EFFECTS OF ELIMINATION OF ALLIGATORWEED ON CERTAIN AQUATIC PLANTS AND THE VALUE OF THESE PLANTS AS WATERFOWL FOODS

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ABSTRACT

The effects of elimination of alligatorweed *(Alternanthera philoxeroides)* by granular silvex on the abundance of 12 species of aquatic plants were studied on the Santee National Wildlife Refuge, Lake Marion, South Carolina, from 1961 to 1964. Three hundred and sixty duck stomachs collected from hunters during the 1961 hunting season were examined to determine the importance of these 12 species as waterfowl food.

INTRODUCTION

Alligatorweed *(Alternanthera philoxeroides)* (Mart.) Grieb. has become a serious aquatic pest plant in the Southeast. In addition to obstructing navigation channels, municipal water supplies, and irrigation systems, it crowds out other plants that are important as food and cover to many forms of wildlife (Lynch, et al., 1947). Weldon (1960) compiled the results of all control experiments published up to 1960. The Division of Wildlife Research, Bureau of Sport Fisheries and Wildlife, in cooperation with the Branch of Wildlife Refuges and the South Carolina Public Service Authority, determined that silvex in a 20 per cent acid equivalent formulation on attaclay granules would control well-rooted alligatorweed in less than 24 inches of water (McGilvrey and Steenis, 1961). This same study included an evaluation of changes in plant composition within the test plots. The present paper reports these changes and also the results of duck food habits studies undertaken to determine the importance to waterfowl of plant species that grew on the test plots from which alligatorweed was removed.

STUDY AREA

The study area was on the Bluff Unit of the Santee National Wildlife Refuge, Lake Marion, South Carolina. Lake Marion was built about 1940 by the South Carolina Public Service Authority for hydroelectric power. It has an area of about 100,000 acres at maximum pool. The refuge is located on the reservoir. Water levels are normally at a maximum in late winter and early spring and at a minimum in late summer. The reservoir is shallow and hence the seasonal fluctuations in water depth create excellent conditions for growth of certain plants. The soils are light and sandy. Water fluctuation on the study plots ranged from dry to a depth of 24 inches.

Alligatorweed was the dominant vegetation in the study plots prior to treatment.

METHODS

Granular silvex was hand sown at 20, 30, and 40 lb. ae/A on 1/40-acres plots at 2-week intervals between May 15 and July 31, 1961, with the result that alligatorweed was eliminated from all plots (McGilvrey and Steenis, 1961). Thirty-two plots were checked periodically for changes in plant species and abundance; 5 of these were untreated check plots, 10 had been treated at 20 lb. ae/A, 12 at 30 lb. ae/A, and 5 at 40 lb. ae/A. Nine of these plots (one untreated) were inadvertently disced in early October 1961. All plots were examined at monthly intervals during the 1961 and 1962 growing seasons and again in September 1963 and June 1964.

Species abundance was rated by the method described by Webb (1942). Plants were grouped into four categories of abundance:

1. 0 to 1/80 of total area— rare
2. 1/80 to 1/3 of total area—uncommon
3. 1/3 to 2/3 of total area—common
4. 2/3 and over of total area—abundant

Forty-one plant species were recorded in the plots, but only 12 were in enough plots to make detailed study meaningful. These included:

1. Broadleaf arrowhead *(Sagittaria latifolia)*
2. Southern cutgrass *(Leersia hexandra)*
3. Hydrochloa *(Hydrochloa caroliniensis)*
4. Common jointgrass *(Paspalum distichum)*
5. Bull paspalum *(Paspalum boscianum)*
6. Maidencane *(Panicum hemitomon)*
7. Wild millet *(Echinochloa crusgalli)*
8. Cyperus *(Cyperus odoratus)*
9. Squarestem spikerush *(Eleocharis quadrangulata)*
10. Annual spikerush *(Eleocharis obtusa)*
11. Swamp smartweed *(Polygonum hydropiperoides)*
12. Buttonbush *(Cephalanthus occidentalis)*

The inspection in September 1963 was made during the low water stage when broadleaf arrowhead and Hydrochloa could not be satisfactorily evaluated. The inspection in June 1964 was made prior to summer drawdown, and common jointgrass, bull paspalum, wild millet, annual spikerush, and cyperus could not be rated.

Duck stomachs were collected from hunters during the 1961 hunting season at a boat landing on the northern boundary of the refuge. Most sportsmen using this landing hunted within a mile of the study area. Three hundred and sixty stomachs were analyzed, including 130 mallard, 62 wood duck, 40 widgeon, 34 pintail, 32 black duck, 32 green-winged teal, 15 ring-necked duck, 7 gadwall, 4 shoveler, and 4 lesser scaup.

RESULTS

Rate of application made no discernible difference on alligatorweed (which was eliminated from all plots) nor on the 12 invading species particularly studied. Abundance of these species at the different observation periods is given in detail in Table 1. The paragraphs below summarize these observations and report conclusions from the food habits studies.

1. *Broadleaf Arrowhead.* Prior to treatment, arrowhead was found in 31 of the 32 plots. Most of the flowering plants were killed by silvex treatments; arrowhead was rare or uncommon in the plots where it remained in September 1961. It had recovered only a little by 1964. Abundance in the check plots did not change appreciably.

   Arrowhead was not an important waterfowl food; a few seeds were found in only one green-winged teal stomach.

2. *Southern Cutgrass.* Cutgrass was present, but rare, in 7 plots prior to treatment. Silvex had no apparent immediate effect on abundance. By 1964, however, it was present on 11 plots (common in one); four of these plots had not contained cutgrass prior to 1964.

   Abundance of cutgrass did not change significantly on the three check plots where it grew.

   Cutgrass produced very little seed in the area in 1961, and the seed was of no importance to waterfowl. However, the culms were very important to mallard (20 per cent of total volume) and to widgeon (32 per cent of total volume), rating first in importance with both species. It was sixth in importance for pintail (8.5 per cent). It was of minor importance to wood ducks and black ducks.

3. *Hydrochloa.* Hydrochloa, called weatherwax in the Santee area, was found in five plots prior to treatment. It was uncommon and rare on the three plots to be treated. It began to invade the treated plots at the lowest elevations in the fall of 1961, when it occurred in eight plots. It remained rare or common, however, until 1964, when water levels were higher in early summer than in previous years. In that summer it occurred on 17 plots, and was common in 3.

   No change in abundance in the two check plots occurred during the study.

   Hydrochloa was an important food item for seven duck species. The stems and leaves were important to mallard (12 per cent); widgeon (22.8 per cent); gadwall (19 per cent); ringneck (18 per cent); and black duck (nearly 8 per cent) of total volume. The seed was taken by pintail (14.5 per cent) and green-winged teal (8 per cent). It was of minor value to wood ducks.

4. *Common Jointgrass.* Jointgrass was uncommon or rare in nine plots to be treated. Elimination of alligatorweed released it almost immediately. In September 1961, it was present on 16 plots, common in 1. It continued to increase in abundance in 1962 ;it became common in eight plots and appeared in one new plot. Abundance did not change significantly in 1963. It was rare throughout the study in one check plot. There was no use by waterfowl.

5. *Bull Paspalum.* This paspalum was uncommon in one plot prior to treatment. By September 1961, it was present in 18 treated plots, common in 1. Abundance increased considerably in 1962 in the same 18 plots, of which 8 had been disced. It was abundant in one plot, common in three. In 1963 it nearly disappeared, being found in only four plots.

   The seed of bull paspalum was taken in small amounts by mallard, black duck, and pintail.

6. *Maidencane.* Maidencane was present in 22 plots prior to treatment, rare in 21 and uncommon in 1. Eighteen of these plots were treated with silvex. In 1962, maidencane was present in 22 treated plots still seemd to hold back the maidencane in all but two plots By 1963, 25 treated plots contained maidencane, and it was abundant in 4, common in 6. The 1961 discing of eight of these plots It continued to increase in abundance in 1964. All but one of in which it was abundant in one and common in the second. Maidencane was still rare in the remaining six treated, disced plots still seemed to hold back maidencane in all but two plots the plots contained maidencane, and it was abundant in 5 plots, common in 7. Between 1963 and 1964, the greatest increases had occurred in disced and check plots.

   Maidencane was not found in any duck stomachs.

7. *Wild Millet.* Millet was rare in four plots prior to treatment. It

was present in 19 treated plots in September 1961. The year of greatest abundance was 1962, when millet was present in 24 treated plots, abundant in 2, and common in 3. The most significant increases were in the disced plots, in which it was abundant in two, common in one. Millet decreased greatly in abundance in 1963. Although still present in 17 plots, it was rare in 11 and uncommon in 6.

Millet occurred infrequently in duck stomachs, mainly in mallard.

8. *Cyperus.* Cyperus was not found in any plots prior to treatment. It was present in 19 treated plots in 1962, and was common in 1. Apparently discing was not particularly beneficial. It again became scarce in 1963.

   It was rare in check plots throughout the study.

   Cyperus culms comprised 7.3 per cent of total volume in black duck stomachs and 4.2 per cent in green-winged teal. It was of minor importance in pintail and mallard stomachs.

9. *Squarestem Spikerush.* Squarestem spikerush was in 13 plots prior to treatment, all at the lowest elevations. This spikerush was very susceptible to silvex. It was not found in any plots in September 1961, and was rare in one plot in 1962 and five plots in 1963. By 1964 it had reappeared in 12 treated plots. There was no significant variation in abundance in the three check plots containing this plant.

   Squarestem spikerush seed was of major importance to pintail, comprising 18.3 per cent of total volume. It was of some value to mallard, with nearly 4 per cent of the total volume, and of minor importance to green-winged teal and black duck. An introduced plant on Lake Marion and of very limited distribution, its relatively high use indicated preference.

10. *Annual Spikerush.* This spikerush was present in 16 plots prior to treatment. Silvex killed all plants that were flowering. However, recovery and increase were excellent in 1962, when it was present on 25 treated plots, of which 9 had ratings of common. By 1964 it was being replaced by more dominant plants and, although still found in 12 plots, it was common in only 1. There was no significant change in the check plots.

    The culms and stems of annual spikerush were important food items for widgeon (13.7 per cent) and gadwall (12.2 per cent). The seeds were of some importance to green-winged teal (6.3 per cent) and pintail (6.2 per cent). All parts of the plant were taken by mallard and comprised 4.6 per cent of total volume.

11. *Swamp Smartweed.* Swamp smartweed was rare on 27 plots prior to treatment. Flowering plants were killed back by silvex. There was little change in abundance until 1963 when smartweed was present in 26 plots, common in 3. There was a small increase in abundance in 1964.

    Abundance increased steadily in check plots until 1964, when all had significant decreases.

    Swamp smartweed seeds were found in more duck stomachs than any other item. However, total volume was rather low. By volume it was important to pintail (9.8 per cent); black duck (8.1 per cent); ringneck (5 per cent); and mallard (4.7 per cent). It was of minor importance to green-winged teal and wood duck.

12. *Buttonbush.* Seedlings of this species were rare in 14 plots prior to treatment. Silvex had no effect. Abundance ratings increased slowly. Five plots had ratings of uncommon in 1963, eight plots in 1964. Some plants were old enough to flower by 1964. Buttonbush was in four check plots throughout the study. Rate of increase was comparable to the treated plots.

Buttonbush seed was found in more duck stomachs than any other item except swamp smartweed. By volume it was the most important food item for shoveler (67.3 per cent); green-winged teal (15.1 per cent); and pintail (14.8 per cent). It was also important in lesser scaup (17.6 per cent); mallard (7.1 per cent); black duck (6.4 per cent); and ringneck (5.6 per cent). It was present in lesser amounts in gadwall and wood duck.

CONCLUSIONS

Effect of Herbicide

The granular silvex was fairly selective. Besides alligatorweed, squarestem spikerush was the only species completely eliminated. The silvex treatments reduced the abundance of broadleaf arrowhead permanently and that of annual spikerush temporarily. Recovery of squarestem spikerush had begun by 1964. Control of alligatorweed was still good, with a limited amount of encroachment from outside the plots.

Effect of Elimination of Alligatorweed

Wild millet, common jointgrass, and bull paspalum increased significantly the year of treatment.

Cyperus and annual spikerush reached maximum abundance the year after treatment.

Maidencane spread rapidly during the second year, and a little more the third year.

Swamp smartweed reached its maximum in the second year after treatment.

Southern cutgrass and Hydrochloa reached their maximum abundance in the third year after treatment.

Buttonbush increased gradually each year.

Effect of Fall 1961 Discing

Discing was very beneficial to bull paspalum and wild millet the year after treatment. Bull paspalum was found in 11 of 19 undisced, treated plots, but was common in only 1. It was in all eight disced plots and was common to abundant in four. Millet was in 18 of 19 undisced, treaeted plots, but was common in only 2. It was in all eight disced plots and was abundant in two and common in two. Discing caused a temporary setback in the spread of maidencane.

Importance as Food for Ducks

Five of the 12 plant species were important food items for ducks. In order of importance, they were: Southern cutgrass (12 per cent of total volume); Hydrochloa (10 per cent); buttonbush (nearly 6 per cent); annual spikerush (nearly 4 per cent); and swamp smartweed (3.7 per cent). Squarestem spikerush was important to pintail and mallard, and cyperus was important to black duck and green-winged teal.

DISCUSSION

Investigation of the importance of these 12 plant species as food for waterfowl shows the need for local studies. Martin and Uhler (1939) stated that southern cutgrass was of little value. Buttonbush was of low value in the Atlantic Flyway, although used extensively in the southern Mississippi Flyway. They found only occasional use of annual spikerush. Hydrochloa was not mentioned. At the time of their study, Lake Marion did not exist and most South Carolina duck stomachs were from the coastal region.

As so often happens when attempting to manipulate waterfowl habitat, especially in the Southeast, alligatorweed control provided mixed blessings. Valuable waterfowl food plants, such as cyperus and

Table 1. Changes in plant composition on 27 treated alligatorweed plots.[1]

Observation	Arrowhead				Cutgrass				Hydrochloa				Jointgrass				Bull Paspalum				Maidencane			
Time	R	U	C	A	R	U	C	A	R	U	C	A	R	U	C	A	R	U	C	A	R	U	C	A
Prior to treatment	3	11	10	3	7	0	0	0	2	1	0	0	7	1	0	0	0	1	0	0	17	1	0	0
September 1961	16	2	0	0	7	0	0	0	6	2	0	0	7	8	1	0	14	3	1	0	17	5	0	0
June 1962	18	6	0	0	4	0	0	0	11	2	0	0	2	7	8	0	6	8	3	1	11	10	1	0
September 1963	5	6	0	0	3	2	1	0	2	1	0	0	3	3	8	1	1	2	1	0	5	10	6	4
June 1964	12	5	0	0	3	7	1	0	6	8	3	0	—	—	—	—	—	—	—	—	1	13	7	5

	Millet				Cyperus				Squarestem Spikerush				Annual Spikerush				Swamp Smartweed				Buttonbush			
Prior to treatment	4	0	0	0	0	0	0	0	4	3	2	1	13	3	0	0	26	1	0	0	10	1	0	0
September 1961	16	3	0	0	8	1	0	0	0	0	0	0	7	0	0	0	18	2	0	0	12	1	0	0
June 1962	10	8	4	2	11	7	1	0	1	0	0	0	1	16	9	0	21	1	0	0	10	1	0	0
September 1963	11	6	0	0	4	2	0	0	5	0	0	0	4	7	1	0	16	7	3	0	9	2	0	0
June 1964	—	—	—	—	—	—	—	—	10	2	0	0	—	—	—	—	10	11	3	0	12	3	0	0

[1] Includes eight disced plots. Figures in the body of the table indicate the number of plots in the indicated categories: R = rare; U = uncommon; C = common; A = abundant.

annual spikerush, increased temporarily. Hydrochloa and southern cutgrass did not materially increase until 3 years following control. By that time maidencane had become the dominant plant. During the normal summer drawdown, much of the shallow-growing alligatorweed became dormant. This allowed growth of many annuals, such as bull paspalum, fall panicgrass, wild millet, annual spikerush, and cyperus. It is very difficult for any plants of value to waterfowl to compete with dense stands of maidencane. It appeared that over a period of several years the benefits to waterfowl of alligatorweed control were outweighed by increased abundance of maidencane.

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WATERFOWL HUNTING ACTIVITIES AND HARVEST IN THE TISHOMINGO NATIONAL WILDLIFE REFUGE, OKLAHOMA, 1960-1963

By

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ABSTRACT

From 1960 to 1963 hunter activity was regulated in a 3,160-acre hunting unit of the Tishomingo National Waterfowl Refuge on perime-

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