TECHNICAL GAME SESSION

AERIAL TREATMENT OF PEST PLANTS WITH HERBICIDES ON NATIONAL WILDLIFE REFUGES IN THE SOUTHEAST

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The history of impounding fresh water for wintering waterfowl on Fish and Wildlife Service Refuges in coastal areas of the Southeast nearly always involves the control of unwanted plants. Many of these impoundments were made by diking areas of salt marshes in cord-grass (*Spartina* spp.) or needlerush *(Juncus roemerianus)*. Rainfall, artesian wells, the combination of these two factors, and sometimes diversion of fresh water from streams or rivers were utilized in changing water qualities from high salinity to various degrees of freshness.

Usually, water depths in these impoundments range from 1.5 to 3.0 feet Under such conditions plant succession is rapid. Such desirable waterfowl food plants as widgeon-grass *(Ruppia maritima)*, sago pondweed *(Potamogeton pectinatus)*, southern naiad *(Najas quadalupensis)*, wild celery *(Vallisneria americana)*, and musk-grass *(Chara)* are part of the plant succession, but frequently after passing through this stage, the succession becomes static in solid cattail coverage, with a greatly reduced holding capacity for waterfowl.

Other impoundments have been constructed by diking tidal fresh water marshes originally in giant cut-grass *(Zizaniopsis miliacea)* or maidencane *(Panicum hemitomon)*. Watershield (Brasenia, *Najas quadalupensis,* and *Chara,* desirable waterfowl foods, are associated with these impoundments, but there are a host of undesirable and aggressive plant competitors. Some of these are alligatorweed *(Alternanthera philoxeroides)*, water primrose *(Jussiaea grandiflora, J. diffusa)*, white waterlily *(Nymphaea odorata)*, spatterdock *(Nuphar advena)*, pickerelweed *(Pontederia cordata)*, water hyacinth *(Eichornia crassipes)*, and water lotus *(Nelumbo pentapetala)*. There is always a tendency for *Zizaniopsis miliacea* and *Panicum hemitomon* to reinvade under water drawdowns.

In a few impoundments management entails dewatering, planting a row or broadcast crop of grain, and flooding in the fall for waterfowl benefits. Under these conditions *Sesbania macrocarpa* and *Melochia corchorifolia* may be added to the list of pest plants already mentioned.

Fringes of natural water areas and intermittently exposed areas in diked impoundments are subject to the encroachment of such woody plants as *Salix* spp., *Baccharis halimifolia, Myrica cerifera, Cephalanthus occidentalis,* and *Borrichia frutescens.*

The relatively new field of organic herbicides has already shown promise in solving some of the problems of pest plant invasion as exemplified by the rather spectacular success in controlling water hyacinth, water lotus, needlerush, and cattail. There is every indication future developments in this field will bring improved control techniques over a wider range of plants.

Because of large acreages involved, the difficulty of using surface equipment on water-logged and shallow flooded soils, the Bureau has emphasized low volume aerial applications in preference to high volume ground or boat applications. This paper deals exclusively with low volume aerial applications and attempts to summarize the results of herbicides applied by aircraft to several pest plants.

Typha spp.

Without counting repeat treatments, approximately 1,600 acres of cattail have been treated in Region 4 with herbicides applied by aircraft from 1948 through 1959. Treatments have been on the basis of both investigations and operations. Of the total acreage covered, 1,157 acres have received multiple

treatments with the isopropyl ester of 2,4-D, 320 acres have received single and split treatments of dalapon, 95 acres have received single and split treatments of amitrol, and 42 acres have received a single treatment of amitrol and dalapon combined.

Treatments with 2,4-D

Because dalapon and amitrol are relatively recent herbicides, the largest acreage of cattail has been treated with 2,4-D. 2,4-D rates have ranged from 3.34 to 5.00 lbs. acid-equivalent per acre of the isopropyl ester per treatment. Number 2 diesel oil has been used as a diluent and volume applied most consistently with the best results has been five gallons per acre. Usually, three treatments spaced a month apart have been applied per season. In some cases two additional treatments in the following season have been necessary. The first treatment was usually applied in the initial stages of cattail heading.

The largest acreage receiving multiple 2,4-D treatments have been located on St. Marks National Wildlife Refuge in north Florida, and on Blackbeard Island National Wildlife Refuge in Georgia. A limited amount of acreage has been treated in South and North Carolina.

Results have been variable with kills ranging from 55 to 99 percent. An average kill for all 2,4-D treatments would approximate 80 percent. In nearly all cases the most successful results have been on areas covered with at least 18 inches of water. On these areas cattail regrowth was retarded and such desirable plant species as *Najas quadalupensis, Vallisneria americana, Potamogeton pectinatus,* and *Chara* spp. appeared. Quite spectacular, but with benefits of less duration, wild millet in dense stands have invaded dewatered areas for two or three seasons following treatment. Eventually, on these areas cattail regrowth or another pest plant replaced the millet. *T. domingensis* and *T. latifolia* appear to be more susceptible to 2,4-D treatments than *T. angustifolia* or *T. glauca.*

Treatments with Dalapon

Initial work with dalapon applications to cattail was started in 1955 and it is still in progress. To date, approximately 320 acres have been treated with single and split applications. These treatments have been located in Virginia, North Carolina, South Carolina, and Florida.

Thus far investigations have shown either rates of 20 lbs. acid-equivalent of dalapon per acre in a single treatment or an initial treatment at a rate of 10 lbs. acid-equivalent per acre followed a month later by a five lbs. acid-equivalent rate will normally yield a kill of 80 to 99 percent. There is little difference in final kill between the two methods of treatments. There appears to be less variation in results from different areas with dalapon applications than is the case with 2,4-D application, especially when *T. angustifolia* and *T. glauca* are present. In a few areas it has been necessary to repeat treatments a year after the initial treatment.

Volumes applied per acre in aerial applications of dalapon have proved unimportant so long as they contained the necessary total pounds of acid-equivalent. Preference, however, has been given to eight gallons per acre volumes in both the single and split treatments since there appears to be less corrosion of equipment than with the lower volumes and higher concentrations. Also, preference has been given to the split treatments because they are cheaper in material cost, there is less damage to some of the desirable waterfowl foods, and corrosion of equipment using the lower concentrations is less. Volumes much over eight gallons per acre are uneconomical to apply.

Timing of treatments with dalapon for cattail control seems less critical than with 2,4-D. Effective treatments have been made in May, June and July.

Treatments with Amitrol and Combinations of Amitrol and Dalapon

The first application of amitrol to cattail was made in 1958 on Mattamuskeet National Wildlife Refuge in North Carolina. To date, this is the only location amitrol or combinations of amitrol and dalapon has been applied. Approximately 95 acres have received single and split treatments of amitrol and amitrol-T.

Approximately 42 acres have received a combination of dalapon with amitrol or amitrol-T.

Both amitrol alone and combinations of dalapon and amitrol are effective in controlling cattail and they appear to be extremely promising. Kills appear comparable to dalapon treatments and, in some cases, they may exceed dalapon treatments. To date, the most effective rate in using amitrol alone has been 10 lbs. active ingredients per acre or six lbs. active ingredients per acre of amitrol-T. A split treatment of three followed by two lbs. active ingredients per acre gave a higher kill than a single five lbs. per acre rate. Five pounds acid-equivalent per acre of dalapon plus three lbs. active ingredients per acre of amitrol in a single treatment has yielded good results.

Sesbania macrocarpa

From 1952 through 1959 approximately 835 acres of this plant have been treated in such crops as rice, millet, and corn. All of the treatments have been post-emergence in nature.

In rice a rate of one lb. acid-equivalent per acre of alkanalamine 2,4-D in water has yielded almost 100 percent control of *Sesbania* without significant reduction in crop yields or quality. A volume of two gallons per acre was used and the treatments were made at the time rice had reached a height of six to eight inches.

In Japanese, brown-top, and wild millets rates of one to 1.67 lbs. acid-equivalent of either the alkanalamine or ester form of 2,4-D have been used successfully, when the millet reached heights of four to six inches. Volumes per acre have been varied from two to four gallons without appreciable differences in results.

Treating corn at a height of two feet, prior to the tasseling stage of growth with .96 lbs. acid-equivalent per acre of an aqueous solution of alkanalamine 2,4-D in a volume of two gallons per acre failed to injure the crop and yielded excellent control of *Sesbania*.

All of the treatments in crops for *Sesbania* control were made on Savannah National Wildlife Refuge in South Carolina.

Nelumbo pentapetala

At rates ranging from two to three lbs. acid-equivalent per acre of the isopropyl ester of 2,4-D in diesel oil or the aqueous solution of the alkanalamine formulation, approximately 810 acres of this plant have been treated from 1949 through 1959. Treatments have been made on Lacassine and Sabine National Wildlife Refuges in Louisiana, Savannah National Wildlife Refuge in South Carolina, and Crab Orchard National Wildlife Refuge in Illinois.

In all of the treatments except one, kills have ranged from 90 to 99 percent. In the one exception, heavy rainfall occurred immediately after applying an aqueous alkanalamine 2,4-D solution, and kills were reduced to 50 percent.

Volumes in the treatments have been varied from two to five gallons per acre without appreciable differences in results so long as proper rates were used. In Louisiana, *Limnobium spongia* and *Brasenia* invaded areas treated.

Treatments have been timed to catch the plant between emergence and the full bloom stage of growth. Treatments later than this have shown the plant to be resistant and in earlier treatments some plants invariably are still under water and escape spray contact. In Louisiana, the most successful treatments have been made in late June.

Raphanus spp.

In a cooperative farming program on Santee National Wildlife Refuge in South Carolina, heavy infestations of wild mustard in oats prevented good yields and marketing of certified seed. From 1952 through 1954 approximately 658 acres of this crop were given post-emergence treatments with an aqueous solution of 2,4-D alkanalamine at a rate of one lb. acid-equivalent per acre. Total volume applied was two gallons per acre. Treatments were made in late March, when the oats had reached a height of four to six inches.

As a result of these treatments the cooperator was able to market certified seed and wild mustard was practically eliminated from many fields.

Alternanthera philoxeroides

Although approximately 555 acres of this plant have been treated at various rates of isopropyl ester of 2,4-D in diesel oil and the alkanalamine formulation in water, treatments have failed to yield more than surface kills, with abundant regrowth of the plant following a month after treatment. 2,4-D rates were varied from two to eight lbs. acid-equivalent per acre.

These treatments were made on Sabine and Lacassine National Wildlife Refuges in Louisiana, and Savannah National Wildlife Refuge in South Carolina. Other than the use of diesel oil, two different hydrocarbon solvents, and a clorinated solvent have been tried as diluents with the ester of 2,4-D, but these also failed to improve root kills. As many as four 2,4-D treatments spaced a month apart in a growing season failed in securing root kills. Volumes of spray used in the treatments varied from two to 11 gallons per acre.

In 1958, 2,4-D in pellet form was applied experimentally to two acres of alligatorweed at a rate of 20 lbs. acid-equivalent per acre without obtaining appreciable kills.

In July, 1959, in cooperation with Dr. Donald E. Seaman of U. S. Department of Agriculture, ARS, approximately 12 acres of alligatorweed were treated experimentally with weighted emulsions of 2,4-D, xylene, and polychlorobenzene. This work involved a pre-treatment with 2,4-D applied at the rate of two lbs. acid-equivalent per acre in order to obtain a knockdown of plants. The treatment was followed a month later with the weighted emulsions at a rate of eight lbs. acid-equivalent of 2,4-D per acre with the emulsion adjusted by additions of xylene and polychlorobenzene to a specific gravity of 1.003. Volumes of eight and 16 gallons per acre were used in the experiments. This treatment also failed in securing root kills.

Juncus roemerianus

Approximately 518 acres of this plant on Chassahowitzka and St. Marks National Wildlife Refuges in Florida, and 10 acres on Back Bay National Wildlife Refuge in Virginia, have been treated with herbicides. With the exception of six acres treated experimentally with silvex, treatments have consisted of applying 16.7 acid-equivalent per acre of the isopropyl ester of 2,4-D. The commercial formulation containing 3.34 lbs. acid-equivalent per gallon was not diluted and a volume of five gallons per acre was applied.

Results with this type of treatment from 1954 through the current season indicate it is possible to obtain 95 to 99 percent kills in a single treatment. Generally, slightly higher kills are obtained on areas burnt in the fall prior to treatment. In Florida, treatments have been made around April 1, and in Virginia the single treatment was made on May 12. Small scale plot applications in Florida have indicated treatments after mid-April have not been effective. Burning within six months after treatments in Florida has reduced kills.

In all of the Florida treatments *Distichlis spicata* has been the principal plant replacement. Traces of *Scirpus* spp., *Fimbristylis castanea,* and *Eleocharis* spp. have appeared on one 80-acre area treated at Chassahowitzka Refuge. In areas having a light sprinkling of *Distichlis* at Chassahowitzka Refuge, April treatments have yielded almost complete stands of pure *Distichlis* by October of the same year.

The re-invasion rate of needlerush has been slow at both Chassahowitzka and St. Marks Refuges. Some of the areas converted from needlerush to *Distichlis* have shown less than 5 percent re-invasion of needlerush over a three-year period. When needlerush re-invasion in the treated areas exceed 15 percent, the areas have been retreated without serious damage to *Distichlis* and there has been almost complete control of needlerush.

Composition of the 10-acre area treated on Back Ray Refuge in 1958 at the time of treatment was as follows: *Juncus roemerianus,* 60%; *Spartina alterniflora,* 15%; *Distichlis spicata,* 15%; *Spartina patens,* 10%; and a trace of *Typha latifolia.*

By the following fall, estimated kill of needlerush was 95 percent, with the following changes in plant composition: *Juncus roemerianus,* 5%; *Spartina alterniflora,* 45%; *Distichlis spicata,* 30%; and *Spartina patens,* 20%.

Experimental work in applying silvex at economical rates to needlerush has not yielded effective results.

Eichornia crassipes

Approximately 282 acres of this plant have been treated at rates from 2 to 4 lbs. acid-equivalent per acre of 2, 4-D on Lacassine National Wildlife Refuge from 1948 through the current season. Both the isopropyl ester in diesel oil and alkanalamine formulations in water have been used with similar results, excepting the ester formulation in diesel oil has proved superior where precipitation has occurred immediately after treatment.

Where hyacinth are growing in the open, 90 to 99 percent kills have been obtained in single treatments. Reduced kills of 40 to 60 percent, however, have occurred on hyacinth growing under overtopping species of sawgrass, maidencane, and buttonbush. Usually, a ground mop-up operation following aerial application is necessary to obtain 100 percent kills on both types of areas.

Jussiaea grandiflora

From 1949 through 1954, approximately 181 acres of this plant were treated with the isopropyl ester of 2, 4-D in single and multiple treatments on Savannah National Wildlife Refuge in South Carolina. Rates were varied from 2 to 3.34 lbs. acid-equivalent per acre. Both diesel oil and water were used as diluents, with volumes ranging from 2 to 4 gallons per acre.

Although high surface kills were achieved in these treatments, approximately 25 percent regrowth occurred in the growing season of treatment and slight reduction of this plant could be found in the following growing season.

Nymphaea odorata

Approximately 173 acres of this plant have been treated with the isopropyl ester of 2, 4-D in diesel oil with variable results. Treatments have been made on Loxahatchee and St. Marks National Wildlife Refuges in Florida, Savannah National Wildlife Refuge in South Carolina, and Lacassine National Wildlife Refuge in Louisiana.

In 1949 three treatments spaced a month apart on St. Marks Refuge failed to secure root kills, although 95 percent surface kills resulted. Treatments were made at a rate of 3.34 lbs. acid-equivalent per acre and the initial treatment was made on May 10. In 1950, a single treatment on St. Marks Refuge at the rate of 3.34 lbs. acid-equivalent per acre yielded 99 percent root kills, with dead rootstocks floating to the surface. This treatment was timed approximately two weeks earlier than the treatment in 1949. Various timing of treatments on Savannah and Loxahatchee Refuges, however, failed to give satisfactory root kills.

On Lacassine Refuge in Louisiana, areas occupied by mixtures of white waterlily and *Brasenia* have been converted to 100 percent stands of *Brasenia* by applying 2, 4-D at a rate of 2 lbs. acid-equivalent per acre. It appears *Brasenia* has a faster rate of regrowth than white waterlily and it will take over areas occupied by this plant after surface kills. Areas treated in this manner have maintained *Brasenia* in dominance for two or more years.

Sagittaria lancifolia

Approximately 164 acres of this plant have been treated with the isopropyl ester of 2, 4-D at rates of 2.8 to 4.7 lbs. acid-equivalent per acre. Volumes used ranged from 3 to 4 gallons per acre and dilution was with diesel oil. About half the treated acreage was on St. Marks National Wildlife Refuge in Florida and half on Lacassine National Wildlife Refuge in Louisiana. Treatments were made in 1949, 1950, 1951, and 1955.

Best results in both Florida and Louisiana were obtained with early May treatments at rates of 3.34 lbs. acid-equivalent per acre or above. In the early May treatments, kills averaged 90 to 99 percent. A mid-August treatment in Louisiana yielded only a 40 percent kill.

Brasenia invaded areas killed in Louisiana and *Chara, Najas quadalupensis, Vallisneria americana,* and *Potamogeton pectinatus* were invading species in Florida.

Panicum hemitomon

A total of 32 acres of this plant has been treated experimentally with dalapon on Savannah and Santee National Wildlife Refuges in South Carolina. Treatments were made in areas flooded intermittently with water depths of 2 or 3 inches and in areas covered with 15 inches of water, without fluctuation.

In 1956, a 10-acre area flooded intermittently with water depths of 2 or 3 inches maidencane was burnt in February prior to treatment. Treatment was made on April 24 at a rate of 20 lbs. acid-equivalent per acre of dalapon. A volume of 11 gallons per acre was used.

A 90 percent overall kill resulted, with almost a complete kill on more than half of the area. Bald rush *(Psilocarya nitens)* and Chocolate weed *(Melochia corchorifolia)* invaded the area in dense stands. No regrowth occurred, and the area was plowed the following spring.

In 1957 and 1958 four 3-acre plots of maidencane growing in water depths of approximately 15 inches were treated with dalapon at rates of 10 and 20 lbs. acid-equivalent per acre. One plot was treated with a split treatment at a rate of 10 lbs. followed in one month by 5 lbs. acid-equivalent per acre. Volumes used in the treatments were 8 gallons per acre. All single treatments were made around May 1, with the split treatments being made on May 1 and June 1.

Results in all plots but one indicated kills higher than 90 percent. The one exception was a 3-acre plot located in water of extreme turbidity and treated at a rate of 20 lbs. acid-equivalent per acre. In this plot maidencane was stunted at the time of treatment to the point of being only about one-half the height of maidencane in the other plots. Kill was negligible.

In 1959 one 10-acre plot of maidencane was treated in water depths of 10 to 24 inches on Santee Refuge with a rate of 20 lbs. acid-equivalent per acre of dalapon. Treatment dates and methods of treatment were identical with the other maidencane treatments. To date, kill in this plot does not appear encouraging.

Natural plant succession in these plots after treatment has not been of sufficient value to waterfowl to warrant the expense of treatment, although in some of the plots not more than 5 percent regrowth of maidencane has occurred in two years following treatment.

Melochia corchorifolia

Chocolate weed sometimes is a serious competitor to brown-top millet and cowpeas on Savannah National Wildlife Refuge in South Carolina. In 1952 ten acres of brown-top and ten acres of cowpeas were treated experimentally with the alkanalamine salt of 2, 4-D in an attempt to control this weed and improve crop production. The treatment of the brown-top was made on July 17 after it had reached a height of 4 to 6 inches. A rate of 1.67 lbs. acid-equivalent per acre was applied in a volume of 4 gallons. Water was used as a diluent. Results indicated 100 percent control of the chocolate weed with little or no damage to the brown-top.

The cowpeas were treated at the same time with an identical application rate. This was a pre-emergence treatment with the application being made after the cowpeas had been planted, but before their emergence. Results indicated the chocolate weed was controlled effectively, but cowpeas after emergence showed typical 2, 4-D symptoms and a reduced yield.

Nuphar advena

Approximately 20 acres of this plant were treated in 1953 on Loxahatchee National Wildlife Refuge in Florida. Treatment was made in early July at a rate of 3.34 lbs. acid-equivalent of the isopropyl ester of 2, 4-D per acre. The 2, 4-D was diluted with diesel oil and applied in a volume of 4 gallons per acre. No kill resulted from the treatment.

Zizaniopsis miliacea

A total of 15 acres of this plant has been treated experimentally with multiple treatments of dalapon and combinations of dalapon and amitrol. The 15 acres were divided into 3-acre plots and each plot was treated separately. The multiple dalapon treatments, spaced approximately two weeks apart, ranged in rates from 1.85 to 10 lbs. acid-equivalent per acre per treatment. Volumes used in all treatments were 8 gallons per acre. The cut-grass was subject to tidal action, with a soft, moist condition prevailing at low tides and one to two feet of water coverage at high tides. The five different treatments follow:

Plot No. 1: Treated at the rate of 10 lbs. acid-equivalent per acre per treatment of dalapon. Three treatments in 1957, beginning June 13 and three treatments in 1958, beginning May 28.

Plot No. 2: Treated at the rate of 10 lbs. acid-equivalent per acre per treatment of dalapon. Five treatments in 1957, beginning June 13.

Plot No. 3: Treated at the rate of 10 lbs. acid-equivalent per acre of dalapon plus 5 lbs. active ingredients per acre of amitrol per treatment. Four treatments in 1958, beginning May 28.

Plot No. 4: Treated at the rate of 1.85 lbs. acid-equivalent per acre per treatment of dalapon. Four treatments in 1959, beginning June 9.

Plot No. 5: Treated at the rate of 3.70 lbs. acid-equivalent per acre per treatment of dalapon. Four treatments in 1959, beginning June 9.

None of these treatments yielded successful results. The 10 lbs. acid-equivalent per acre of dalapon in five treatments in one growing season gave the best results with an estimated kill of 90 percent in the spring following treatment. Regrowth of cut-grass quickly nullified this kill and by mid-summer the plot had regained a solid stand of cut-grass.

Jussiaea diffusa

In contrast to poor results experienced in treating *Jussiaea grandiflora*, *Jussiaea diffusa* appears to be quite susceptible to 2, 4-D. Results from treatment of 10 acres on Lacassine National Wildlife Refuge in Louisiana with 3 lbs. acid-equivalent per acre of the alkanalamine salt of 2, 4-D was a 100 percent kill. Volume used in the application was 2 gallons per acre. Part of the 10 acres was treated on May 25 and the remaining acres were treated on August 19. It appears the plant is susceptible throughout the summer months as well as in mid-spring. The plant was growing in shallow water at the time of treatment.

Salix spp.

From 1948 through 1953 approximately 1,410 acres of willow were treated with various 2, 4-D applications. Species involved were either *Salix nigra*, *S. caroliniana* or mixtures of these two species. Of the total acreage treated, 800 acres were successful with 95 percent or higher root kills, but treatment of the remaining 610 acres resulted in complete failure. Treatments were made on Loxahatchee and St. Marks National Wildlife Refuges in Florida, Tennessee National Wildlife Refuge in Tennessee, and Tishomingo National Wildlife Refuge in Oklahoma. The willow in all of these areas was growing on what could be considered normally moist sites subject to frequent inundations.

None of the treatments were successful on willow with average heights of 15 feet or higher or on sites where surface water was present at the time of treatment or shortly after treatment. The only successful treatments were on St. Marks Refuge and one operation on Tishomingo Refuge.

In 1950, 1951, and 1952 a total of 500 acres of a mixture of *S. nigra* and *S. caroliniana* were treated on St. Marks Refuge. The willow was growing within a diked impoundment, but at the time of treatment and throughout the summer months the area was relatively dry. The willow averaged approximately 6 to 10 feet in height and the growth ranged from medium dense to scattered patches. The isopropyl ester of 2, 4-D was applied at the rate of 3.34 lbs. acid-equivalent per acre. A volume of 3 gallons per acre was used per treatment. Two treatments—one made in late April and the other in early June, resulted in root kills of 95 percent or higher.

In 1949, 500 acres of *Salix nigra* were treated on Tishomingo Refuge. Three hundred acres consisted of willow approximately 12 feet in height growing in dense stands on a river delta. The remaining 200 acres were located at a slightly higher elevation and contained stands of older willow ranging in height from 25 to 30 feet. Both areas were treated in July with the isopropyl ester of 2, 4-D at a rate of 3.34 lbs. acid-equivalent per acre. Both areas were relatively dry at the time of treatment and remained dry throughout the balance of the summer. Results on the young willow on 300 acres were root kills of 95 percent or higher. Results of the single treatment on the older willow, however, were little more than leaf defoliation with slight or no root kills.

In 1950 an additional 300 acres adjacent to and identical with the 300 acres of young willow treated in 1949 received a single treatment on April 6 at a rate and volume of application similar to treatment in 1949. Approximately three weeks after treatment flood water enveloped the area and the water level remained high through the remainder of the spring, summer, and fall. No kill resulted from the treatment.

In 1951 and 1952, 220 acres of *Salix nigra* with an average height of 15 feet received the following treatments on Tennessee Refuge: On May 18, 1951, 3.34 lbs. acid-equivalent per acre of the isopropyl ester of 2,4-D was applied in a volume of 3 gallons per acre; the area was retreated at the same rate and volume on September 29, 1951, and May 6, 1952. On October 2, 1952, one-half of the area was retreated at the same rate and volume and the other half was retreated with a mixture of 2 lbs. acid-equivalent per acre of the butyl ester of 2, 4-D and 2 lbs. acid-equivalent per acre of the butyl ester of 2, 4, 5-T. The final results of all of these treatments were little or no root kill. Although the area was in one of TVA dewatering projects, some surface water was present at the time of treatments and throughout the summer months.

The uncertainty in results of treating these two species finally led the Service into abandonment of treatment on other areas. It should be kept in mind these treatments were all low volume aerial applications since improved kills are usually obtained on woody species with high volume ground spraying.

Mixtures of Salix spp. and Myrica cerifera

From 1952 through 1956 approximately 658 acres of a mixture of *Salix caroliniana* and *Myrica cerifera* were treated with various herbicides on Mattamuskeet National Wildlife Refuge in North Carolina without complete satisfactory results. Most of the treatments consisted of applying a combination of 1.67 lbs. acid-equivalent per acre of 2, 4-D isopropyl ester and 1.67 lbs. acid-equivalent per acre of 2, 4, 5-T isopropyl ester in a volume of 4 gallons per acre. Diesel oil was used as a diluent. Willow averaged approximately 15 to 20 feet in height and the myrtle about 6 feet. Three treatments, one in early spring followed by a fall treatment and another early spring treatment failed to yield more than 70 percent kills. A single treatment in July at the same rate yielded approximately the same percentage kill. Another July treatment using 5.0 lbs. acid-equivalent per acre of both esters failed to improve root kills.

Investigational treatments with silvex and 2, 3, 6-trichlorobenzoic acid did not increase root kills.

Mixtures of Salix nigra and Baccharis halimifolia

Approximately 100 acres of a mixture of *Salix nigra* and *Baccharis halimifolia* growing on dikes at Lacassine and Sabine National Wildlife Refuges in Louisiana were treated in 1954 and 1955. At the time of treatment the willow ranged in height from 15 to 25 feet and the *Baccharis* averaged four to five feet. A single treatment in late June at the rate of 5 lbs. acid-equivalent per acre of the isopropyl ester of 2, 4-D in diesel oil failed to obtain root kills on either species. A volume of 5 gallons per acre was used. Three treatments at the rate of 6.54 lbs. acid-equivalent per acre per treatment yielded 95 percent kill of willow and 90 percent kill of *Baccharis*. The three treatments were spaced as follows: May 27 and July 21 in 1954, and May 18 in 1955. Treatments were spaced to keep the plants defoliated throughout a complete growing season.

In Florida small seedlings of *Baccharis* were readily killed by a single 2, 4-D treatment at the rate of 3 lbs. acid-equivalent per acre.

Borrichia frutescens

Sea oxeye, *Borrichia frutescens*, a woody plant of negligible value to waterfowl, encroached on Bulls Island National Wildlife Refuge in South Carolina as a result of drought conditions which exposed all "flats" in an impoundment. At the time little was known relative to the control of this plant or its susceptibilities to herbicides. In 1956, 21 acres were divided into three 7-acre plots and each plot received the following treatment:

Plot No. 1: One treatment on May 15 with the isopropyl ester of 2, 4-D applied at a rate of 5 lbs. acid-equivalent per acre. The 2, 4-D was diluted with diesel oil and a volume of 5 gallons per acre was used.

Plot No. 2: Two treatments, the first being applied May 15 and the second June 19. Both treatments used rates and volumes identical with the application in Plot No. 1.

Plot No. 3: One treatment on June 19 at the same rate and volume as the other applications.

The sea oxeye was growing on soils of a high salinity due to previous flooding with salt water. No surface water was present at the time of either treatment.

The plant was in a full-leaf stage of development at the time of the May treatment, but had not begun to flower. In the June treatment the plant was in the very initial stages of flowering. Average height of the plant at the time of both treatments was approximately 3 feet.

Final results indicated little differences between Plots No. 1 and 2 where 95 percent root kills were in evidence. The final kill in Plot No. 3 was estimated at 75 percent, indicating the mid-May treatment was the most successful. It may be possible lower rates of 2, 4-D could accomplish similar kills. Giant foxtail invaded the area after treatment.

Acknowledgement for much of the field information in this report is made to the following personnel of the U. S. Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife: Biologist, Royston R. Rudolph; Refuge Manager, Carl Yelverton; and Assistant Refuge Manager, Enos O. Mellinger.

THE OTTER IN NORTH CAROLINA

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ACKNOWLEDGMENTS

The writer is grateful to Frank B. Barick, Chief, Game Division, and T. Stuart Critcher, Federal Aid Coordinator, for the editing and other help received in writing this paper.

ABSTRACT

The fall-winter foods of otters living along the coast are largely fish—principally carp, catfish, suckers, and sunfish. The otters' diet at other seasons of the year is largely comprised of fish, blue crab, and crayfish. Other foods, all taken in small quantities, are shrimp, clam, water beetles, decapod, muskrat, rails, and waterfowl.

An examination of 53 female otters from northeastern counties over a 12-winter period (1947-48—1958-59) showed that breeding starts during January and continues into February and possibly into March.

Of eight gravid otters in a study sample of 53, five contained three embryos, two contained two, and one contained four embryos. This is an average of 2.88 embryos per female.

Sex data obtained on 273 otters showed 149 (55%) males and 124 (45%) females. This is 120 males for every 100 females.