurea) and 75 percent inert ingredients. The one-eighth inch cylindrical pellets were applied to the surface of the marsh just as they come from the container. No sprayer or outside equipment was required. According to Dupont literature, Dybar is non-volatile, non-corrosive, non-flammable, and low in toxicity to humans and animals (Dupont Weed and Brush Killers for Effective, Economical Vegetation Control on Industrial Sites).

Bromacil is sold under the Dupont trade name of Hyvar X. It is a wettable powder containing 80 percent bromacil (5-bromo-3-*sec*-butyl-6-methyluracil) and 20 percent inert ingredients. Hyvar X is non-flammable, non-volatile, non-corrosive and low in toxicity to man and animals when used as directed. Bromacil has two distinct advantages as a soil sterilant. First, it is activated with a very small amount of rainfall - as little as one-half inch. Secondly, its breakdown by heat and light is negligible so that it will persist on the soil surface and become active when rainfall occurs (Dupont Weed and Brush Killers).

Karmex is sold under the Dupont trade name of Karmex. It is a wettable powder which contains 80 percent active Diuron [3-(3-4-dichlorophenyl)-1, 1-dimethylurea] and 20 percent inert ingredients. It is a substituted urea compound which gives weed control at low rates of use. It is only slightly soluble in water, and persists in the soil to give long-term weed control, particularly in wet areas and under conditions of high rainfall. This product is non-flammable, non-volatile, non-corrosive and is low in toxicity to humans and animals under recommended conditions of use (Dupont Weed and Brush Killers).

Burned plots were treated by backfiring (setting the fire with a drip-torch on the downwind side of the plot and allowing the fire to burn upwind). This gave a slow burning, hot fire. Six rows of plots were burned in their entirety. Several other plots were burned singly.

Tilled plots were treated by running a rotary tiller suspended from the rear of a marsh buggy across the plots. The tiller was adjusted to cut to a depth of eight inches. At least six cuts were required to till one 20-foot wide plot. The tiller cut was 48 inches wide and it was necessary to slightly overlap each cut to insure that the plot would be tilled adequately. As in the burned plots, entire rows were tilled to facilitate the rather limited mobility of the marsh buggy.

For plots treated with combinations of burn, till, and chemicals, the above procedures were followed. The sequence in which the treatments were applied was important. For burn plus till, the plots were burned first. For till plus chemicals, the plots were tilled initially and then chemicals were applied when the vegetation began to sprout. Plots were burned, tilled and then the chemicals applied after sprouting. Plots were burned and allowed to sprout before chemicals were applied.

Five by five-foot weldwire exclosures were placed on the plots as protection primarily from geese, nutria, rabbits, and muskrat. This weldwire was heavily galvanized and the mesh size was one by two inches. These exclosures were made by cutting a 20-foot piece of 36-inch weldwire and bending the wire at right angles at intervals of five feet. After the corners were bent, the two ends were closed by using galvanized hog rings. Once the five-foot square was completed, a one-inch poultry neeting top was ringed to the weldwire. These exclosures were placed in the centers of the plots. Vegetation samples were taken within these exclosures. Figure 1 shows some of the exclosures and the general layout of the vegetation control study area.

Methods of Assessment. As a basis for determining percent kill and changes that occurred in the vegetation, 25 one-square-foot vegetation samples were taken before both the spring and fall treatments. The vegetation within the square-foot samples was clipped even with the marsh floor from control and undisturbed adjacent plots. A measuring quadrat, described by Hoffpauir (1961), was made from a ¼-inch diameter welding rod. This sampling tool was open at one end to facilitate insertion into the dense vegetation at the marsh floor. After it was placed at the base of the vegetation, the fourth side was added to form the complete quadrat. The vegetation was then cut at ground level, placed in plastic bags, labeled, and sealed. The live vegetation within each sample was separated according to species and both wet and dry weights were taken. The number of live stems of each species was recorded as well as the lengths of individual stems. The wet weights and dry weights of the dead vegetation in each sample was recorded. The measurements of the dead vegetation should be regarded as a minimum because of the loss of fragments of dead vegetation which broke off in taking the sample. This dead vegetation was generally very brittle and a considerable amount of it was inadvertently lost in removing the sample from the marsh.

After all of the plots for each of the applications were treated and sufficient time had elapsed for the treatments to take effect, square foot samples were taken from each plot. The same data as previously described were recorded and these were used in calculating the percent kills.

Visual observations were made and also a photographic record was kept at various stages during the trials.

Water Depth and Salinity Data. water level readings were taken from two stations established on the east and west boundaries of the study area. The water depth was recorded to the nearest one-fourth of an inch by reading the

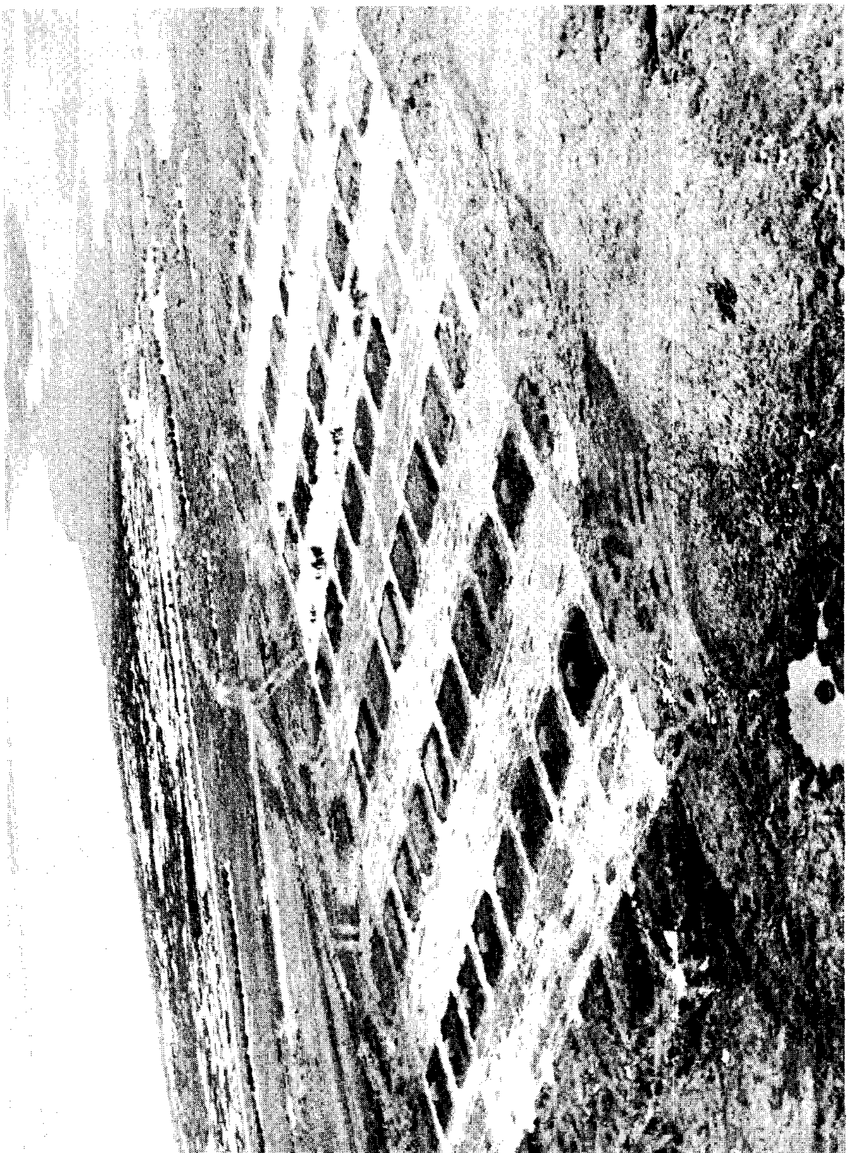

Figure 1. Aerial photograph of vegetation control study area

level from a permanently established meter stick. The marsh floor level at the well site was arbitrarily set as the zero point. A plus reading indicated that the water level was above the level of the marsh floor.

Water samples were taken from each of the two sampling wells established at the same stations as that for the water fluctuation recordings. Two four-inch diameter wells were established to a depth of 18 inches. These wells were lined with one-fourth inch hardware cloth to facilitate the drainage of water into the well and at the same time restrain the soft marsh soils. A quart water sample was taken from each well bi-weekly and salinity determined.

Water salinity was measured with a Model RC-16B1 Conductivity Bridge manufactured by Industrial Instruments, Incorporated, Cedar Grove, New Jersey. This instrument is designed for the measurement of electrolytic or solution conductivity. The determination of conductivity consists basically in measuring the resistance to current flow of a column of solution placed between two electrodes. Resistance readings were then converted to adjusted electrical conductivity and salinity determined from this reading.

Vegetation Data

Morphology and Vegetative Composition Based on Square Foot Samples. The samples mentioned previously in the section on "Methods of Assessment" were used in determining general information concerning wiregrass and saltmarsh grass. This information included the number of stems of wiregrass and saltmarsh grass per square foot, lengths of live stems, percent moisture, percent live vegetation by dry weight, average weight of wiregrass and saltmarsh grass per square foot sample, and the seed production of *Spartina patens* per acre.

Chemical Analyses. Composite vegetation samples of wiregrass, saltmarsh grass, and leafy three-cornered grass were taken monthly from control plots. These samples were then taken to the lab and put into drying ovens and allowed to dry for three days at 100° C. After drying, the samples were ground with a Wiley Mill, labeled, and sealed in small plastic bags. These samples were then submitted to the Feed and Fertilizer Laboratory of Louisiana State University for chemical analyses. Determinations of moisture, protein, fat, fibre, ash, calcium, and potassium were made according to the procedures outlined in the tenth edition of Official Methods of Analysis of the Association of Official Agricultural Chemists (1965).

Fire Breaks

The effectiveness of the marsh buggy-rotary tiller combination to construct fire breaks in the marsh was tested on three separate occasions.

In the spring of 1965 two strips of marsh 276 feet long and 20 feet wide were initially used to test the adaptability of the machine in constructing fire breaks. Four strips of the same dimensions were burned in the fall of 1965. Each block was encompassed by an eight-foot wide tilled strip and an additional eight feet that resulted when the buggy tracks pushed the marsh vegetation into the soft soil.

The water table was below the marsh floor level during both burns resulting in a partial burn of the peat layer. Winds were variable and moderate.

After the tilled strips had been completed, the buggy was readied for action in the event that one of the fires should break out.

The fire for each strip was set with a drip torch. Backfires were used on all six burns.

A single one-half acre plot was burned in the early fall, using a four foot tilled strip as a boundary. A head fire was used in this phase of the experiment.

RESULTS AND DISCUSSION

Soil Depth-Rhizome Relationship

The percentages of roots by one-inch depth classes of wiregrass and leafy three-cornered grass from 25 samples taken in the Price Lake area of Rockefeller Refuge and from 10 control samples are presented in Tables I and II. *Spartina patens* and *Distichlis spicata* roots were grouped into one category for the control samples.

Ninety-eight and two-tenths percent of the rhizomatous roots of leafy three-cornered grass at the Price Lake area and 99.51 percent of the rhizomatous roots from the control samples were contained in the top four inches of marsh soils.

Ninety-six and two tenths percent of the rhizome-type roots of wiregrass at the Price Lake area and 99.71 percent of the roots of *Distichlis-Spartina* from the controls were contained in the top six inches of marsh soil.

Based on the preceding information, it was concluded that the depth of cut of the rotary tiller could not be regulated on these two sites to favor the growth of leafy three-cornered grass.

Based on the information obtained from the samples taken in the Price Lake area, approximately 50,000 pounds (wet weight) of rhizomatous roots per acre are contained in the top four inches of marsh soil.

Soil Chemistry

Chemical analyses of the soil on selected plots at the Price Lake Vegetative Control Study Area are presented in Table III. All of the soil samples were classified as heavy clay. Even though organic matter content was not determined chemically on any of the samples, physical measurements indicated appreciable quantities. Soil phosphorus varied from a low of 153 ppm to a high of 243 ppm. This difference of 90 ppm, of phosphorus, which is equivalent to 180 pounds per acre, would be considered significant for certain agronomic crops growing under non-submerged moisture conditions if it were not for the fact that all of the soil test values for phosphorus are considered to be medium to high (Fertilizer Recommendations for Louisiana, 1960). Soil levels of potassium, calcium, and magnesium are considered to be adequate for normal growth and reproduction of grasses. Soluble salts in this area are considered to be excessive and only salt tolerant plant species could grow normally under existing conditions. The water soluble salt concentration in these marsh samples varied from a low of 13,200 ppm, to a high of 30,000 ppm.

Since the desirable species, *Scirpus robustus,* was not present to any appreciable degree on the plots during this investigation a relationship between fertility status of the soil and growth of this species cannot be established. A *Scirpus robustus* seeding experiment conducted in an area adjacent to this investigation indicated that environmental conditions other than soil fertility levels may have been associated with the growth of leafy three-cornered grass. Growth of *Scirpus robustus* was observed under one-inch by two-inch weld-wire exclosures. These exclosures afforded protection from animal damage. The exclosure also tended to "hold together" the decaying vegetation and soft marsh soils, especially during periods of high water, and probably influenced seed germination.

Morphology and Vegetative Composition

The number of wiregrass stems per square foot averaged 159.8 for the 25 samples taken in May. The average dry weight was 143.03 grams. Each stem averaged 33.9 inches in length and 0.92 grams by dry weight.

The number of wiregrass stems for 25 samples taken in January averaged 159.3 per sample with an average dry weight of 131.78 grams. Each stem averaged 0.87 grams by dry weight and 28.4 inches in length.

TABLE I

PERCENTAGES OF ROOTS BY DEPTH CLASSES FROM 25 SAMPLES TAKEN IN THE PRICE LAKE AREA OF ROCKEFELLER REFUGE.

	Spartina patens		Scirpus robustus	
Depth in inches	All roots (%)	Rhizomatous roots (%)	All roots (%)	Rhizomatous roots (%)
0-1	16.63	15.57	28.59	25.94
1-2	15.05	19.47	32.88	37.59
2-3	15.30	23.16	25.53	25.41
3-4	12.33	18.24	9.85	9.24
4-5	10.42	11.58	1.08	0.70
5.6	8.98	8.18	0.99	0.57
6-7	7.54	1.93	0.43	0.56
7-8	6.43	0.85	0.12	0.00
8-9	4.50	0.47	0.00	0.00
9-10	2.79	0.54	0.00	0.00
Summary				
1-2		35.04		63.53
1-4		76.44		98.18
1-6		96.20		99.45

TABLE II

PERCENTAGE OF ROOTS BY DEPTH CLASSES FROM 10 SAMPLES TAKEN WEST OF ROCKEFELLER REFUGE.

	Distichlis-Spartina		Scirpus robustus	
Depth in inches	All roots (%)	Rhizomatous roots (%)	All roots (%)	Rhizomatous roots (%)
0-1	27.03	25.36	21.55	17.18
1-2	28.13	35.69	40.37	41.98
2-3	18.68	24.43	31.15	34.64
3-4	9.24	9.13	6.51	5.71
4-5	5.76	5.09	0.42	0.48
5-6	3.36	0.01	0.00	0.00
6-7	2.49	0.00	0.00	0.00
7-8	2.22	0.00	0.00	0.00
8-9	1.82	0.00	0.00	0.00
9-10	1.27	0.00	0.00	0.00
Summary				
1-2		61.05		59.16
1-4		94.61		99.51
1-6		99.71		99.99

TABLE III

CHEMICAL ANALYSES OF THE SOIL ON SELECTED PLOTS ON THE PRICE LAKE VEGETATION CONTROL STUDY AREA.

Sample Number	P	K	Ca	Mg	pH	Water Soluble Salts
			ppm			ppm
1	243	455(1)	760	450(2)	6.6	19,800
2	239	455	720	450	6.5	13,200
3	205	455	720	450	6.4	18,400
4	191	455	760	450	5.7	30,000
5	200	455	850	450	5.9	28,700
6	229	455	680	450	5.9	25,300
7	153	455	890	450	6.4	22,400
8	167	455	980	450	6.4	22,300
9	162	455	800	450	6.2	24,500

(1) The soil contained more than 455 ppm of K.
(2) The soil contained more than 450 ppm of Mg.

Saltmarsh grass averaged 26.7 stems per square foot in May and 32.12 stems in January. The average dry weight per sample was 15.50 grams in May and 18.97 grams in January. In May the average dry weight per stem was 0.62 grams and the average length was 22.53 inches. The average dry weight per stem in January was 0.53 grams and the average length was 16.87 inches.

The average dry weight of the dead vegetation per square foot was found to be 119.43 grams in May and 104.77 grams in January. This dead vegetation constituted 39.58 percent of the material by dry weight in May and 40.47 percent in January. Sixty and four-tenths percent (dry weight) of the vegetation sampled in May and 59.53 percent of that sampled in January was live vegetation.

The average depth of the rough (dead and decaying vegetation) was 5.42 inches. This figure was the average from 12 plots and the range was 5.00 inches to 7.00 inches.

Live vegetation contained 38.89 percent moisture when sampled in May and 42.79 percent in January. Dead vegetation contained 42.88 percent moisture and 49.46 percent for the same months.

Seed production of wiregrass was studied by clipping the seed heads from five selected square-foot samples, obtaining the dry weights and projecting the results to pounds per acre. These five samples were taken in June, 1966 from the dense stands of wiregrass in which seed production was high. The average weight of the seed heads was 4.7 grams per square foot. The optimum production of wiregrass seed heads by dry weight was projected to be approximately 451 pounds per acre. Visual observations indicated that seed production was higher on burned plots than on adjacent control plots.

Spartina patens and *Distichlis spicata* both have blooming periods in the spring and fall (Penfound and Hathaway, 1938). This is due partly to the mild winters and exceptionally long growing period of 326 days. Seed production reaches a peak in late summer.

Spring Treatments for Control of Wiregrass and Saltmarsh Grass

The percent kill on wiregrass for each treatment is presented in Table IV and the percent kill for saltmarsh grass is presented in Table V. The figures presented are the means of the replications of each treatment. The percent kills were calculated in July, 1965, three months following the initial treatment of the plots;

February, 1966, nine months following treatment; July, 1966, 15 months following treatment, and again in June, 1970, or 62 months following initial treatment.

The statistical analysis of this problem was conducted through the facilities of the Computer Center of the Department of Experimental Statistics.

Tests of significance were conducted for the fall treatments, for three analyses of the spring treatments, and in comparing the spring and fall treatments at nine months.

The results of the statistical analysis for the spring treatments are presented in Table VI.

Fall Treatments for Control of Wiregrass and Saltmarsh Grass

The percent kill for each type of treatment applied in the fall of 1965 is presented in Table VII. The kill was calculated in July, 1966, nine months following treatment, and in June, 1970, 55 months following initial treatment.

The results of the statistical analysis for the fall treatments are presented in Table VIII and the results for the comparison of spring and fall treatments are described in Table IX.

Ranwell and Downing (1959) used Dalapon and substituted urea herbicides for the control of species of *Spartina* in the estuarine marshes along the European coasts. They found that Dalapon at 50 pounds per acre gave 100 percent kill of *Spartina* main growth one year after spraying. Application was made in July. They also reported that re-invasion by seedlings suggests that repeated applications may be necessary.

They also reported that Fenuron at 40 pounds per acre gave 99 percent kill when applied as a spray in April. There was no significant regrowth in plots, or new seedling establishment one and one-half years after spraying. A pelleted combination of Fenuron, 2,4-D and sodium borate injected into the mud or sprinkled on the surface at 15 pounds per acre, gave a 60 percent kill in a *Spartina* marsh inundated daily by tidal action.

Martin (1965) reported that in the mid 1950's herbicides used on marsh plants were largely the same as those employed on upland weeds. The most popular was 2,4-D, applied in its various ester and salt formulations. He reported that 2,4-D had been used effectively on national waterfowl refuges. Ammate has also proven effective on certain marsh weeds.

Martin also pointed out that combination treatments frequently have special usefulness in controlling marsh weeds. Dual or multiple attacks may involve various combinations such as burning and spraying, burning and disking, mowing and flooding, flooding and spraying, or spraying followed later by another application of the same or different kind of herbicide.

Chandler (1969) reported that tilling in fresh marsh reduced wiregrass and increased the growth of more desirable annual grasses and sedges. He also pointed out that burning prior to tilling reduced the rough on the marsh and allowed the rotary tiller to cut more efficiently.

Chandler also reported that tilling, burning, and chemicals or combinations of these were unsuccessful in increasing leafy three-corned grass in the salt marsh. He reported that tilling reduced both wiregrass and saltmarsh grass in the salt marsh. Burning actually increased the number of live stems of saltmarsh grass. Tri-fen decreased the number of stems of saltmarsh grass, but till in combination with Tri-fen was more effective than the chemical alone. No mention was made of reinvasion by desirable plants for treatments in the salt marsh.

Soileau (1968), in a two-year analysis of the investigation under report noted that Bromacil allowed a better growth of leafy three-cornered grass than did Karmex or Fenuron and that burning and tilling successfully allowed leafy three square to reinvade plots. However, samples taken in 1970 did not bare this out. Leafy three-cornered grass simply did not turn up in any of the 112 plots sampled in 1970, indicating that factors other than the treatments under study were responsible for the loss of *Scirpus* from 1968 to present.

TABLE IV

AVERAGE PERCENT KILL OF *SPARTINA PATENS* FOR PLOTS TREATED IN SPRING (APRIL, 1965).

Treatment	Percent Kill After 3 months	9 months	15 months	62 months
Dalapon	68.51	88.07	39.31	35.62
Fenuron	66.01	94.98	79.70	38.13
Karmex	73.10	88.70	69.66	30.00
Bromacil	87.07	99.37	45.57	54.30
Burn	26.18	21.52	3.31	23.14
Burn-Dalapon	38.06	90.16	87.44	26.25
Burn-Fenuron	83.53	97.91	98.12	74.39
Burn-Karmex	79.56	97.49	74.47	54.38
Burn-Bromacil	80.81	100.00	100.00	87.50
Burn-Till-Dalapon	97.29	99.16	100.00	100.00
Burn-Till-Fenuron	99.58	99.64	100.00	100.00
Burn-Till-Karmex	97.70	99.37	100.00	100.00
Burn-Till-Bromacil	98.96	99.16	100.00	100.00
Burn-Till	92.29	92.47	79.07	97.50
Till	95.41	82.42	85.56	70.00
Till-Dalapon	97.92	95.61	99.79	89.38
Till-Fenuron	97.70	98.54	98.74	100.00
Till-Karmex	98.54	96.86	99.16	89.38
Till-Bromacil	98.96	99.64	99.37	100.00
Control	4.49	33.52*	16.92	9.38

*Indicates an increase in number of live stems.

TABLE V

AVERAGE PERCENT KILL OF *DISTICHLIS SPICATA* FOR PLOTS TREATED IN SPRING (APRIL, 1965).

	Percent Kill After			
Treatment	3 months	9 months	15 months	62 months
Dalapon	83.82	88.57	71.90	3.70*
Fenuron	55.16	100.00	97.91	55.56
Karmex	75.07	58.50	14.84*	36.67
Bromacil	97.50	100.00	97.94	11.11
Burn	17.07*	3.77*	90.94*	22.22*
Burn-Dalapon	70.10	96.89	91.87	74.08
Burn-Fenuron	72.69	97.91	92.75	77.78
Burn-Karmex	49.29	77.18	40.10*	22.22**
Burn-Bromacil	95.03	100.00	100.00	163.22*
Burn-Till-Dalapon	97.50	93.77	100.00	100.00
Burn-Till-Fenuron	100.00	97.91	100.00	100.00
Burn-Till-Karmex	97.50	92.75	100.00	100.00
Burn-Till-Bromacil	96.26	94.80	100.00	37.00
Burn-Till	93.76	97.91	69.89	92.60
Till	98.77	95.86	82.35	81.49
Till-Dalapon	86.29	100.00	95.86	92.59
Till-Fenuron	100.00	100.00	95.86	100.00
Till-Karmex	97.29	98.97	90.66	100.00
Till-Bromacil	96.26	100.00	94.80	100.00
Control	2.13*	28.39	120.02*	37.00

*Indicates an increase in number of live stems.

TABLE VI

STATISTICAL ANALYSIS OF SPRING TREATMENTS (INCLUDING DATA FROM THE 3-MONTH, 9-MONTH, AND 15-MONTH CHECK ON PERCENT KILL)

Component	*Spartina patens*	*Distichlis spicata*
R (Burn)	*	N.S.
A (Till)	**	**
RA	*	N.S.
B (Chemicals)	**	**
AB	**	**
RB	N.S.	N.S.
RAB	N.S.	N.S.
C (Analysis; 1st, 2nd and 3rd check)	*	**
AC	*	**
BC	N.S.	**
ABC	N.S.	N.S.
RC	N.S.	N.S.
RAC	N.S.	N.S.
RBC	N.S.	N.S.
RABC	N.S.	N.S.

** Highly significant (.01 P)
* Significant (.05 P)
N.S. Non-significant

TABLE VII

AVERAGE PERCENT KILL FOR PLOTS TREATED IN FALL (NOVEMBER, 1965)

	Spartina patens		*Distichlis spicata*	
	Percent Kill After			
Treatment	9 months	55 months	9 months	55 months
Dalapon	88.32	13.88	52.65	50.00
Fenuron	58.08	21.38	4.63*	37.50
Karmex	34.31	35.22	17.97	62.50
Bromacil	26.80	44.66	56.39	59.38
Burn	35.98	23.90	29.56*	12.50
Burn-Dalapon	93.32	28.30	93.74	56.25
Burn-Fenuron	55.37	54.72	46.45	59.38
Burn-Karmex	97.50	68.55	97.50	31.25
Burn-Bromacil	97.70	71.07	81.32	18.00*
Burn-Till-Dalapon	100.00	100.00	100.00	62.50
Burn-Till-Fenuron	100.00	100.00	100.00	87.50
Burn-Till-Karmex	100.00	98.11	100.00	75.00
Burn-Till-Bromacil	100.00	96.86	100.00	90.62
Burn-Till	100.00	98.10	100.00	50.00
Till	91.68	90.57	85.05	50.00
Till-Dalapon	100.00	97.48	100.00	68.75
Till-Fenuron	100.00	86.17	100.00	65.63
Till-Karmex	100.00	96.21	100.00	28.12
Till-Bromacil	100.00	90.57	100.00	68.75
Control	8.30	10.07	98.06*	28.12

*Indicates an increase in number of live stems.

TABLE VIII

STATISTICAL ANALYSIS OF FALL TREATMENTS AT 9 MONTHS.

Component	*Spartina patens*	*Distichlis spicata*
R	**	**
A	**	**
RA	**	**
B	**	**
AB	**	**
RB	**	N.S.
RAB	**	N.S.

** Highly significant (.01 P)
* Significant (.05 P)
N.S. Non-significant (.05 P)

TABLE IX

STATISTICAL ANALYSIS OF SPRING AND FALL TREATMENTS AT 9 MONTHS.

Component	*Spartina patens*	*Distichlis spicata*
R (Burn)	**	**
A (Till)	**	**
RA	**	*
B (Chemicals)	**	**
AB	**	**
RB	*	N.S.
RAB	*	N.S.
C (Season)	N.S.	*
AC	N.S.	**
BC	**	N.S.
ABC	**	N.S.
RC	**	**
RAC	**	**
RBC	**	N.S.
RABC	**	N.S.

Vegetative Reinvasion of Treated Plots

Percent vegetative reinvasion for both the spring and fall treatments are included in Table X. Widgeon grass was the only invader encountered during the June, 1970 samples, probably as a result of the high water levels maintained over the study area for an extended period of time. Also, it was apparent that the soil on plots treated by tilling had subsided. This resulted in a miniature pond type situation. Reinvasion by desirable species of *Scirpus* was nil five years following initial treatment.

TABLE X

VEGETATIVE REINVASION FOR PLOTS TREATED IN SPRING AND FALL, 1965. SAMPLED IN JUNE, 1970.

	Percent Reinvasion of Widgeon Grass	
Treatment	Spring Treatments	Fall Treatments
Dalapon	0	0
Fenuron	0	0
Karmex	0	0
Bromacil	4.0	0
Burn	0	0
Burn-Dalapon	2.0	0
Burn-Fenuron	7.0	0
Burn-Karmex	13.0	2.0
Burn-Bromacil	10.0	4.0
Burn-Till-Dalapon	33.0	7.0
Burn-Till-Fenuron	30.0	11.0
Burn-Till-Karmex	17.0	40.0
Burn-Till-Bromacil	28.0	17.0
Burn-Till	35.0	5.0
Till-Dalapon	33.0	3.0
Till-Fenuron	28.0	10.0
Till-Karmex	25.0	48.0
Till-Bromacil	15.0	43.0
Till	33.0	15.0
Control	0	0

Water Depth and Salinity

Water depths recorded during the course of this study ranged from a low of 10.50 inches below the marsh floor level in July, 1965 to a high of 16.00 inches above marsh floor level in February, 1966. The salinities ranged from a high of 31,000 ppm in June and July of 1965 to a low of 1,836 ppm in January, 1967. As a result of evaporation and transpiration, water depths dropped to their lowest levels in late summer and early fall. The general trend was that water depth and salinity were inversely proportional. The water depths were at their highest in the late fall and winter. Tidal action and rainfall were the major factors causing frequent and drastic changes in water levels and salinities.

Salinity data are presented to show the extremes under which *Spartina* and *Distichlis* grow. No attempt was made to draw conclusions concerning the actual influence of salinity on wiregrass and saltmarsh grass. Salinity and water depths combined with edaphic conditions, are important factors in determining vegetational zonation.

According to Chapman (1960), *Spartina patens* will not tolerate waterlogging and the growth and size of the plant are controlled largely by drainage. In poorly drained areas it tends to be eliminated and replaced by *Distichlis spicata.* He also reported that in the central part of the geographical range of wiregrass, its vigor is usually unaffected by mowing but near its northern limit it is affected.

Spartina patens in Louisiana reacnes only 18 inches in height under saline conditions but under freshwater conditions (less than 0.5 percent salt) it may grow to five feet (Penfound and Hathaway, 1938).

Numerous reports dealing with plant responses on salt-affected soils have appeared in the literature. The salt tolerance of wiregrass was determined to be:

Min.	Max.	
0.40% salt	4.25% salt	(Harshberger, 1909)
0.75% salt	3.25% salt	(Taylor, 1939)
0.12% salt	3.91% salt	(Penfound and Hathaway, 1938)

These values may vary depending upon the time in the ontogeny of the plant when the salinity was acting.

Penfound and Hathaway reported that saltmarsh grass will tolerate 0.45 to 4.97 percent salt while leafy three-cornered grass will tolerate 0.64 to 3.91 percent salt.

Excessive salt concentrations may affect plants by: inhibiting seed germination or seedling emergence; reducing water uptake by plants because of increased osmotic pressure in saline soils; or by decreasing absorption of essential nutrients, with the accumulation of some toxic ions (Hayward and Bernstein, (1958).

Based on recent studies, Bernstein (1961) reported that lowered turgor in plants, associated with increased osmotic pressure, can no longer be held responsible for the lack of growth on saline soils. By conditioning the roots of pepper and cotton plants in a solution of high osmotic pressure for several hours, Bernstein found that the water-absorbing capacity of roots appeared to be unaffected by salinity. This contradicts earlier reports which indicated that plant roots had only limited capacity to adjust to osmotic pressure. Bernstein offered two suggestions as to why plant growth is retarded under saline conditions. First, it is possible that in osmotic subcellular units the plastids and mitochondria may not adjust to higher osmotic pressure despite the apparent capacity of the vacuole to do so. Second, osmotic adjustment may usually be achieved only at the expense of growth reduction.

Hayward and Long (1941) pointed out that, under high salinity conditions, protein synthesis was greatly retarded even though plant tissues contained large amounts of carbohydrates and nitrogen.

Chemical Analyses of Wiregrass, Saltmarsh Grass, and Leafy Three-Cornered Grass

Chemical analyses of whole plants of *Scirpus, Distichlis* and *Spartina* taken from control plots over a period of one year indicated:

Component	*Scirpus*	*Distichlis*	*Spartina*
protein	xx	xxx	x
fat	xxx	xx	x
fiber	x	xx	xxx
ash	xxx	x	xx
calcium	xx	x	xxx
phosphorus	comparable		x

XXX HIGHEST
XX NEXT HIGHEST
X LOWEST

Fire Breaks

The marsh buggy-rotary tiller combination was adequate for fire lane production for all seven of the burns tested in this phase of the study. All of the fires were contained within the boundaries set down by the tiller without any assistance from personnel.

This investigation was carried out on a limited scale and the writer deems it advisable to test the machine on a larger scale where a larger acreage could be burned.

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