JOURNAL OF THE TENNESSEE ACADEMY OF SCIENCE
VOLUME 38, NUMBER 1, JANUARY, 1963

AN EVALUATION OF THE AQUATIC PEST PLANT CONTROL PROGRAM AT REELFOOT LAKE

JAMES H. BURBANK
Wetlands Biologist
Tennessee Game and Fish Commission

Reelfoot Lake, located in the northwest corner of Tennessee and extending slightly into neighboring Kentucky has long been recognized as one of the famous meccas of waterfowl and waterfowling in the South. And, it has been equally classed as one of the finest lakes for bass, bream, and crappie fishing anywhere.

The lake is owned by the citizens of Tennessee and has been supervised by the Game and Fish Commission since 1941. In August of that year, the upper one-third of Reelfoot was leased to form the Reelfoot National Wildlife Refuge.

In the early 1940's there came to the attention of the biologists managing Reelfoot Lake, a problem of unknown but potentially serious possibilities. Certain aquatic plants were becoming well established and propagating to the extent that they feared much of the open water would be claimed by these pest plants. Reelfoot Lake is, uniquely, a very large but shallow lake, averaging only about three to four feet in depth. Consequently, adverse encroachment by certain floating-leaved and emergent aquatics was quite possible.

Three particularly obnoxious aquatic pest plants were, and still are, found on Reelfoot Lake: giant cutgrass (*Zizaniopsis miliacea*), mulefoot (*Nuphar advena*), and lotus (*Nelumbo lutea*). In 1942, Eyles estimated some 1,900 acres of cutgrass and 1,400 acres of mulefoot claiming a portion of the 27,713 acres of swamp, woods, marsh, and open water comprising Reelfoot Lake. Although lotus was undoubtedly present in 1942 no acreage estimates are given for it until 1945 when over 1,000 acres were estimated by Steenis (1945). In 1955, Charles Rawles estimated over 2,000 acres of cutgrass existing on Reelfoot Lake.

Using October, 1960, aerial photos of Reelfoot Lake I planimetered a total of 2,453 acres cutgrass, 384 acres lotus in deep water, and 1,671 acres mulefoot present on the lake. An undetermined acreage of lotus was probably scattered within the dense beds of mulefoot, but the tendency for mulefoot to attain specific purity by crowding out other species leads me to suspect that not over 50 acres of lotus collectively would be found growing within the mulefoot beds.

RESULTS FROM PREVIOUS STUDIES

When employed as wildlife biologist for the Fish and Wildlife Service in the early 1940's, John Steenis prepared various reports concerning the aquatic pest plant situation on Reelfoot Lake. The writer was unable to obtain copies of these reports. His publications in the *Journal of Tennessee Academy of Science* deal only with the fact that there were aquatics that had become a problem on Re- foot Lake. No detailed corrective measures w included, except that herbicidal treatment sho be considered.

In 1950, PR Project W-19-D was created a included experimental research using herbicides an attempt to ascertain an economically feasible a biologically sound method of controlling cutgr Mr. Charles Rawles, State Game and Fish Comm sion, was assigned this problem. The project later incorporated in PR Project W-22-R and c tinued for four years.

Briefly, after testing many chemicals and com nations of chemicals, Mr. Rawles concluded: control cutgrass in aquatic situations (wherein rootstalks and portions of leaves were submerg Polybor-chlorate 88 (Chapman Chemical Co., M phis) would give the best results biologically a economically speaking if used at a concentrati of not less than three-fourths pound per gallon water – preferably one pound per gallon. In m soil situations he concluded that best control wo be afforded using Polybor-chlorate at not less th one pound – preferably one and one-half pou – per gallon of water; or 2-4-5-T at two ounces gallon; or Dalapon (Dowpon) at four ounces gallon.

He stipulated further that all applicati should be made on warm, sunny days with little no wind, and with reasonable assurance that least three hours of sunshine would remain follo ing application. He determined that the best ti of year for cutgrass control by herbicidal treatm on Reelfoot Lake was between August 10 a September 25 (after the peak of anthesis in c grass).

Once the proper chemical had been determin he suggested that the lake be drawn down 1.2 at the proper time in order to expose rootsta after the peak of anthesis and aerial methods application be employed.

THE CONTROL PROGRAM

The herbicidal treatment program was beg in 1948, spraying lotus in Lost Pond, Joe Ba Nix Field, and Brewer's Bar, and spraying cutgr in Nix Field, First Pocket, and Brewer's B Each year following 1948, all previously trea areas were checked and sprayed again as needed.

In 1949, lotus control continued in Lost Po and progressed into Forked Pond. The areas cover the year previous were again sprayed to curb b lotus and cutgrass.

In 1950 and 1951 control work progressed i Upper Blue Basin, particularly to reduce the de

beds of lotus growing there. This area and all previously treated areas were sprayed extensively in 1952 and 1953.

By 1954, lotus control work commenced in Kirby Pocket and along the Palestine Stumps. Cutgrass control was begun along Walnut Gap, Rat Island Shore, and Rat Island Stumps.

Essentially the same areas were treated in 1955, and some lotus and cutgrass control was begun in Starve Pond. In 1956, lotus work progressed to Buzzard Slough, into Snaggy Basin, and up into the Glory Hole. Cutgrass control operations remained unchanged.

In 1957 lotus control was initiated along Rat Island Pocket and in East Ridge Arm. Cutgrass work commenced in Goose Pocket, along the periphery of Mud Bar and Willis' Drift, and within Grooms' Pocket.

In 1959, lotus control work was begun near Simon Pocket, and cutgrass was treated near the large cutgrass stand south of Snaggy Towhead. In 1960, two additional areas were sprayed for lotus: Tri Timber and the southern entrance to Blackjack Hollow.

Two other methods of cutgrass control were tried early in the investigative portion of the program but were soon disbanded. Prior to 1948 some effort was made to remove the cutgrass using an underwater mower, but the presence of numerous hidden stumps soon proved to be too damaging to the cutters. Later, burning of cutgrass was tried after it had browned off in the fall, but complete root kills were never obtained. Water levels were too high at the time of burning; therefore, the root systems escaped the killing flames.

Natural Factors of Control

During the summer of 1947 high water conditions resulting from a series of cloudbursts drowned out hundreds of acres of cutgrass and lotus. It was said then that the lake essentially was devoid of aquatic vegetative life. Both lotus and cutgrass were back in quantity the following year.

Again, in June, 1957, another series of cloudbursts inundated many acres of cutgrass and lotus but the effects were not as devastating as in 1947. There are some, today, who believe that Nature controlled more cutgrass and lotus than the control program could, or ever would. Nevertheless, with nearly 2,500 acres of cutgrass and 2,100 acres of mulefoot and lotus present as of October, 1960, aquatics control is still a problem on Reelfoot Lake.

A heavy infestation of the lotus petiole beetle was noted by Steenis in 1945. What effect this parasite or others such as it have had on the cutgrass, lotus, and mulefoot populations is a subject open for conjecture and study.

Winter kill of cutgrass due to freezing of the rootstalks may have also induced some natural control. Since no records, or mention, of this phenomenon have been provided, its effect can only be suggested.

The Control Program Evaluation

From a historical viewpoint, Reelfoot Lake is a relatively young body of water. Born from a series of earth tremors commencing on December 15, 1811, and leading up to the great quake of February 7, 1812, Reelfoot Lake is judged quite young, especially if compared with the pleistocene-aged Great Lakes of north-central United States.

Ecologically, however, Reelfoot Lake is dying of old age. Spurred by rapid deposition of sediments from the surrounding watershed, the lake is successionally progressing from open water — to rooted submergent growth — through rooted floating aquatics — to the emergent growth forms — thence to the moist soil, woody bottomland forms.

Essentially, the aquatic pest plant program is attempting to retard this natural successional trend — the "aging" of a lake — through vegetative reversals or set-backs. It is the hope of state and federal personnel involved that by removing such species as lotus, mulefoot, and cutgrass, other more important waterfowl foods, such as American or sago pondweeds, will be induced to fill in the area treated. Successful herbicidal treatment may encourage such succesional reversals.

Of course, there is absolutely no guarantee that once removed the acreage vacated will be utilized by desirable species. Fanwort (*Cabomba caroliniana*), coontail (*Ceratophyllum demersum*), water milfoil (*Myriophyllum* sp.), water stargrass (*Hederanthera* dubia), water primrose (*Jussiaea* sp.), or mulefoot may invate the newly vacated area. These less desirables can in turn become as much a problem as the original pest plants were.

Vegetative Changes Due to Herbicidal Treatment

Unfortunately, no records have been kept of the original extent of pest plants prior to control efforts, or of the amount of areal vegetative control provided each year. Therefore, it has been practically impossible to ascertain the "before" picture prior to control or the "during" picture as the control effort progressed. I have no knowledge of the methods Eyles, Steenis, and Rawles used to obtain their acreage estimates for the pest aquatics on Reelfoot Lake. However, judging from the comments of Mr. John DeLime (Reelfoot Refuge Manager), who observed the pest plant problem on the lake in the 1940's these areal estimates were probably quite conservative.

I spent two days on the lake with Mr. Waldon "Fick" Fickle (Reelfoot Refuge employee) to recreate a pictorial record of the lake as it appeared prior to the first control measures in 1948. Mr. Fickle probably knows more about the lake, its vegetation, and its wildlife, for this time interval than any other one person. While he pointed out the original extent of beds of lotus, stands of cutgrass, and mats of mulefoot, I cover-mapped these areas on a copy of the Game and Fish Commission map of Reelfoot Lake, issued in 1959.

It is difficult to judge the accuracy or value of this map. I am confident that Mr. Fickle has, to the very best of his knowledge, related to me all that he knew about the status of the pest plants prior to control. However, remembering these facts is a very large task for any one man to complete. But, regardless of the accuracy of the map, it is still dangerous to state that the change in areal extent of these plants occurred solely from the herbicidal treatment incurred, for there is no corroborative evidence to offer as proof. How much control has been provided by such natural factors as high water, siltation, parasites, and the like, is open only to conjecture.

What can be said concerning the significance of the herbicidal treatment that has been provided? In an effort to answer that question, Mr. Walter Stieglitz (Fish and Wildlife Service), Mr. Robert Tarrant (State Game and Fish Commission), and I initiated an evaluative study during the summer of 1960 ("Preliminary Report on Evaluation of Aquatic Pest Plant Control at Reelfoot Lake," March 2, 1961, unpublihsed).

Mr. Tarrant attempted to uncover the implications of the vegetative treatment by herbicides on the fish populations of Reelfoot Lake, but left the employ of the Game and Fish Commission before he could reach any decision on this matter. No attempt was made by the other members of the evaluation party to follow this line of investigation; therefore, the fishery aspects of the control program have yet to be analyzed.

Mr. Stieglitz and I established five permanent, square, one-quarter acre sample plots to evaluate the effects of herbicidal treatment on lotus and mulefoot, and to observe the ecologic features produced. Three plots were placed in lotus; two in mulefoot. No sample plots were established in cutgrass, for we believed the results Mr. Rawles obtained through his research efforts would suffice our purpose.

Sampling Techniques — Mulefoot and Lotus

Using the yard-square quadrat method, each plot was sampled to determine the relative abundance of plant species before herbicidal treatment was initiated. An estimate of coverage (per cent of plot shaded by each species) and species abundance was made for duckweeds (*Lemna minor, Wolfia* sp.) and water velvet (*Azolla caroliniana*). All other floating and emergent vegetation were recorded by stem count and per cent coverage. Each submergent species was given a rating of low, medium, or heavy, depending on density within each quadratic sample. Twenty random quadrats were taken in each one-quarter acre sample plot.

Herbicidal Application — Mulefoot and Lotus

A boat-mounted, boom-type mist sprayer was used to apply herbicide formulations to the vegetation. Mr. Stieglitz carried out all spraying operations. Each plot was sprayed and checked two weeks later for immediate kill results. The following formulations were used:

1. Devils Race Track plot — Lotus

Sprayed August 16, 1960, with a mixture of pounds acid equivalent 2-4-D per acre, and pounds acid equivalent 2-4-5-T per acre. Fif gallons of formulation were applied per acre. apparent kill of 100% was observed.

2. Forked Pond plot — Lotus

Sprayed August 16, 1960, with 2.4 pounds equivalent 2-4-D per acre and 1.2 pounds equivalent 2-4-5-T per acre. An apparent kil 100% resulted.

3. Middle Strip Timber plot — Lotus

Sprayed August 16, 1960, with 3.6 pounds equivalent 2-4-D per acre and 1.2 pounds equivalent 2-4-5-T per acre. An apparent kil 100% resulted.

4. Campbell's Gap Annex plot — Mulefoot pl

Sprayed once August 9, 1960, and twice Au 16, 1960, with a total accumulation of 6.3 pou acid equivalent per acre 2-4-D and 32 pounds D pon per acre. Approximately 35 gallons of solu were applied August 9 and 45 gallons were each time August 16. Observations three weeks l showed 75% reduction of mulefoot, but a nun of small late-growth leaves were still present. manent effects of the herbicides on the rootst were not immediately evident.

5. Campbell's Gap Annex plot *b* — Mulefoot

Sprayed August 16, 1960 and again Septem 28, 1960 with a total of 13 pounds acid equiva 2-4-D per acre, 6.7 pounds acid equivalent 2-4 per acre, and 12.0 pounds Downpon per acre. results approximated that observed on plot *a*.

Results and Analysis — Lotus and Mulefoo

During the third week of August, 1961, Carrell Ryan (Reelfoot Refuge) and I checked five sample plots to note the changes in spe composition, abundance, and density which acc in the year following herbicidal treatment.

Lotus Control

Lotus has been readily controlled using formulations of 2-4-D and 2-4-5-T as given ab and as has been used for some time in the con program. I believe that a highlight of the con program has been the drastic reduction of this plant from the open waters of Reelfoot. Undoub ly, some natural control has been provided du the treatment interval, but the vitality and ge native success of this species leads me to sus the herbicidal control measures as a major fa in reducing the spread of this plant. True, lot readily killed by such natural controls as prolon periods of high water. This occurred at Reel in 1947 and again in 1957; but within a year o lotus was again as thick as before.

Of course, once killed there is no guarantee new lotus will not regenerate on previously-tre areas. Unless lotus areas are checked regularly, beds may again form, sometimes within two y or less. Lotus seeds are known to remain dorm for an indefinite number of years, then sudd germinate. Killing any one year's growth does

therefore, guarantee the absence of this species in subsequent years, for the seeds deposited years before treatment may germinate at any time.

When lotus is removed from an area, the intense shading effect by the leaves of this species is gone. In addition, the physical space utilized by these plants becomes available to other vegetative forms. Improved light conditions and the availability of space encourages plant invasion — sometimes by quite important waterfowl food species. Sago pondweed (*Potamogenton pectinatus*) particularly has been favored by lotus treatment, invading these areas for apparently four reasons: 1) sago is abundant at Reelfoot, thereby providing the reservoir necessary for successful spread; 2) sago is a species able to tolerate heavy shading; therefore, it is to be found in sparse stands within the dense lotus beds; 3) given light, the species is quick to respond and rapidly grows into the vacated area; and 4) open water treatment, common for lotus control, usually occurs in water too deep for other rooted floating-leaved aquatics and emergents but is at a depth which encourages invasion by rooted submergents, such as sago pondweed.

In 1960, just a trace of sago was noted beneath the dense lotus in the Middle Strip plot. Checked again in 1961, sago had become the dominant vegetative form in the absence of lotus. Sago was not even found in the Forked Pond plot in 1960, but upon removal of lotus, moved in and assumed the dominant role a year later.

The above two plots were located in relatively quiet situations, protected from harsh wind and wave action by the surrounding cypress stands. What occurs when lotus is treated in more exposed sites? The plot in Devil's Race Track was chosen to obtain these data and the following were noted.

Once a rooted bed of lotus is removed from open water, harsh wind and wave action may hinder the establishment of other rooted aquatics. Although some coontail and a moderate amount of duckweeds were noted prior to herbicidal treatment at Devil's Race Track plot, none were present after treatment. How soon will forms such as sago pondweed, coontail, or fanwort take root here alone? Or, will such establishment have to "wait" until lotus once more regenerates at this exposed site? This cannot be answered until further studies are made.

Lotus control has moved from an all-out attack on vast beds of vegetation to spot-check control of previously treated areas. There is virtually no significant area on the lake wherein lotus, once multitudinous, has not been controlled. Each year, however, finds a new regentration in areas treated one or more years before.

Mulefoot Control

Mulefoot has not come into prominence as a pest plant until recent years as a result of its rapid encroachment in areas vacated by intensified cutgrass removal, and along ditches created for public access and waterfowl management. It has not figured in any practical control measures to date.

In the belief that, though it is of some importance as waterfowl food, mulefoot could become a real problem as cutgrass control continued, Mr. Stieglitz and I attempted to determine whether mulefoot could be killed by herbicidal treatment. We established two one-quarter acre sample plots in a vast bed of mulefoot located near Campbell's Gap in Blackjack Pocket. The sampling techniques were the same as for lotus. Herbicidal application data have been given previously.

Upon checking the plots this year, Mr. Ryan and I noted the following items:

1) Mulefoot in the treated areas was found to have ratios of live-to-dead stems of 5/4 and 5/3, respectively, for plots *a* and *b*. Upon checking an untreated portion of the mulefoot bed, a ratio of 4.5/3 was determined. Averaging the ratios obtained in the two treated plots, a ratio of live-to-dead stems was 4.4/3; therefore, the number of dead stems detected on the sample plots probably reflected only natural die-off in fall, not die-off as a residual effect of the spraying operation in 1960.

2) A difference in stem count was noted only in plot *b*. In 1960, 114,224 stems were estimated per acre, prior to treatment. In 1961, the number of stems per acre was estimated to be 79,666, a reduction of about 30 per cent. Plot *a* experienced a reduction of about 2 per cent, but this slight difference probably could be charged to sampling error only.

3) In plot *b*, floating dead rootstalks were observed on roughly one-third of the plot. None were observed on plot *a*.

4) In both plots, this year's growth appeared stunted both in height and in leaf area.

5) Free-floating vegetation, especially water meal (*Wolfia* sp.) increased astronomically, but the relationship here cannot be ascertained. The increase could have been due soley to the whimsy of wind direction and velocity.

From the above observations, I must conclude that little, if any, real control was provided mulefoot using the herbicidal methods employed. Some inhibition was detected in growth. There was one difference in treatment between plots that may prove to be significant. Stem count changed significantly only on plot *b*, wherein 2-4-5-T was used in combination with 2-4-D and Dowpon. And, only on this plot were any dead floating rootstalks observed. Our results suggest that mulefoot control will be most effective only if 2-4-5-T is included in the herbicidal formulation used. In addition, it has been asserted that mulefoot may be killed more easily if treatment began in spring when the vegetative parts are still tender. This, too, could be a key to mulefoot control.

Cutgrass Control

Cutgrass has been treated using a boat-mounted, boom-type mist sprayer to control cutgrass along the periphery of dense stands and along dredged and dynamited ditches. Mounted on an air boat

the sprayer has been used to control cutgrass within the vast stands of the weed, following a path cut through the stands by the "ditch-digger."

Although Polybor-chlorate 88 was the herbicide preferred by Rawls, Dowpon has since been used exclusively – and successfully – for cutgrass control. Fifteen to twenty pounds acid equivalent per acre is the estimated treatment, but in the absence of conclusive data, this can be merely termed an intelligent guess.

Areal Extent of Control. Unlike lotus, which once covered tens of hundreds of acres but has been markedly reduced in the past 14 years, cutgrass acreage has at best been reduced only slightly, and more probably has increased during this period of control.

Does this mean that cutgrass control efforts have been unsuccessful? I believe this would be an unfair conclusion to render. To answer a question with a question, how much greater would encroachment be, had there been no annual cutgrass control effect?

Increased siltation due to poor watershed management practices is a serious threat to the future of Reelfoot Lake. Steps are being taken to remedy this situation but the fact remains that the lake has been rapidly filling with sediment. Building up the lake bed through sedimentation has encouraged the spread of emergent forms such as cutgrass, and rooted semi-emergents such as mulefoot. Taking the conservative 1942 estimates of 1,900 acres cutgrass and 1,400 acres mulefoot at face value and comparing them with the planimetered estimates I achieved, it is note-worthy that these pests have been apparently held in some degree of check in lieu of the siltation problem. And, judging from the comments of Mr. DeLime, it is quite possible that cutgrass *has* suffered significant areal reduction since instigation of herbicidal treatment.

Let us analyze the control effort in a little more detail. Conventional boat-mounted mist spraying is used to treat cutgrass along the open water edge of cutgrass stands, along the margins of ditches, or in stands where density does not prevent free access by boat. Seven and twenty-three hundredths miles of dragline ditching has been accomplished on Reelfoot Lake. This has been done primarily to facilitate public access to the various basins of open water. Cutgrass has been controlled along 1.5 miles of these ditches. One dynamite ditch has been created, measuring 0.44 miles in length. Cutgrass is controlled along the entire margin of this ditch.

In order to combat the cutgrass within the confines of the vast stands on the lake, a unique piece of equipment has been employed. The "ditch-digger" works on the principle of a boat screw. Instead of propelling a vehicle by forcing water past its blades, the "digger" virtually chews its way through cutgrass blades, rootstalks, muck and other debris, utilizing two front-mounted, heavy-duty propellers installed at the water line of a large scow.

The "digger" chews its way through everything . . . except stumps! And Reelfoot Lake is *well* known for its stumps. Consequently, breakdown frequent and expensive. No accurate estimate be made for the yards or miles of ditching produ each day by this machine because of the variabi due to this factor.

No records were kept of the miles of ditch dug each year. In order to arrive at some estim of this datum, I measured the length of all dit as of October 20, 1960 from the aerial photos that date. Twenty and thirty-five hundredths m of ditches have been provided using the "di digger" since commencement of control operati Although cutgrass acreage is approximately o third greater on the state managed portion of R foot, the amount of ditching is about equally vided between state and federal holdings. Co quently, the ditching on the federal holdings be termed more intensive than on the state land.

Some cugrass control is also provided alon portion of the old stream which serves to f boat traffic from all points south into Upper B Basin. Three and seventy-five hundredths mile Rat Island shoreline are also treated for cutgra

"Holes" have been created within stands cutgrass to provide hunting opportunity for sp men. Usually this is done in areas where the st are too dense for hunting, but can be penetrated the conventional Reelfoot Lake inboard boat. undetermined number of these openings – p ably between one and two dozen – have b treated, then subsequently enlarged when dee necessary. An estimated 30 acres of "hole" crea and improvement have been provided each y since 1948.

The boom sprayer covers an average 15 feet each side of the propelling vehicle. Twenty-six four hundredths miles of ditches and stream co are now sprayed for cutgrass each year. Addin this the 2.87 miles of shoreline controlled and 30 acres of "hole" treatment, the following estim of areal coverage per year since 1957 (when present ditches were essentially completed) is gi below:

1) Cutgrass control along steram course and dit
26.04 mi. × 0.0056 mi (30') = 0.146 sq.
=96.0 a
2) Cutgrass control along shoreline
2.87 mi. × 0.0028 mi. (15') = 0.008 sq. m
= 0.5 a
3) Cutgrass controll: "Hole" creation and impr
ment estimated =30.0 a

TOTAL CUTGRASS ACREAGE CONTROLLED EACH YEAR SINCE 1957: 120.5 a

There is an undetermined amount of ca (*Typha* sp.) growing within and adjacent to grass which also is controlled each year in con tion with cutgrass removal. Since it is of such sl extent it cannot materially affect the acreage mate given above, and its influence has been counted.

Can some figure be given to estimate the T acreage of cutgrass treated since the beginnin

the control program? Having no data on which to base the primary determining factor – e.g., the miles of ditching completed each year, I have to make two questionable assumptions: 1) all "digger" ditching was completed by 1957, the year in which the last great stand of cutgrass was invaded to date; and 2) prior to that time, there was only half the amount of "digger" ditching present. Both of these assumptions have no real basis-in-fact, but some cognizance must be made of the fact that none of these ditches were present at the beginning of control operations. The year 1957 seems to be the most logical breaking point between the intensive ditching on the Refuge and the extensive ditching on the state-managed portion of the lake.

Shoreline control did not commence until 1954; therefore, the breaking point for this treatment can be ascertained. No effort was made to compensate for the amount of control provided along the dredged or dynamited ditches as the length involved was minor.

Utilizing the assumptions and facts given above, my estimate for the total accumulated cutgrass control provided at Reelfoot Lake since commencement of treatment operations is as follows:

1) Miles of ditching treated each year prior to 1958
   1948-1957: 10 Years at estimated 10 miles sprayed each year
   10 mi. × 0.0056 mi. (30') × 10 years)
   =0.56 sq. mi. = 358.4 acres
2) Miles of shoreline treated each year beginning in 1954
   1954 - 1961: 8 years @ estimated 0.5 acres per year =4.0 acres
3) Miles of ditching treated each year after 1957
   1958 - 1961: 4 years @ estimated 120.5 acres per year =482.0 acres
4) Acres of "Hole" treatment: 1948-1961
   14 years @ estimated 30.0 acres per year
   = 420.0 acres

TOTAL ACCUMULATED CONTROL OF CUTGRASS THROUGH 1961 =1264.4 acres

Conclusions and Recommendations

It has been extremely difficult to uncover any concrete facts concerning the progress of the aquatic pest plant control program on Reelfoot Lake. Records just were not kept when they should have been. Except for the compilation of data from the experimental work by Rawles on cutgrass, the sample plot work for lotus and mulefoot, and the assimilation of data from the October, 1960, air photos of Reelfoot Lake, all conclusions and recommendations have to be based on assumptions and intelligent guesses in order to arrive at any critical remarks concerning these control efforts. This is not the soundest foundation upon which to draw conclusions, but after fourten years of operations it has come time to do so.

Lotus has materially decreased from the waters of Reelfoot Lake. Areas such as Buzzard Slough and Lost Pond, once heavily covered by this pest, now contain only scattered remnants of this species. Whereas it may be too optimistic to state that the herbicidal control program was *the* factor which produced the reduction of lotus, I firmly believe that the initial spraying, then yearly check of areas treated before, has been especially helpful in controlling the regeneration of lotus. And, because of the unusual vitality and germinating characteristics of this species, I believe that lotus control shall have to be continued indefinitely. It is a safe assumption that as long as Reelfoot Lake contains open water, lotus will in some measure be present. Therefore, yearly surveillance will have to be provided in order to insure a check against this pest plant. But, the money expended, or time involved, should only be a minor portion of the pest plant control program at Reelfoot Lake.

Mulefoot holds a disturbingly unique position in the control program. At first ignored as a problem, it has become one primarily because it nearly always invades the space vacated through the control of cutgrass. Its tenacity, vitality, a stubbornness-to-control, has caused some concern and question as to the feasibility of continued cutgrass treatment on the lake. I prefer the optimistic viewpoint that mulefoot can be controlled, by means as of yet unconceived; therefore, this should not deter measures for increased cutgrass control. The fact that mulefoot often does replace cutgrass upon control should not be considered entirely a bad feature. Mulefoot does provide: 1) shelter for small fish; 2) stable waters; 3) shaded, cooler waters; 4) protection from adverse weather for waterfowl: 5) an undetermined food supply for waterfowl; and 6) an ecologic set-back, which may prolong the life of the lake.

Giant cutgrass control has moved with cautious steps these past fourteen years. Once the proper herbicidal treatment was effecuated, a conscientious effort was made to curb the spread of cutgrass. But, utilizing the tedious, time-consuming, expensive-to-maintain, "ditch-digger" as the primary control does not seem to be the answer to cutgrass treatment.

I believe Mr. Rawles suggested the correct approach to this problem: use aircraft – preferably helicopters – to achieve the widespread treatment necessary to make any real headway in reducing the acreage of cutgrass. I recommend the use of helicopters for two reasons: 1) landowners are generally very sensitive about any herbicide program; therefore, only by utilizing a 'copter will drift be kept to a minimum and proper application methods be insured; and 2) the many willow and cypress trees scattered throughout the cutgrass stands may prevent efficient aerial control using conventional crop-dusting aircraft. The time has come to decide whether to keep using ground application measures only (to me this is like mowing the yard with a pair of scissors) or to expand the operation and install aerial treatment as the primary control for cutgrass.

Ground application measures will still be necessary to touch up areas missed by aerial spraying; to maintain ditches used by fishermen and hunters as travel lanes between the larger basins, or to provide access to hunting spots; and to treat areas too small to be sprayed efficiently by aircraft. But, emphasis should be changed to place ground application measures secondary to the aerial method of spraying.

Recognition must be given to the fact that an expanded cutgrass control program will involve an increase in cost. However, if an expanded aerial treatment program is authorized, cost of treatment per acre can be expected to drop from the present rate. Aerial treatment will lessen the per acre labor and application costs, and will greatly reduce the per acre treatment interval.

The control program has significantly altered the composition of the aquatic pest plant communities at Reelfoot Lake. The changes wrought in the past fourteen years have been notable toward lotus, slight for cutgrass, and incidentally beneficial to mulefoot, an "opportunist" which has successfully spread into the areas vacated through cutgrass removal.

Except for lotus, control efforts have been overshadowed by ecologic vegetative advancement. Obviously, unless the *status quo* is to be desired (and it is not) the control effort will have to be intensified to adequately combat cutgrass encroachment. New treament measures will have to be instigated to curb the competitive tendency of mulefoot replace cutgrass wherever cutgrass is herbicidica removed. And, improved watershed manageme practices to reduce the excessive siltation into Re foot will have to be initiated in order to effectiv retard the "death" of Reelfoot Lake.

ACKNOWLEDGEMENTS

I wish to acknowledge the following Fish a Wildlife Service personnel for their assistance the various phases of this report: Mr. John DeLi Mr. Carroll Ryan, Mr. Harvel Denton, Mr. Wald Fickle, Reelfoot National Wildlife Refuge; a Mr. Preston Lane and Mr. Walter Stieglitz, forme of Reelfoot Refuge, presently re-assigned to ot Service refuges. Their physical labors, commen and criticisms were helpful and greatly appreciat

In addition, I would like to express my tha to Mr. Calvin Barstow, Mr. Harold Warvel, a Mr. Hudson Nichols, Tennessee Game and F Commission for their able assistance in reviewi and editing this manuscript.

LITERATURE CITED

Eyles, M.S. 1942. Plants of Reelfoot Lake with special erence to use as duck foods. *Rep. Reelfoot Lake Biol.* #6.

Steenis, John H. and Cottam, Clarence. 1945. A prog report on the marsh and aquatic plant problem: Reelf Lake. *Rep. Reelfoot Lake Biol. Sta.* January. Volume

Rawles, Charles K. 1955. A report on experimental con of giant cutgrass (Zizaniopsis miliacea): Reelfoot La 1950-1954. Tenn. PR Project No. W-22-R. Unpublish