

November 25, 1960

To the Graduate Council:

I am submitting herewith a thesis written by William V. Sigler, Jr. entitled "Residual Effects of Soil Sterilants." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agronomy.

Laurence V Skold  
Major Professor

We have read this thesis and  
recommend its acceptance:

H.C. Smith

M.E. Springer

Henry Fusham

Accepted for the Council:

W.E. Spivey  
Acting Dean of the Graduate School



RESIDUAL EFFECTS OF SOIL STERILANTS

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A Thesis  
Presented to  
the Graduate Council of  
The University of Tennessee

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In Partial Fulfillment  
of the Requirements for the Degree of  
Master of Science

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by  
William V. Sigler, Jr.  
December 1960



#### ACKNOWLEDGEMENTS

The writer wishes to express his gratitude to:

Professor L. N. Skold for advice, encouragement, and assistance in preparation of the manuscript and for serving as Chairman of the author's graduate committee.

Dr. M. E. Springer for serving on the author's graduate committee and Professor Henry Andrews for guiding the study.

Mr. R. F. Richards, former faculty member, and Professor H. C. Smith, member of the author's graduate committee, for help in initiating the study.

Mr. J. K. Underwood for assistance in the identification of many of the plant species.

Dr. L. F. Seatz, Dr. W. L. Parks, and Professor Homer Swingle for advice and aid in the laboratory and greenhouse phases.

Other members of the Agronomy Department for their cooperation and helpful suggestions.



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## CHAPTER I

### INTRODUCTION

Weeds and brush growing on land used for industrial purposes cause inconvenience, create a safety hazard, and may be injurious to health. If these could be controlled for several years by making one application of a herbicide, millions of dollars of labor and machinery expense could be saved annually. In addition, there would be much help in reducing allergies and other ailments that affect the health and safety of our population.

Herbicides for controlling vegetation are finding wide use by railroads on roadway and ballast. Some railroads have spent as much as \$200.00 per acre for herbicides in switchyards each year. Other areas of extensive use include utility substations, petroleum tank farms, industrial plant areas, storage areas, terminals, lumber yards, parking areas, roadsides, highway guard-rails, fence lines, pipe lines, airport runways, and other non-crop areas.

Although many materials are on the market, little research has been conducted to determine the residual effects of sterilants. Much of the observational work to date has been on coarse textured soils and in areas of low rainfall. This study was initiated to determine the effectiveness of vegetation control by different herbicidal materials used at selected rates and times of application on soils of contrasting physical properties under the climatic conditions found in East Tennessee.



## CHAPTER II

### REVIEW OF LITERATURE

#### Definitions

Crafts and Harvey (8) describe terms commonly used when dealing with soil sterilants: "Soil sterilization" denotes treating the soil with chemicals to make it unsuitable for plant growth. "Residual effect" indicates the length of time a chemical will persist in the soil and create the desired results. "Temporary soil sterilant" designates effect for less than one year, "permanent soil sterilant" for more than one year.

#### History

Chemicals have been used for centuries to control weeds (23). Salt, ashes, and various industrial by-products have been applied to roadsides, fence rows, pathways, and areas of fields infested with noxious weeds to rid them of vegetation. Little scientific progress was made until the latter part of the nineteenth century. Jones and Orton (13) in 1899 compared the use of crude carbolic acid to arsenite of soda, a mixture of white arsenic and sal soda. He reasoned that the former, though a very powerful and quick acting herbicide did not endure as long as the latter.

Ashlander (2) in 1928 reported the use of sodium chlorate,  $\text{NaClO}_3$ ; potassium chlorate,  $\text{KClO}_3$ ; sodium thiocyanate,  $\text{NaCNS}$ ; sodium cyanide,



NaCN and sodium arsenite,  $\text{NaHASO}_3$ . He stated that the effectiveness of chlorates on perennials was due to rapid penetration through the soil and slow decomposition, especially at low temperatures. Crafts (6) compared several soil sterilants on a cost basis and found trivalent arsenic to be the most feasible chemical for soil sterilization. Extension of its use has since been impaired because of the great potential loss due to mammalian toxicity.

Since 1937, with the discovery of phenoxyacetic acid, researchers have been trying to find out the effects of herbicides on the soil in addition to their deleterious effects on weeds. Much research on residual effect has concerned the substituted phenoxyacetic acid materials and carbamates used for pre- and post-emergence control of weeds in crops. This information has been summarized by Roberts (24). These materials, when applied at the proper rate, kill germinating weed seeds but do not damage some crop plants.

The question raised was whether these herbicides build up a residue in the soil. Reid (21) reported no long-time damage to soil from use of organic herbicides. Hernandez and Warren (11) found that factors affecting microbial activity determined to a large degree the length of time 2,4-dichlorophenoxyacetic acid persisted in the soil. An increase in soil temperature shortened the period of inactivation; an increase in moisture in an air dry soil had the same effect. In sterilized moist soil 2,4-D was still toxic at the end of 12 weeks of storage in the greenhouse; however, in unsterilized soil, 2,4-D was inactivated at the end of 4 weeks.



Many herbicides ordinarily used at pre- and post-emergence rates for controlling weeds in crops are used today for industrial purposes at higher rates against annual and perennial broadleaf weeds and grasses on nonagricultural land.

The 1957 season completed a total of 18 years of research by the Railroads on the control of vegetation. This work represented more than 5,000 individual tests of herbicides, combinations of herbicides, and of rates and dates of application under a wide variety of soil, ballast, climatic and vegetational conditions.

Parris (20) reported no single chemical available that would economically control all plant species found under the many varied conditions throughout the United States. However, he indicated the possibility of reducing costs by following a properly planned long-term weed control program.

In Iowa, seasonal control was obtained by the use of a number of materials, but certain chemical combinations provided the most effective results. Parris (20) favored the use of soil sterilant materials followed in succeeding years with herbicidal oils, and stated that the use of certain soil sterilant chemicals on small areas of particular persistent perennials resulted in a substantial saving. In Florida, a mixture of a systemic grass herbicide and a relatively insoluble soil sterilant controlled most native vegetation for at least one growing season. Montana results showed better control from fall than from spring application of soil sterilant chemicals. With the control of perennial grasses, Canada thistle (Cirsium arvense), became a serious problem. Soil



sterilant type materials appeared expensive and good for only one season on Bermudagrass (Cynodon dactylon), in North Carolina.

All of these were empirical studies. Certain treatments were applied to plots and a tabulation of species not controlled was made (22).

### Factors Affecting Residual Control

Researchers agree that several factors affect the persistence and movement of herbicides in the soil (8, 11, 23, 24). These factors according to Robbins et al. (23) and explained by Crafts and Harvey (8) and Roberts (24) determine the usefulness of a particular chemical:

1. Inherent toxicity. This is the nature and arrangement of atoms and molecules in some chemicals that make them toxic to plants. Application rate and formulation are important.
2. Absorption. Some chemicals adhere to the surface of soil colloids more than others. Thus, in clay soils they may be so tightly held by the soil particles that they are not available to the plant roots even though they are present in the soil in relatively large amounts. Organic matter also has an influence.
3. Decomposition. Chemicals break down in soils at different rates. Factors affecting bacterial action are of utmost importance.
4. Leaching. Chemicals used as soil sterilants differ in solubility and in the ease with which they move. Soil texture and structure affect the rate of vertical and



lateral movement of water through it.

5. Soil composition. Fertility, salt content, and acidity or alkalinity of soils all affect the toxicity and persistence of a soil sterilant.
6. Species tolerance. Weed species vary widely in their inherent tolerance of chemicals.

Hill et al. (12) continue the list:

7. Physical removal of the chemical by windblow or chemical decomposition by exposure to ultra-violet light in arid areas such as are found in parts of the western United States when the chemical is applied and remains on the soil surface.

Several research workers believe that no one of the afore mentioned factors determines the usefulness of a soil sterilant for vegetation control (8, 17, 25). Rather the interplay of the several factors determine whether a given chemical will kill shallow or deep rooted weeds, whether it be temporary or relatively permanent and to a large degree how much will be required to give satisfactory results. To give successful control of perennial vegetation a herbicide must be distributed in the soil where the roots are located and at the time these roots are active. It must be present in a lethal concentration for a period long enough to permit enough absorption by the roots for killing.



## Past Research on Materials Used

### Borate

Crafts and Raynor (9) reported that since borates are non-poisonous and fire deterrent, they have advantages over arsenic or sodium chlorate. Furthermore low solubility and high toxicity at low concentrations to some plants reduce probability of reinfestation by seedlings. Crafts and Cleary (7) agreed; however, Crafts and Raynor (9) stated that borates are not retained against the leaching power of moving water to the same extent as arsenic. Stone and Stahler (28) indicated that a unit of boron trioxide is equivalent to a like unit of sodium chlorate as a plant toxicant. Crafts and Raynor (9) would confine the use of borates to coarse soils and gravelly areas where rainfall exceeds 10 inches annually to insure the leaching of the material into the root zone.

### Monuron

According to Loustalot et al. (15) experiments in Puerto Rico have shown 3-(p-chlorophenyl)-1,1-dimethyl urea to be potent, non-selective and capable of controlling most weeds when applied at relatively low rates. Weise (31) reported that when monuron was applied at the rate of 60 pounds per acre to soil in Texas vegetation was controlled for 3 to 5 years.

Other researchers have found varying results. At soil sterilization rates, Danielson in Florida (10), stated that 50 pounds per acre of monuron was dissipated sufficiently in 24 months to allow early vegetative growth of snap beans and sweet corn in a sandy clay loam. Andrews and Richards (1) found that 38.4 pounds of monuron was needed to give 70% control of



woody species by the end of the second year in Tennessee.

Upchurch and Pierce (29) in a greenhouse experiment found monuron was leached readily from Lakeland soil when present in soil sterilant quantities. They found that 12 inches of simulated rainfall, applied in 8 increments at 1/2-hour intervals, leached 89% of a 40-pound per acre application below 2 inches and 51% below 24 inches.

Differences in findings after a similar experiment were reported by Loustalot et al. (14), who indicated that monuron at 80 pounds per acre failed to leach beyond the 15-inch soil depth.

Other factors causing decomposition of monuron were reported by Loustalot et al (15) and Upchurch and Pierce (30). Upchurch and Pierce (30) reported that greater soil temperatures, above 50° to 45° C, caused less leaching. An increase of organic matter from 0.87 to 1.44% caused an increase from 35 to 95% in the amount of monuron retained against leaching. Loustalot et al. (15) reported that factors generally favoring soil microbial action seemed also to favor disappearance of monuron from the soil. Monuron persisted longer at 10° C than at room temperature. Monuron persisted longer in air dry soil than in soil with a medium or saturated moisture level. Sandy soil retained the toxicity longer than did soils with a higher clay content. Toxicity persisted longer at the higher rate of application.

#### Simazine

Scudder (26) experimented with 2-chloro-4,6-bis(ethylamino)-S-triazine persistence in two central Florida soils. Thirty-two pounds



per acre incorporated into the soil lasted 1 year on peat, stunting squash the second spring. All vegetables including the sensitive turnips and lettuce grew on the plots 1 1/2 years following the initial application.

### Sodium Chlorate

Weise (31) reported that an application of this material at the rate of 800 pounds per acre sterilized soil for 3 to 5 years in Texas. Crafts (5) stated that deep rooted perennials could be killed either by rapid absorption and translocation of chlorates within the plant from foliage application or by absorption from the soil by the roots, and that both actions operating simultaneously were more effective than either alone. Wilson et al. (33) agreed with this statement. Ashlander (2) reported that chlorate effectiveness was due to rapid penetration into the soil and slow decomposition, especially at low temperatures. Crafts (5) reported that proper vertical leaching and distribution of chlorate within the soil was essential to success with the soil treatment method, but that leaching sterilized areas with 36 inches of irrigation water returned the area to crop use within one season. Mucher (16) mentioned this method of controlling perennial weeds as too expensive to be employed on large areas.

### T C A

This material has been studied more for weed control in crop production than as a soil sterilant (3, 4, 18). Absorption by underground parts was established by Barrons and Hummer (3) as being the



primary avenue of entry by trichloroacetic acid for wheat and soybeans. The material had a greater effect on grasses low in carbohydrate reserve than grasses higher in stored carbohydrates. A wide variation in the tolerance of crop plants was found. Blouch and Fults (4) found that TCA gave selective control of annual grasses without crop injury on Fort Collins loam, and non-selective phytotoxicity at the same rate on Valentine loamy fine sand and Terry silty clay loam. The latter soils were low in organic matter and fertility whereas the former soil was high in organic matter, nitrate and phosphate.

Owens (18) reported that without tillage, sodium TCA at the rate of 100 pounds of formulation per acre and up was effective in eradicating centipede grass in Northwest Florida. The herbicide at 50 pounds and 75 pounds per acre without tillage reduced the stand of centipede grass by 50 to 75%, but the remaining sprouts engulfed the entire area. Decomposition of the material allowed the area to be seeded to bahia grass (Paspalum notatum), 1 1/2 months after treatment.

#### Combinations or Mixtures

Parris and Rodgers (19) observed 50 herbicidal treatments for controlling weeds on railroad right-of-way in Florida. A mixture of TCA and sodium chlorate at the rate of 40 to 80 pounds per acre, repeated at 60-day intervals, provided the most effective control in all growth stages. Generally, better response was obtained when the treatments were applied during the dormant season and early plant growth stage with little difference observed between the January and March application. A combination of TCA-sodium chlorate-monuron at rates



40-80-20, 80-80-10 and 80-160-10 effectively controlled weeds throughout the season in all dates of application.

Crafts and Cleary (7) found that a borax-chlorate combination for soil sterilization had several advantages. In addition to being practically non-poisonous the borax reduced the fire hazard to a low level and probability of reinfestation by seedlings. Antagonistic reactions between the two materials were reported to have been reduced to a minimum by using the lowest effective dosage of chlorate and adding enough borax to complete the destruction of the vegetation.

Stone and Rake (27) stated that cumulative effects concerning combinations of materials would be considered by some investigators as demonstrating synergistic action. He would consider the additional increment in herbicidal effectiveness of the complex as resulting from the biostatic activity of the borate addition to the complex.



### CHAPTER III

#### MATERIALS, METHODS AND EQUIPMENT

##### Field Procedure

This study was designed to study the effectiveness of vegetation control by five selected soil sterilants used at selected rates, applied in the fall and spring, on soils of contrasting physical properties.

These materials were applied to three different soil types: Etowah silty clay, Tellico loam and Neubert fine sandy loam, in order to determine differences in vegetation control by residual effect of the herbicides as influenced by soils of different texture, bulk density, and available water storage capacity. Each soil was within a 3-mile radius of the Tennessee Agricultural Experiment Station at Knoxville. None of the areas selected had been cultivated for at least 5 years, and all were heavily infested with annual and perennial grasses and broadleaf species.

The dominating vegetation on Etowah silty clay was broomsedge (Andropogon virginicus), and crownbeard (Verbesina sp.). Broomsedge, Bermudagrass (Cynodon dactylon), sericea lespedeza (Lespedeza cuneata), and common blackberry (Rhus allegheniensis) were dominant on Tellico loam. Kentucky bluegrass (Poa pratensis), goldenrod (Solidago sp.), sericea lespedeza, and tall red-top (Triodia flava) were dominant on the Neubert fine sandy loam.

Prior to the application of herbicides a botanical survey was made of each area to identify and record the species present. The



selected areas were mowed and the weeds raked and removed in September of 1957 to facilitate application of the chemicals.

Five soil sterilants were applied, at three different rates, as shown in table 1. Chemicals were chosen to represent: 1. a commercial mixture; 2. a substituted urea; 3. a triazine; 4. sodium chlorate; and, 5. sodium TCA. The middle rate of each herbicide used was the approximate rate recommended by the manufacturer. The lower rate was  $1/3$  to  $1/2$  less and the higher rate was  $1/3$  to  $1/2$  more.

A randomized block design with split plots replicated three times was used on each soil type. Plots were 10 feet by 10 feet in size and were split into sub-plots 5 feet by 10 feet for fall and spring applications. An 18-inch border was left between plots. Alleys 5 feet wide separated each range of treatments permitting an evaluation of lateral movement.

Materials applied were first mixed with 3 gallons of water so as to form a slurry. To insure uniformity in distribution of the herbicide  $1/3$  of the total amount was applied to the plot area in each of 3 successive applications. The fall application was made November 5, 1957, and the spring application March 15, 1958. The following May, July, August, and October plots were rated visually according to the degree of vegetation control. A scale of 0 to 10, using 0 for no control, and 10 for complete kill, as described by Willard (32) was used.

In June, 1958, a second botanical survey was made to identify and record the species that were not controlled by the several treatments.



Table 1.--Herbicides and rates of application.

| Herbicide            | Rate in<br>lbs. active ingredient per acre |
|----------------------|--------------------------------------------|
| "Chlorea" <u>a/</u>  | 2320<br>3480<br>4640                       |
| Momuron              | 50<br>75<br>100                            |
| Simazine <u>b/</u>   | 10<br>20<br>40                             |
| "Atlacide" <u>c/</u> | 800<br>1600<br>2400                        |
| Sodium TCA <u>d/</u> | 75<br>125<br>175                           |
| Untreated Check      | ----                                       |

a/ CBMM (Chlorea); sodium chlorate (40%), sodium metaborate (57%), and momuron (1.25%), 3-(p-chlorophenyl)-1,1-dimethylurea.

b/ 50% wettable powder.

c/ Sodium chlorate 58%.

d/ 90%.



Both colored and black and white photographs were made to provide a permanent record of the degree of control.

#### Laboratory Bioassay

A laboratory bioassay was conducted in order to determine the residual effect of the herbicides. In May, following the application of chemicals, soil samples were collected from each of the plots which had been treated with the heaviest rate of each chemical in the fall and from untreated adjacent areas. Five cores about  $7/8$  inches in diameter were taken from each plot with a soil sampling tube to depths of 0 to 2, 4 to 6, 8 to 10, 12 to 14, and 28 to 30 inches. The core sections of a given depth of three replications of each treatment on each soil type were composited in the field and placed in quart ice cream cartons.

Samples were removed to the greenhouse within 3 hours and thoroughly mixed. Enough soil was transferred from each sample to nearly fill a  $1/2$ -pint ice cream cup. Indicator crops, a grass and a legume, were sown in each cup, their germination and growth providing a measure of residual effect of the herbicide in the soil.

Because of their large seed size and vigorous germination, Ogden soybeans (Glycine max) and Martin milo (Sorghum vulgare) were selected as sensitive legume and grass indicators. Ten seeds of each were planted in each cup and covered with 2 tablespoons of soil from the original sample. A filter paper cover prevented disturbance of the soil by watering. Sufficient distilled water was added from a polyethylene water jar to keep the soil near field capacity. A hole in the bottom of the cup was



an aid to aeration. The cups were placed in a growth chamber having an average day temperature of 74° F., relative humidity of 52%, and a day length of 16 hours, light being provided by incandescent and cool white fluorescent lights. The night temperature did not deviate appreciably from the day temperature because of automatically controlled electric heaters. Samples were watered each day and at the end of 10 days a stand count was made. At the end of 5 weeks, ratings and photographs were made of the total growth.



## CHAPTER IV

### RESULTS

#### Field Results

A botanical survey was made in the fall of 1957 to identify and record the species present on each of the three soil types to be treated; a report is presented in Appendix A. The assistance and counsel of Mr. J. K. Underwood, Associate Agronomist, University of Tennessee, is gratefully acknowledged for identifying many species.

Environmental factors are known to influence the persistence of herbicides in soils. Therefore, rainfall and temperature data from the Tennessee Agricultural Experiment Station Greenhouse which was located approximately centrally among the treated areas are given in Appendixes B and C, respectively.

Soil sterilization herbicides were applied to the fall treated plots on November 5, 1957, and spring treatments were made March 15, 1958.

Figure 1 shows the average number of species on each plot when the tabulation of species not controlled was made. Generally the herbicides in decreasing order of effectiveness of vegetation control during the time studied were "Chlorea", monuron, simazine, "Atlacide", and TCA, respectively. Within 10 days after treatment all rates of all herbicides had killed the vegetation of each plot. "Chlorea" gave immediate control of annual and perennial broadleaf plants and grasses. Monuron did not give as rapid kill as did "Chlorea" but its delayed action was as effective. Monuron failed; however, to control Bermudagrass. Simazine gave control of



Average number of different  
species per plot

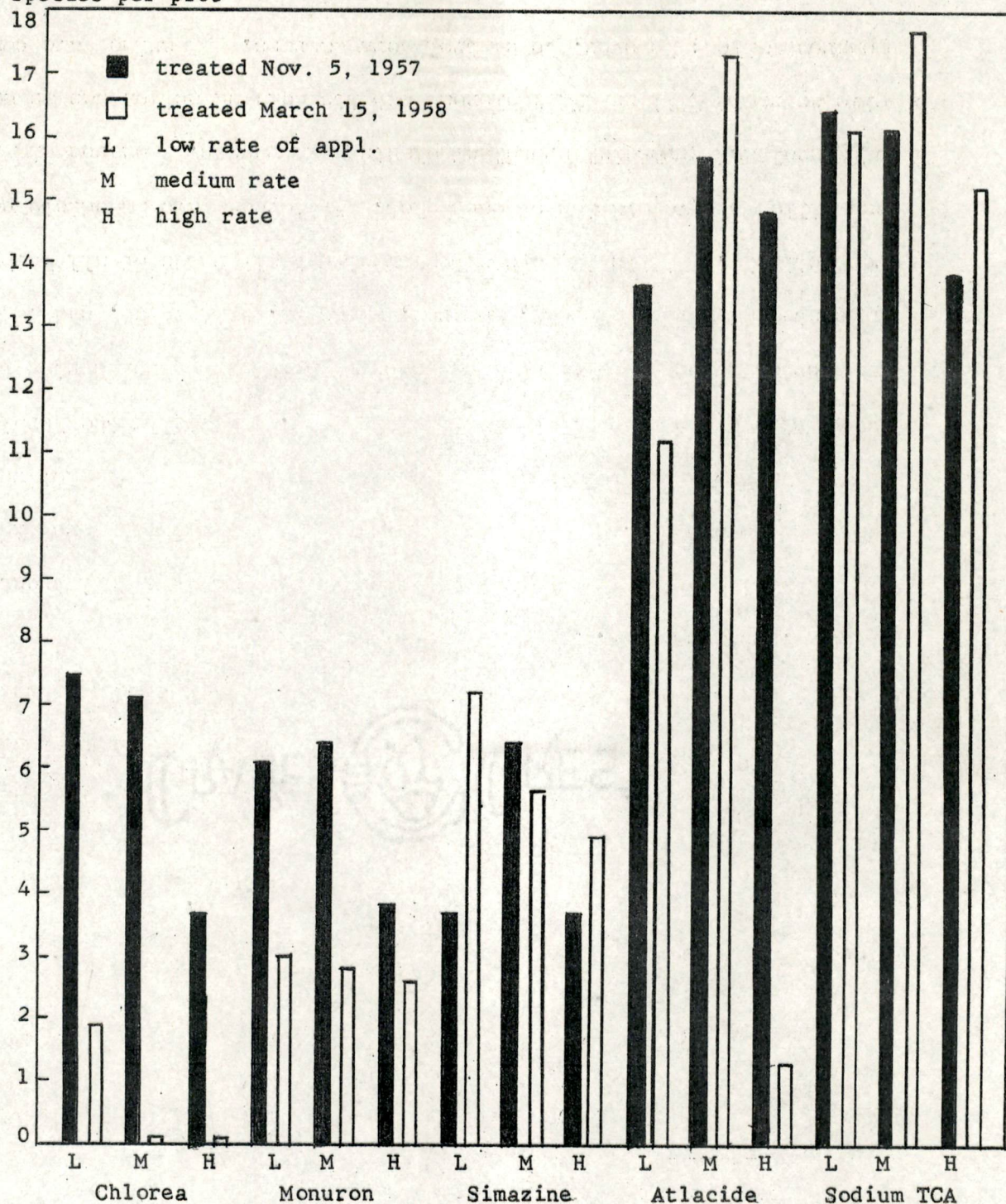


Figure 1--Average number of species per plot not controlled June 20, 1958, after treatment with specific rates of certain herbicides fall and spring 1957 and 1958, respectively. Figures represent an average of 3 replications and 3 soil types.



annual weeds and grasses but did not control perennials, such as Johnson-grass, Bermudagrass and sericea. "Atlacide" controlled broadleaf plants better than grasses, while TCA controlled grasses better than broadleaf plants.

Control ratings were made in May, July, August, and October 1958. The July ratings for fall and spring applications are shown in figures 2 and 3, respectively, on Etowah silty clay, 4 and 5 on Tellico loam, and 6 and 7 on Neubert fine sandy loam. These ratings indicate the degree of control of broadleaf plants and of grasses by each treatment on each soil type. These data show that several of the herbicides failed to control both grasses and broadleaf annuals and perennials.

The differences in residual toxicity among the three soil types were less pronounced than differences among the herbicides used. The only major influence of soil type and time of application in vegetation control is shown in figure 6. On Neubert fine sandy loam, the coarsest textured soil of the three treated herbicides dissipated and gave less general control than on any other treatments when applied in the fall. Parris (20) showed better control in a more arid area, Montana, from fall than from spring application of soil sterilant type chemicals.

In October, photographs were taken of the plots treated with the high rate, and control ratings made. These are shown in figures 8 through 22. It is apparent from these photographs that the chemicals had lost their effectiveness within 1 year from the time they were applied. Vegetation had partially covered the treated areas in all cases, and completely in some. The "Chlorea" treated plots showed less encroachment of vegetation than did the others.



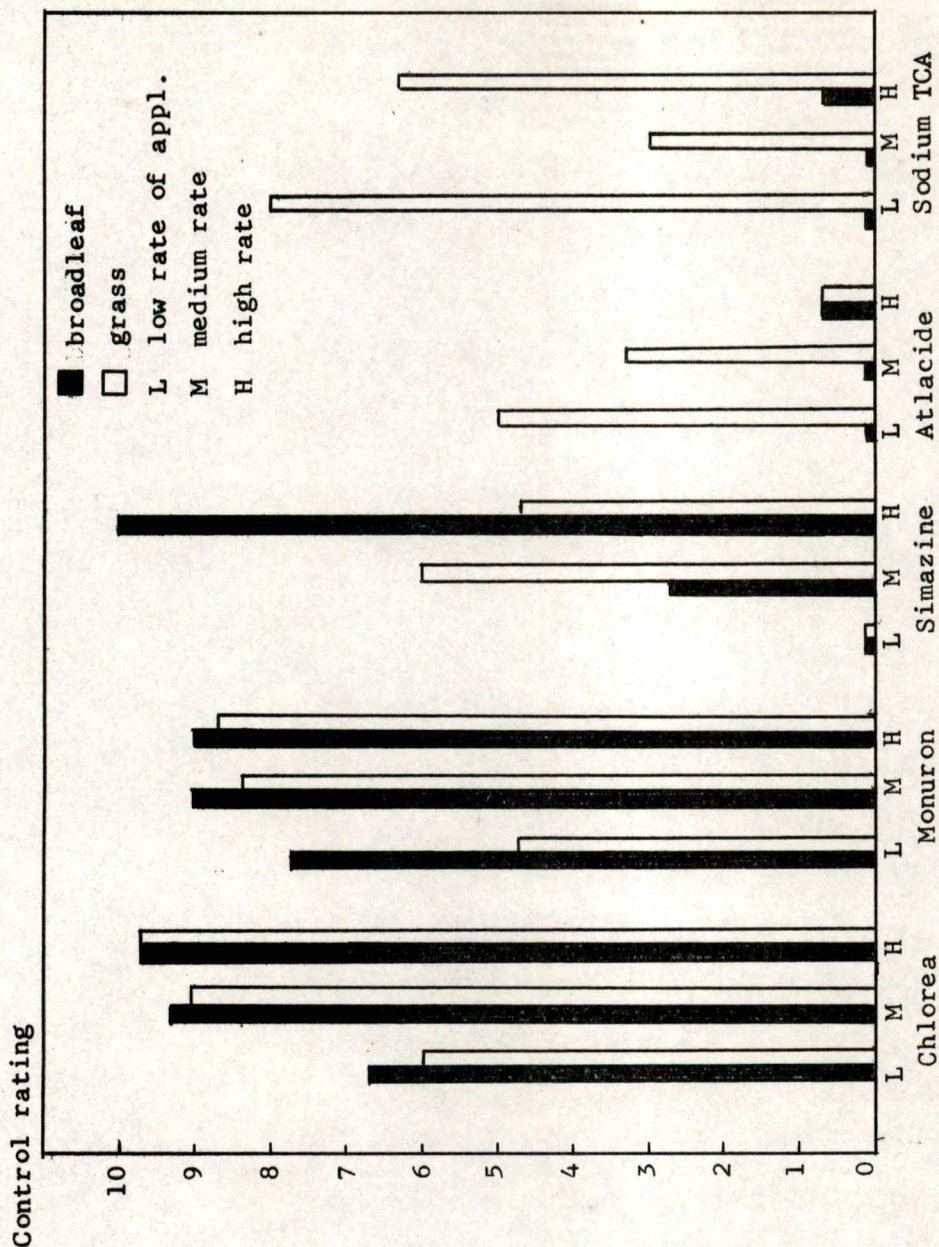


Figure 2--Control rating (July 5, 1958) of plots treated with certain soil sterilization herbicides.  
 Zero indicates no control; 10, complete control of vegetation.  
 Herbicides applied November 5, 1957.  
 Etowah silty clay, Knoxville, Tennessee.



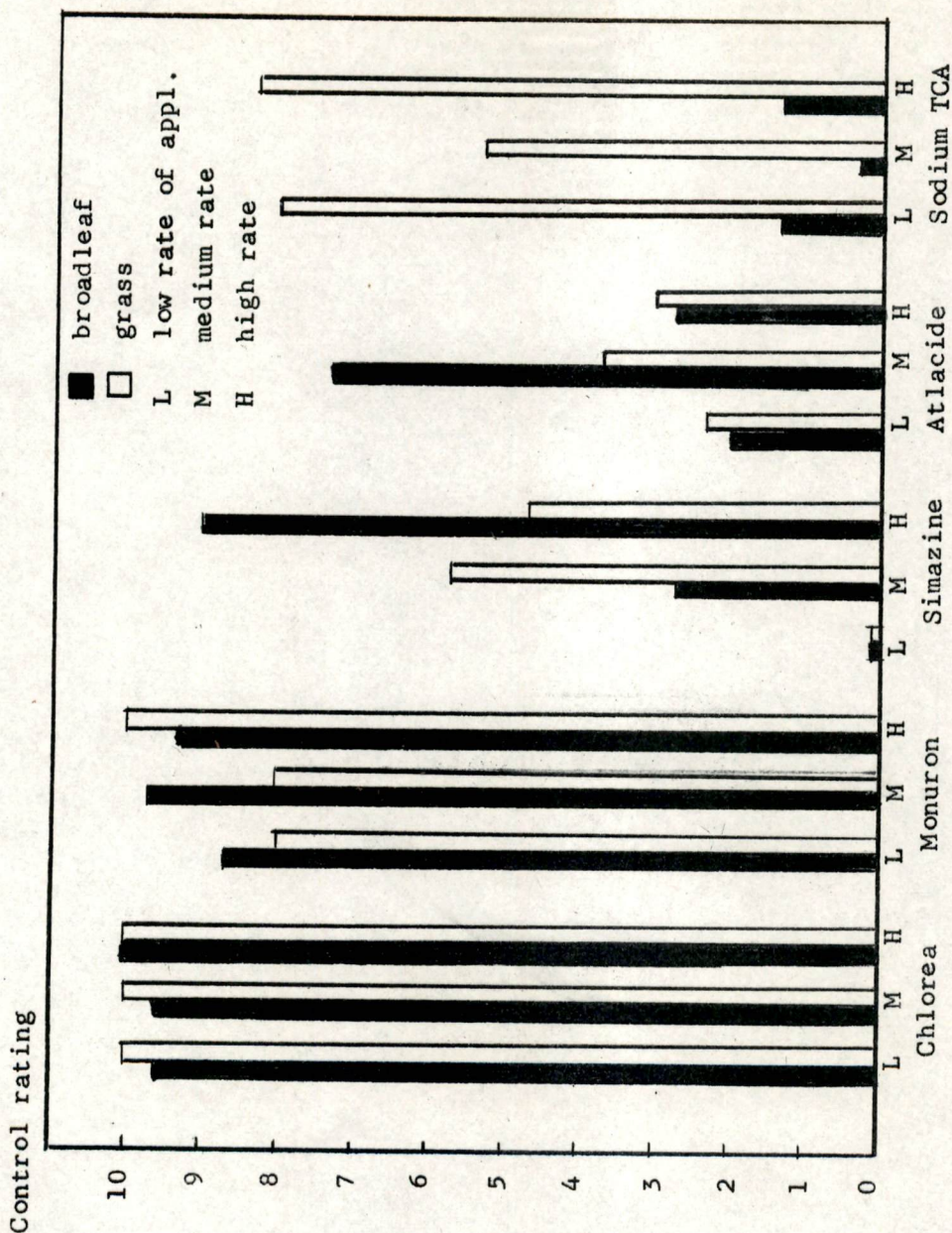


Figure 3--Control rating (July 5, 1958) of certain soil sterilization herbicides. Zero indicated no control; 10, complete control of vegetation. Herbicides applied March 15, 1958. Etowah silty clay, Knoxville, Tennessee.



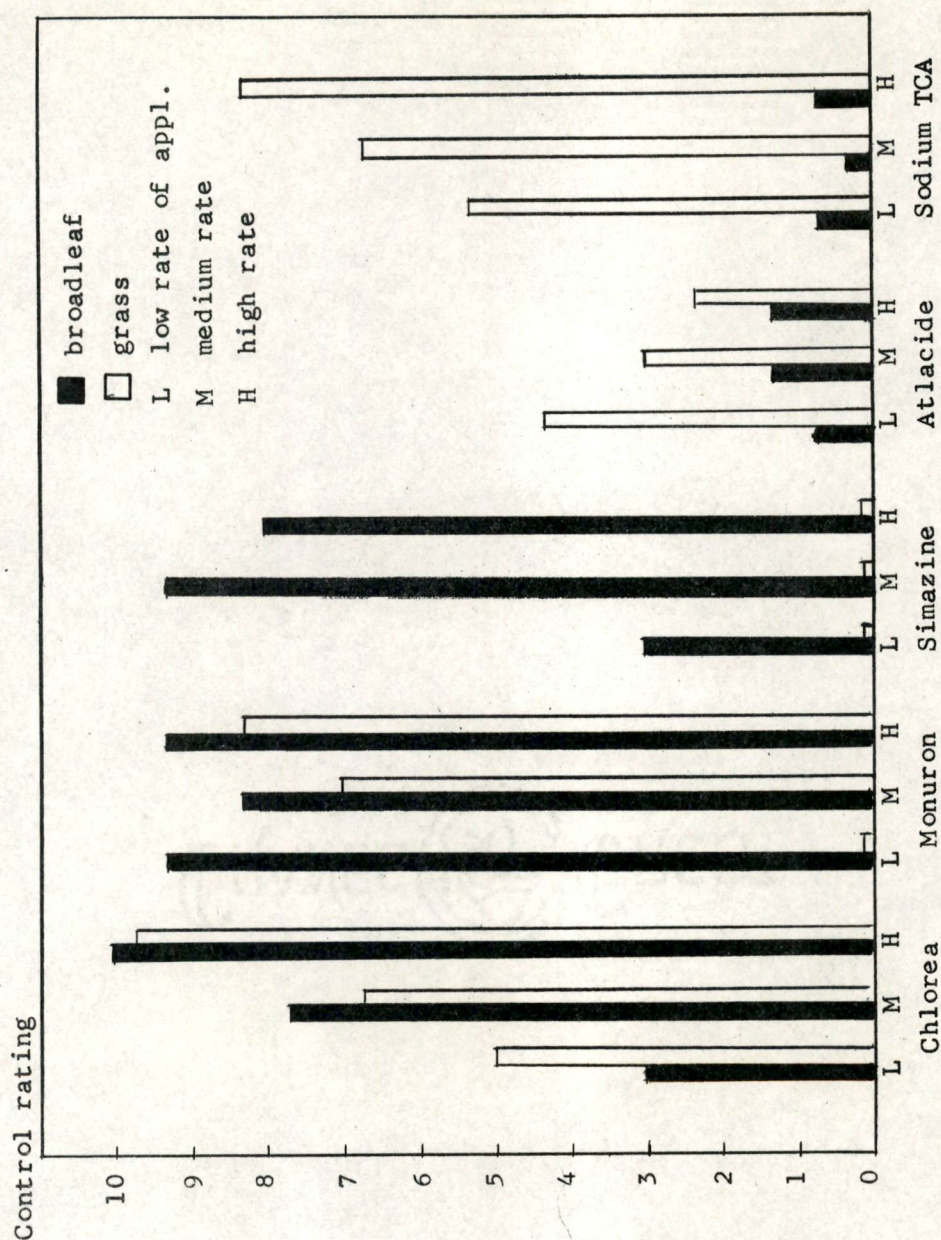


Figure 4--Control rating (July 5, 1958) of certain soil sterilization herbicides. Zero indicates no control; 10, complete control of vegetation. Herbicides applied November 5, 1957. Tellico loam, Knoxville, Tennessee.



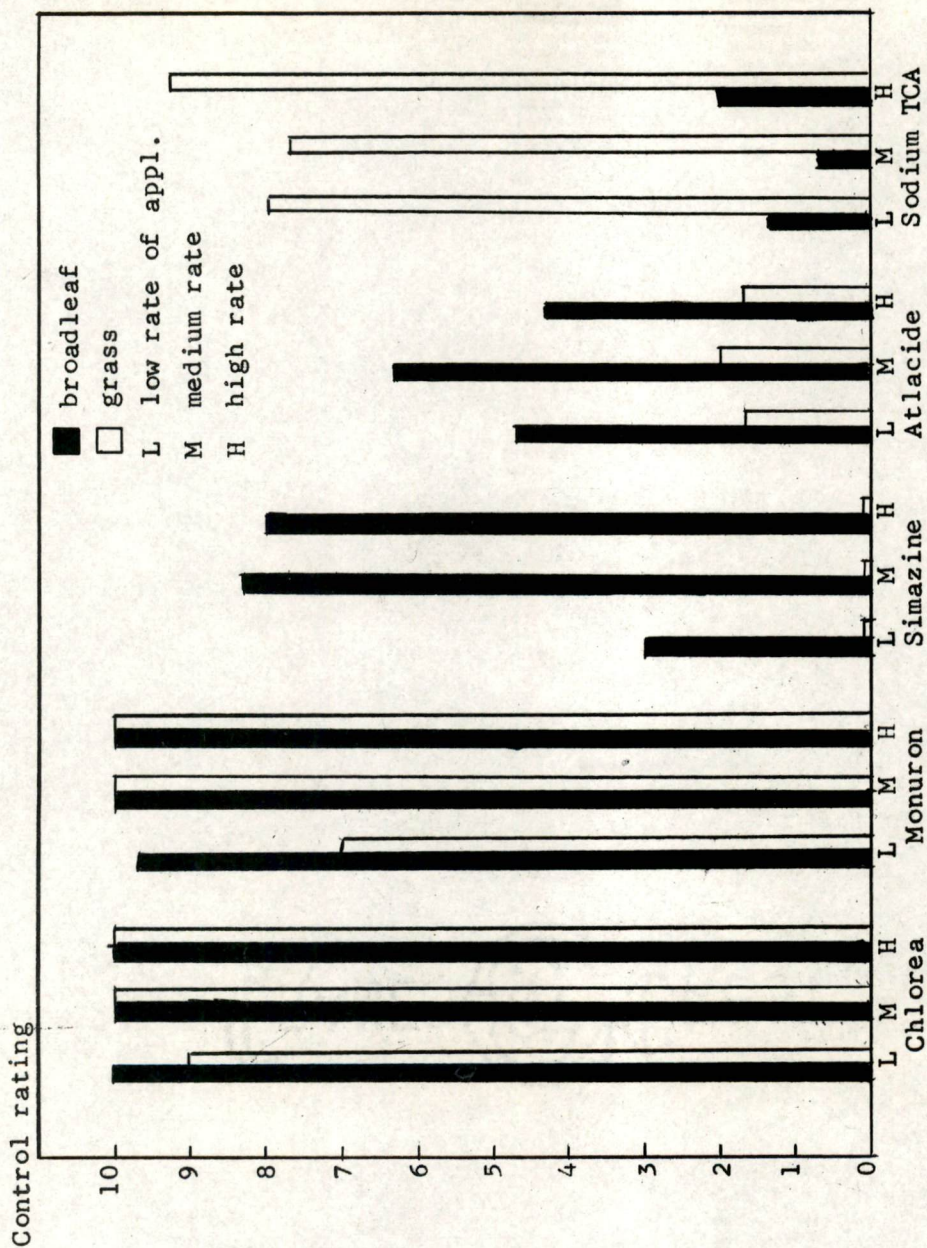


Figure 5--Control rating (July 5, 1958) of certain soil sterilization herbicides. Zero indicates no control; 10, complete control of vegetation. Herbicides applied March 15, 1958. Tellico loam, Knoxville, Tennessee.



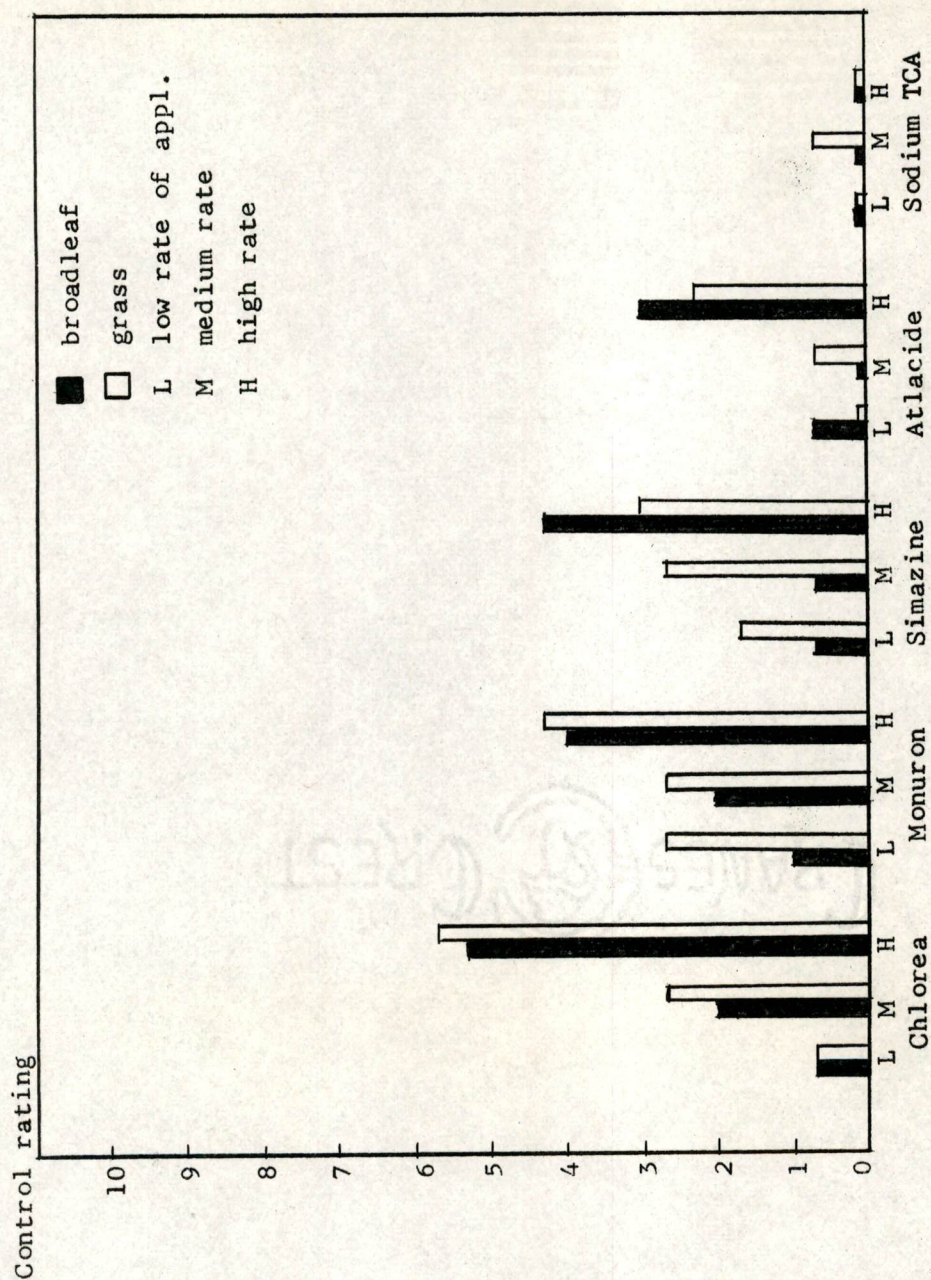


Figure 6--Control rating (July 5, 1958) of certain soil sterilization herbicides. Zero indicates no control; 10, complete control of vegetation. Herbicides applied November 5, 1957. Neubert fine sandy loam, Knoxville, Tennessee.



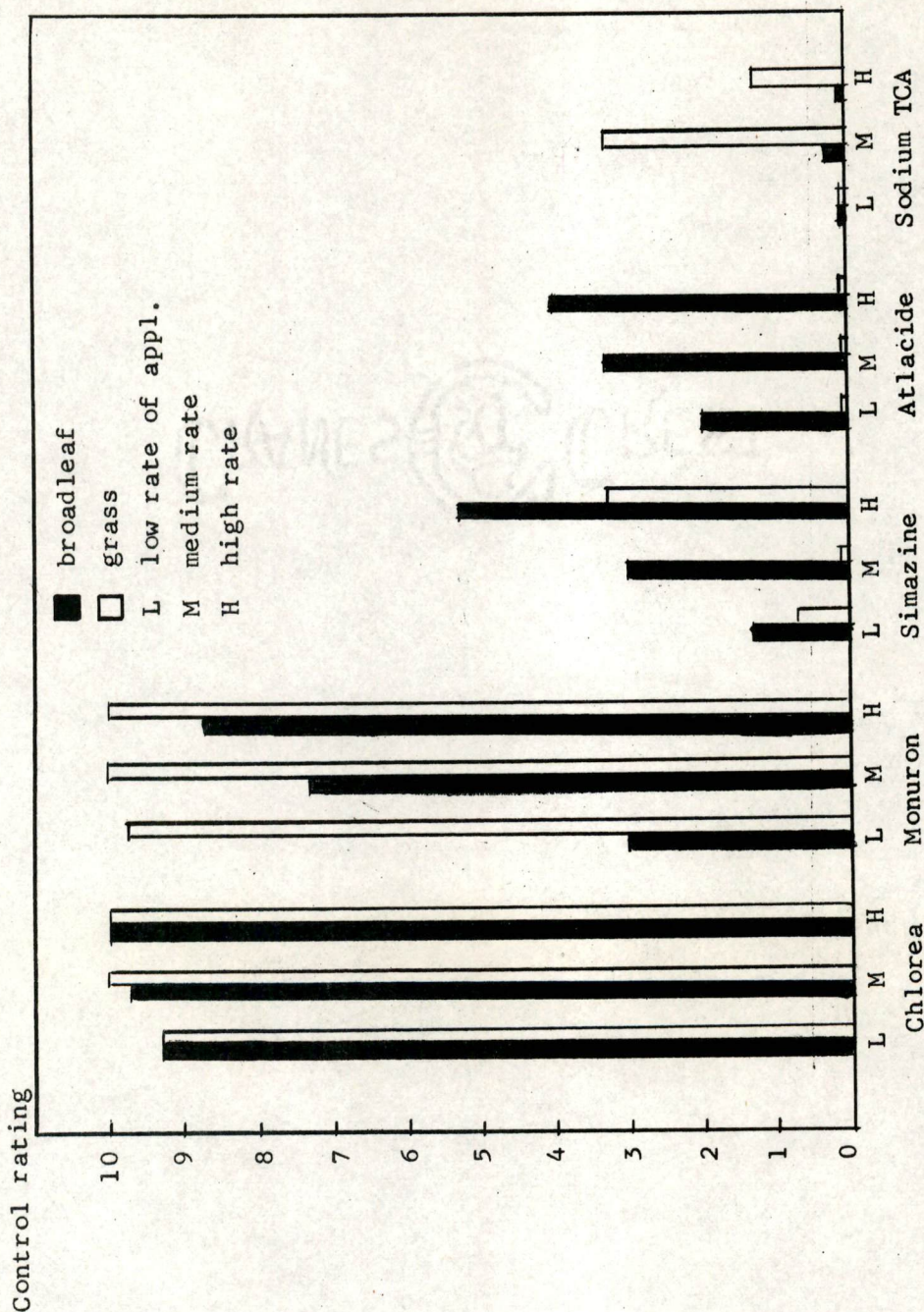
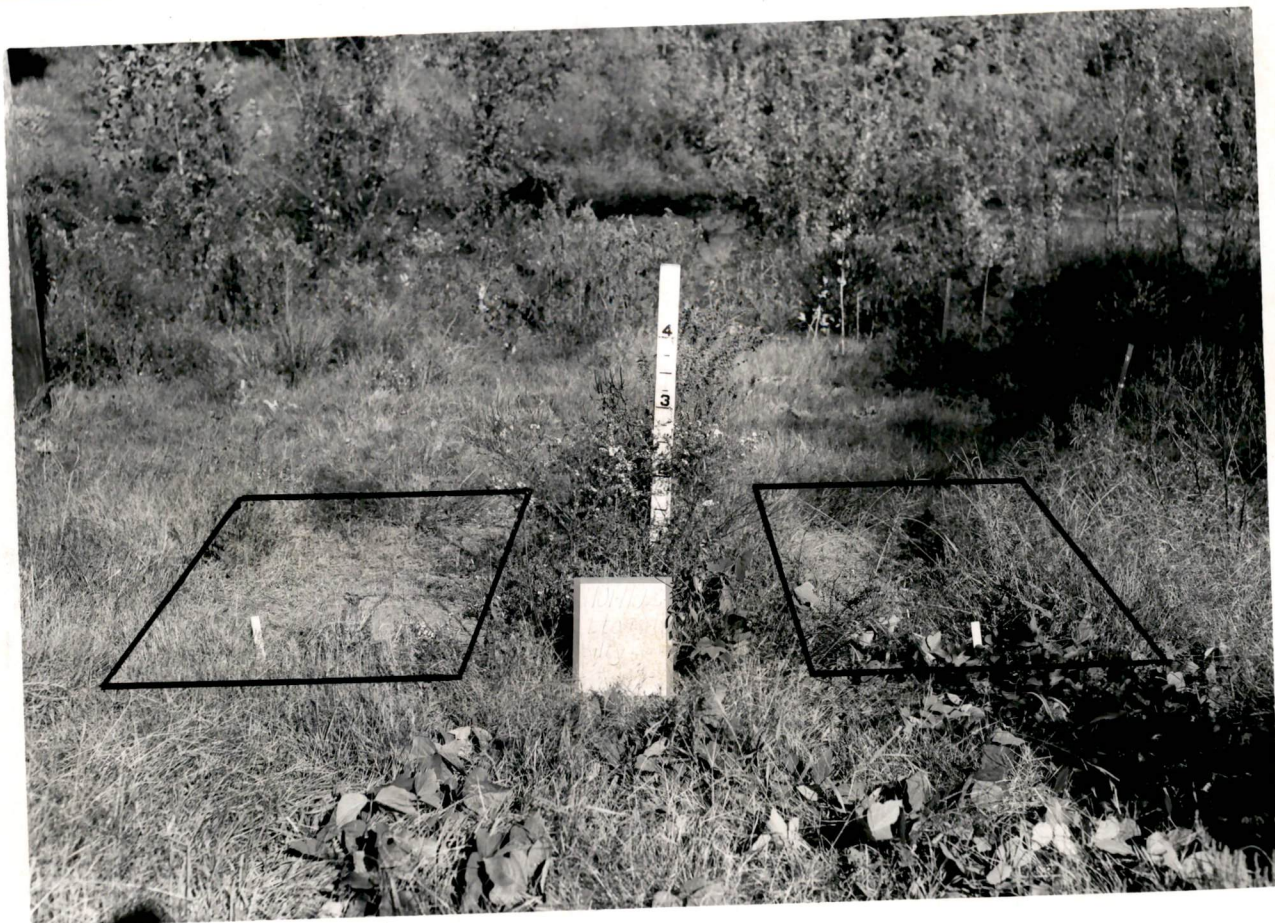


Figure 7--Control rating (July 5, 1958) of certain soil sterilization herbicides. Zero indicates no control; 10, complete control of vegetation. Herbicides applied March 15, 1958. Neubert fine sandy loam, Knoxville, Tennessee.





Fall treated

Spring treated

Figure 8--Photograph (October 28, 1958) of Etowah silty clay soil treated with the high rate of "Chlorea".



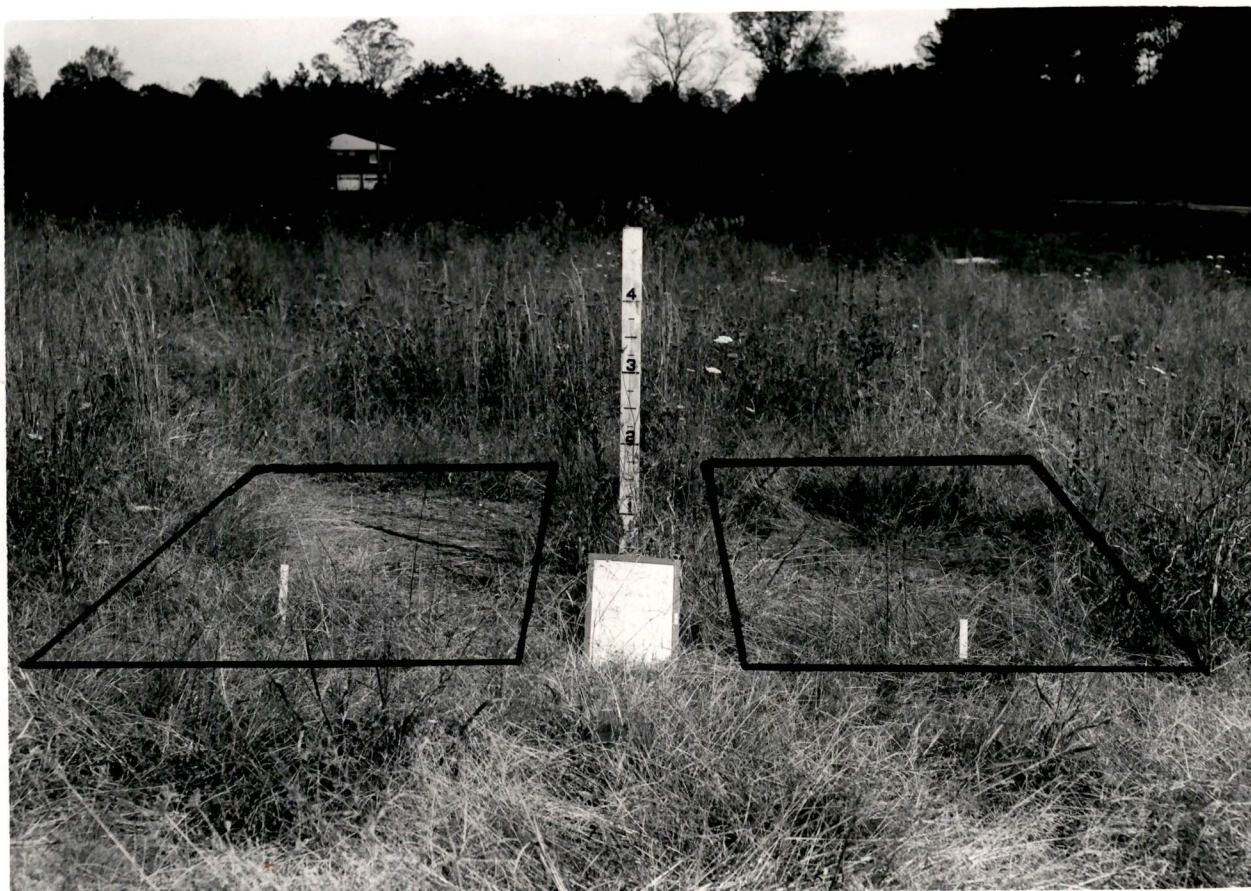


Fall treated

Spring treated

Figure 9--Photograph (October 28, 1958) of Tellico loam treated with the high rate of "Chlorea".



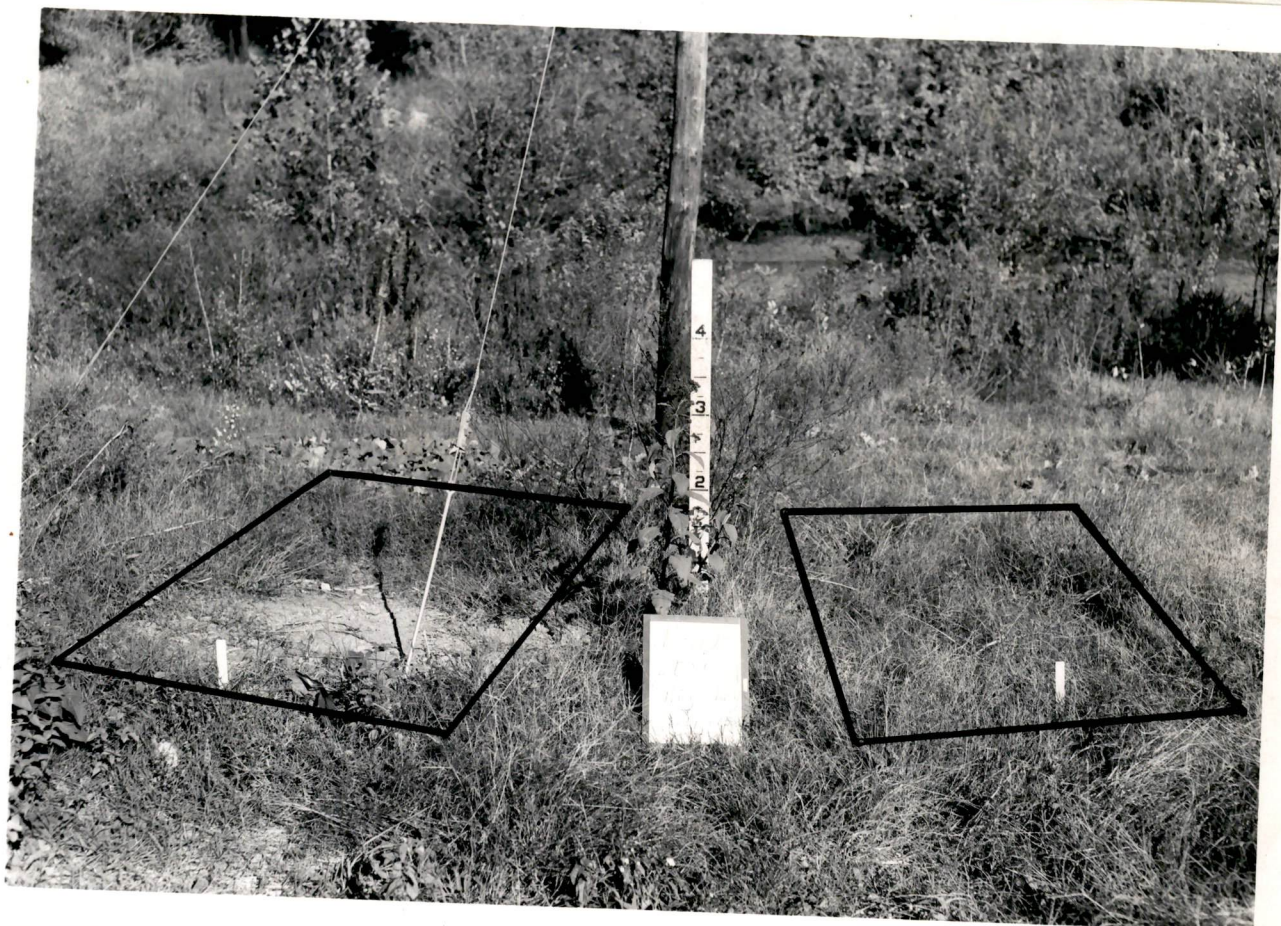


Spring treated

Fall treated

Figure 10--Photograph (October 28, 1958) of Neubert fine sandy loam soil treated with the high rate of "Chlorea".



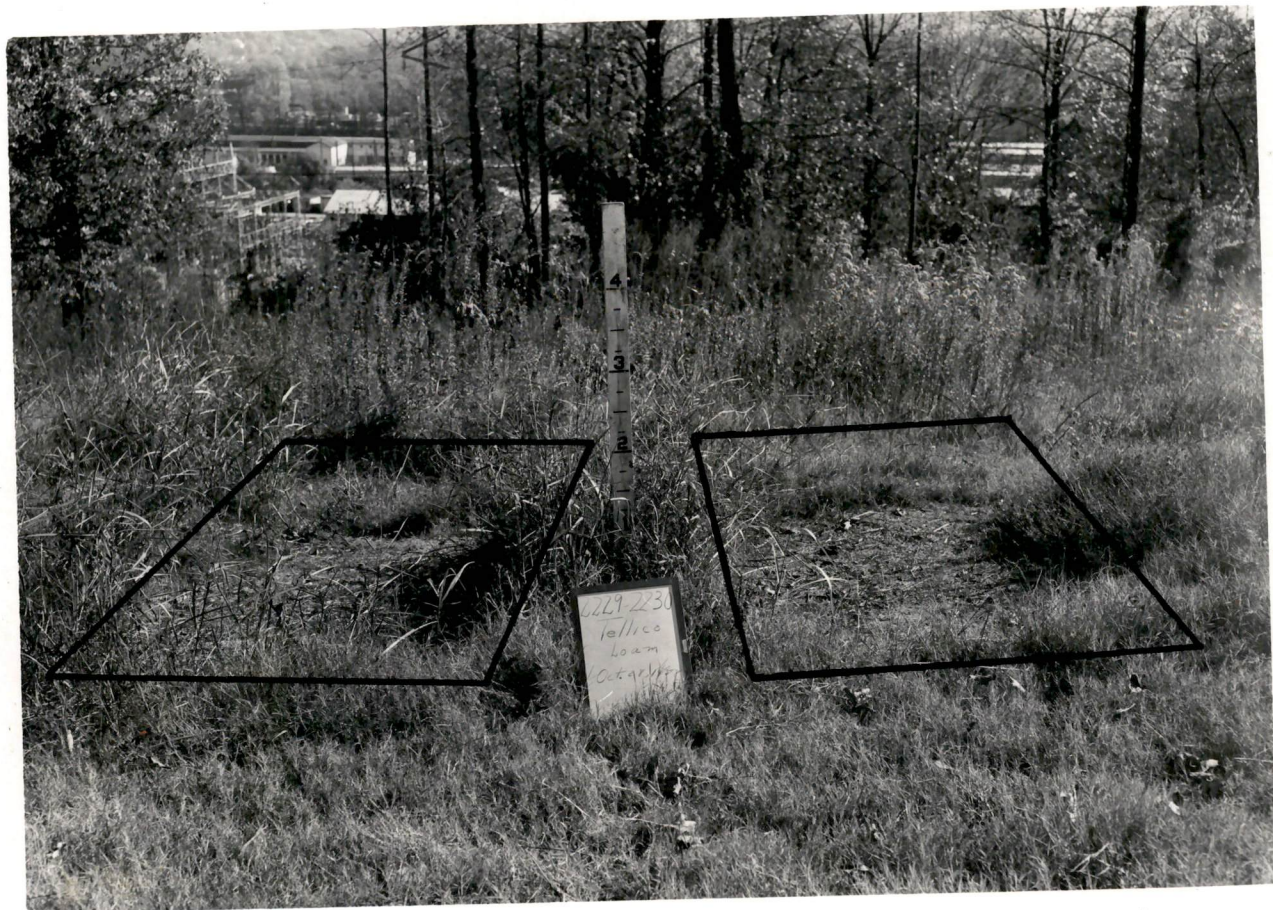


Spring treated

Fall treated

Figure 11--Photograph (October 28, 1958) of Etowah silty clay soil treated with the high rate of monuron.



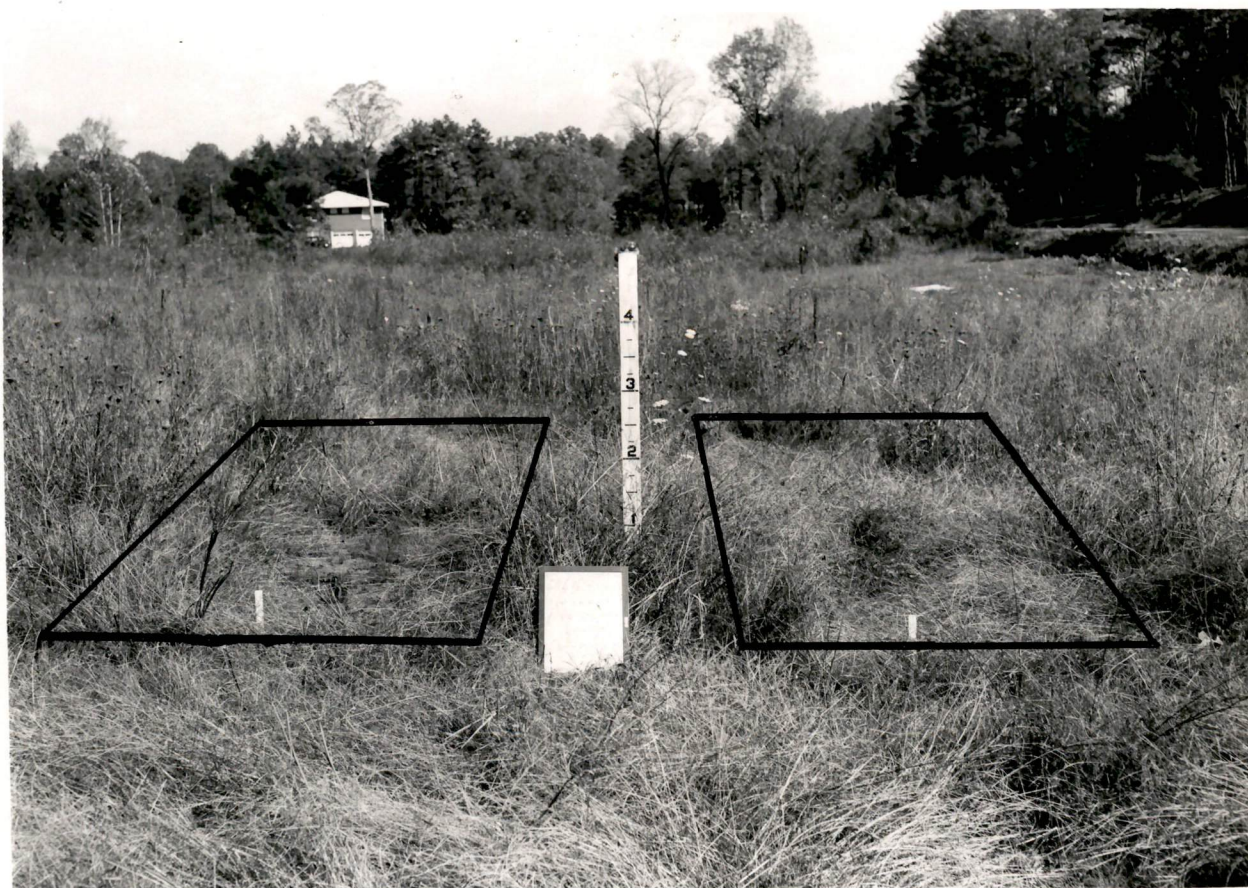


Spring treated

Fall treated

Figure 12--Photograph (October 28, 1958) of Tellico loam soil treated with the high rate of monuron.



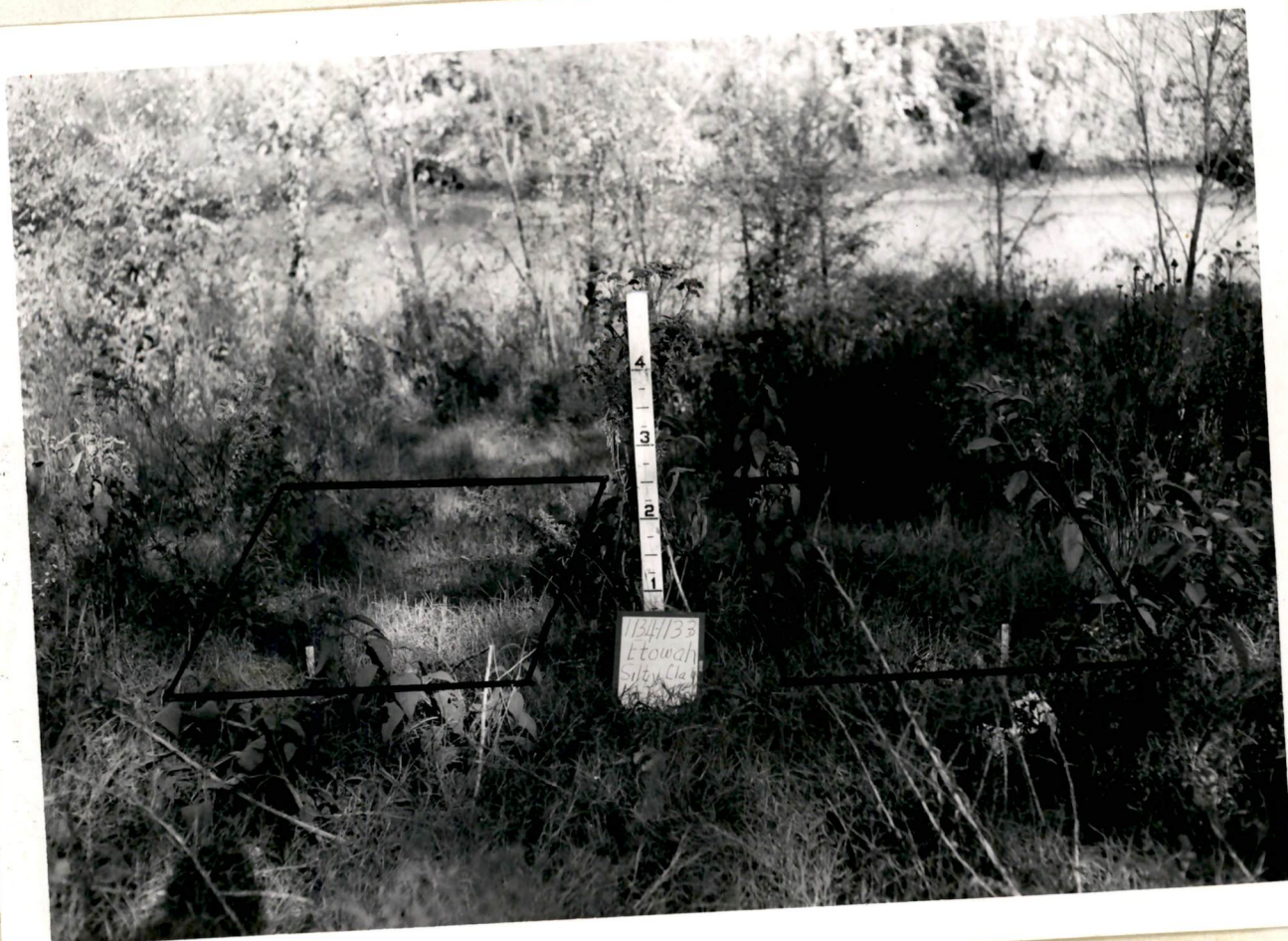


Spring treated

Fall treated

Figure 13--Photograph (October 28, 1958) of Neubert fine sandy loam soil treated with the high rate of monuron.





Spring treated

Fall treated

Figure 14--Photograph (October 28, 1958) of Etowah silty clay soil treated with the high rate of simazine.



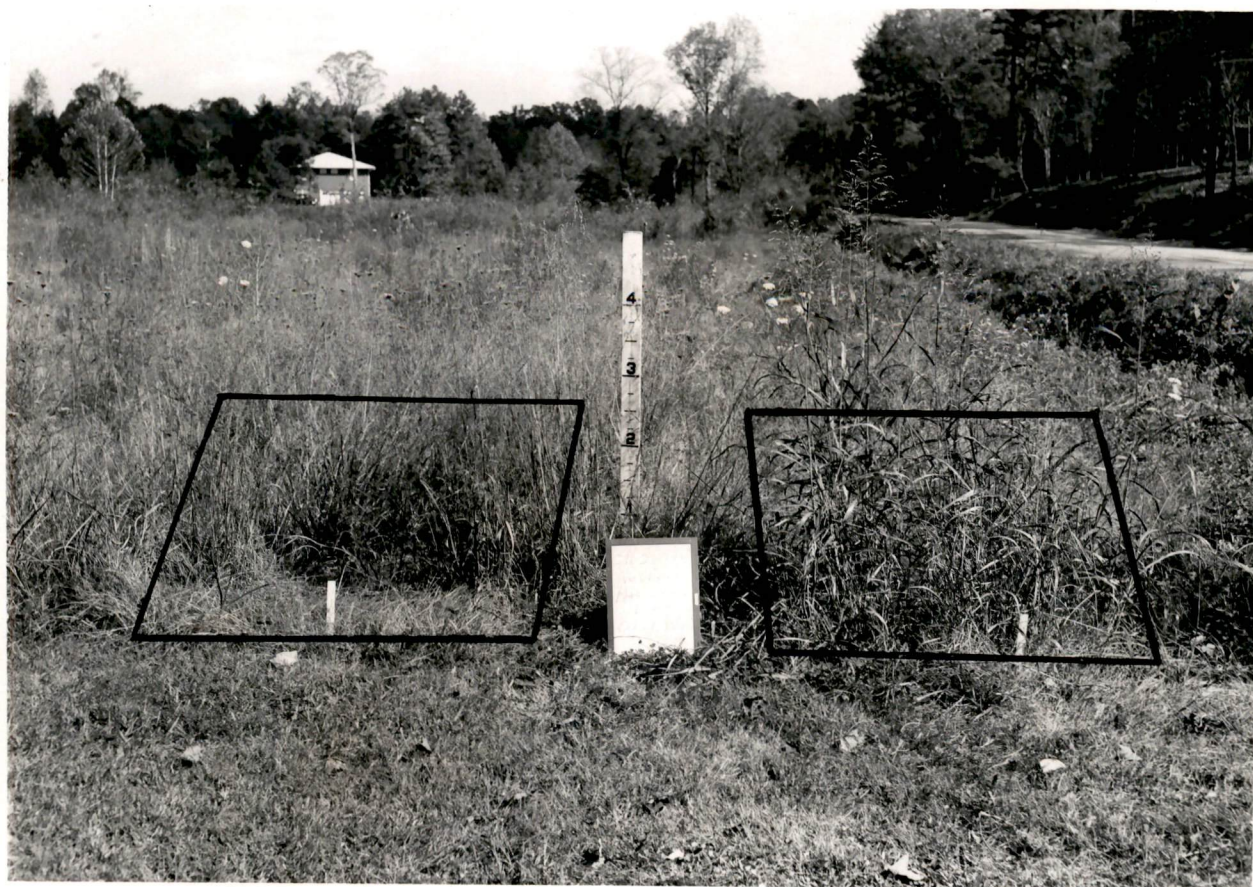


Fall treated

Spring treated

Figure 15--Photograph (October 28, 1958) of Tellico loam soil treated with the high rate of simazine.





Fall treated

Spring treated

Figure 16--Photograph (October 28, 1958) of Neubert fine sandy loam soil treated with the high rate of simazine.



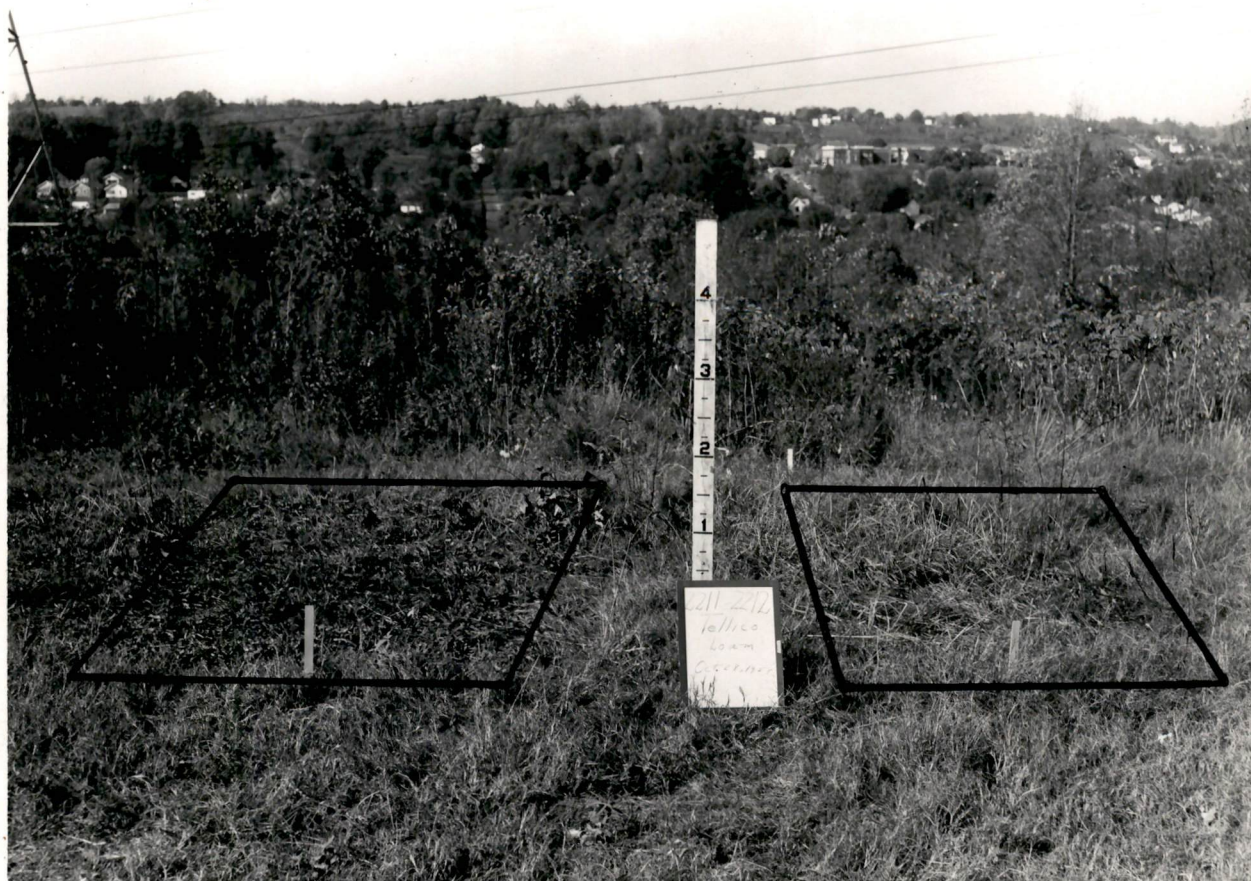


Fall treated

Spring treated

Figure 17--Photograph (October 28, 1958) of Etowah silty clay soil treated with the high rate of "Atlacide".



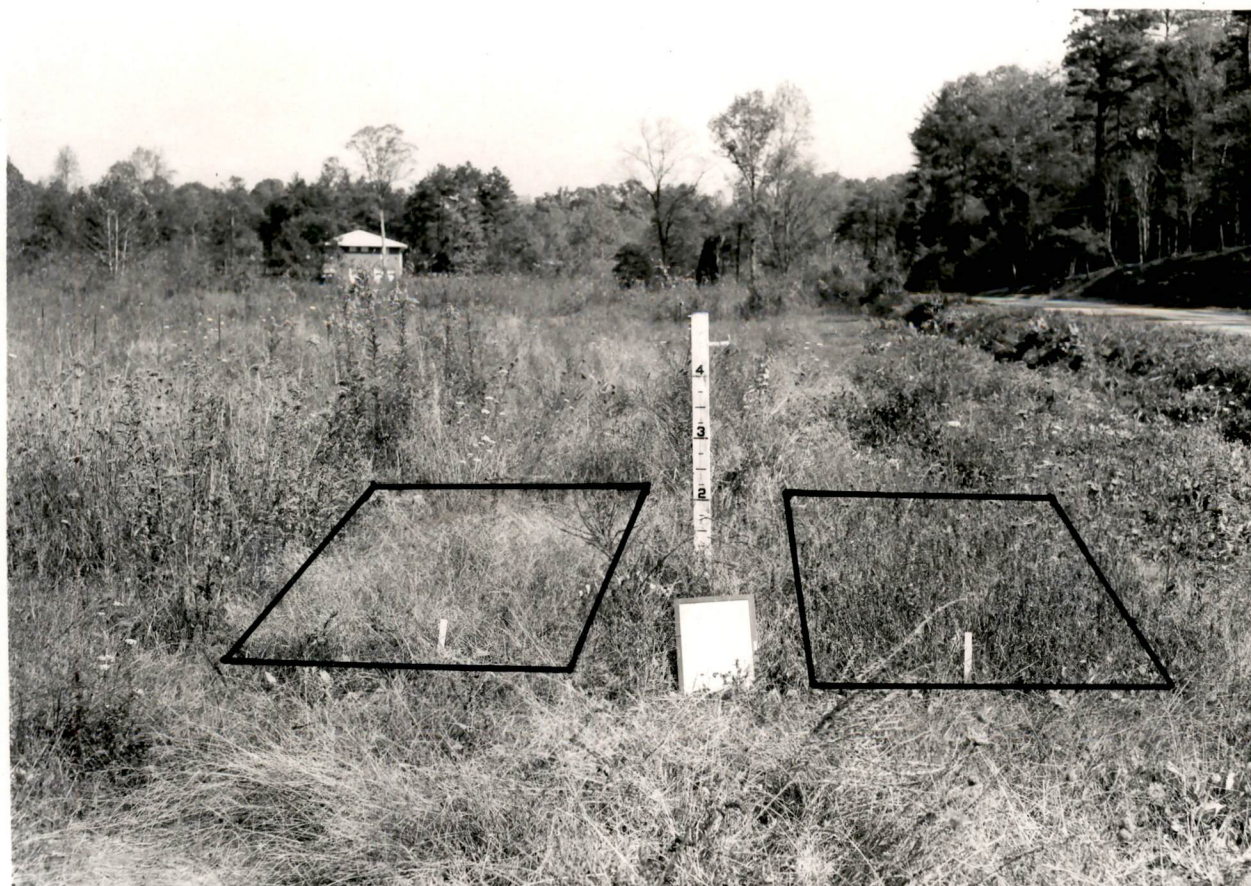


Fall treated

Spring treated

Figure 18--Photograph (October 28, 1958) of Tellico loam soil treated with the high rate of "Atlacide".



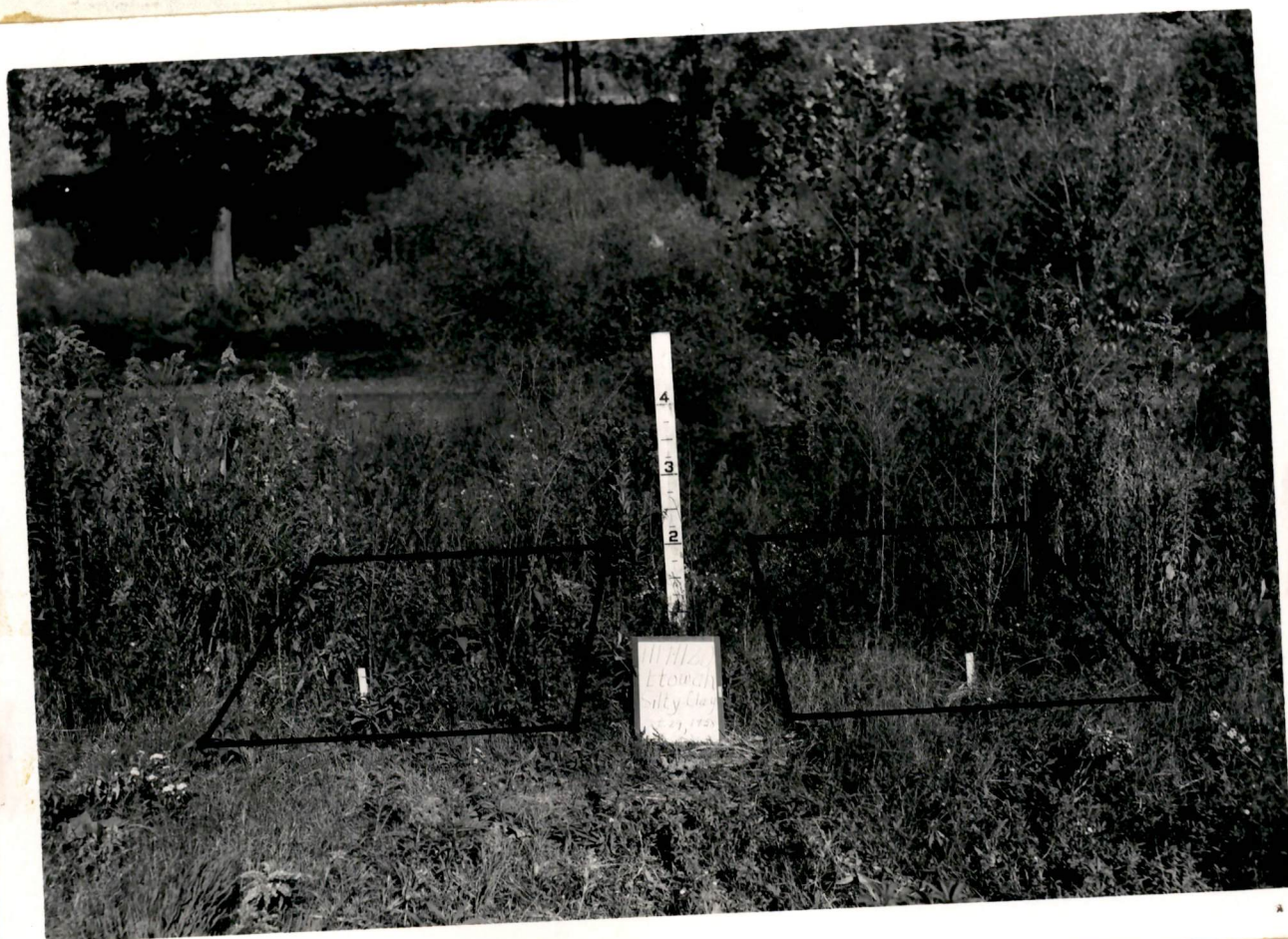


Spring treated

Fall treated

Figure 19--Photograph (October 28, 1958) of Neubert fine sandy loam soil treated with the high rate of "Atlacide".



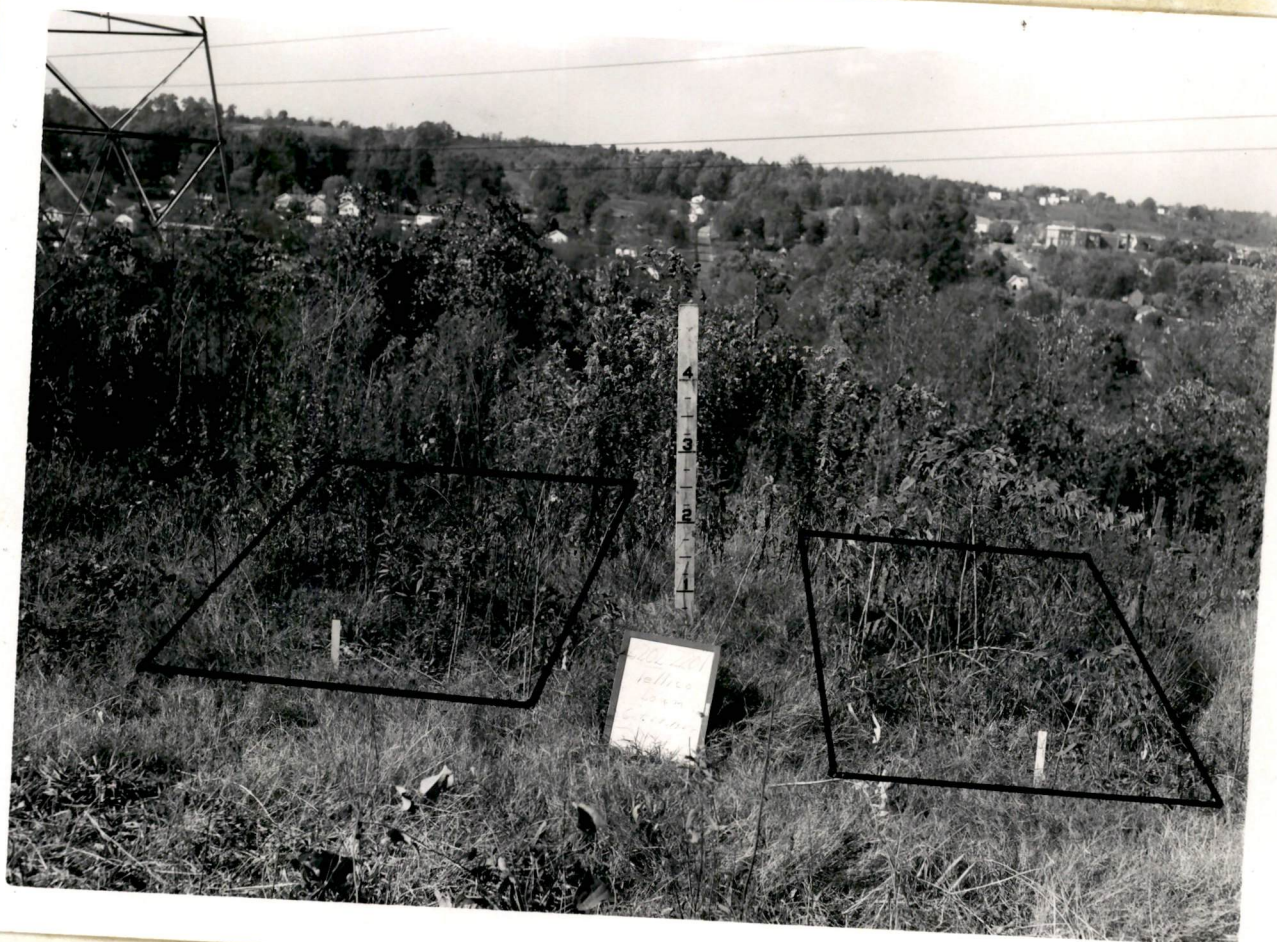


Spring treated

Fall treated

Figure 20--Photograph (October 28, 1958) of Etowah silty clay soil treated with the high rate of Sodium TCA.



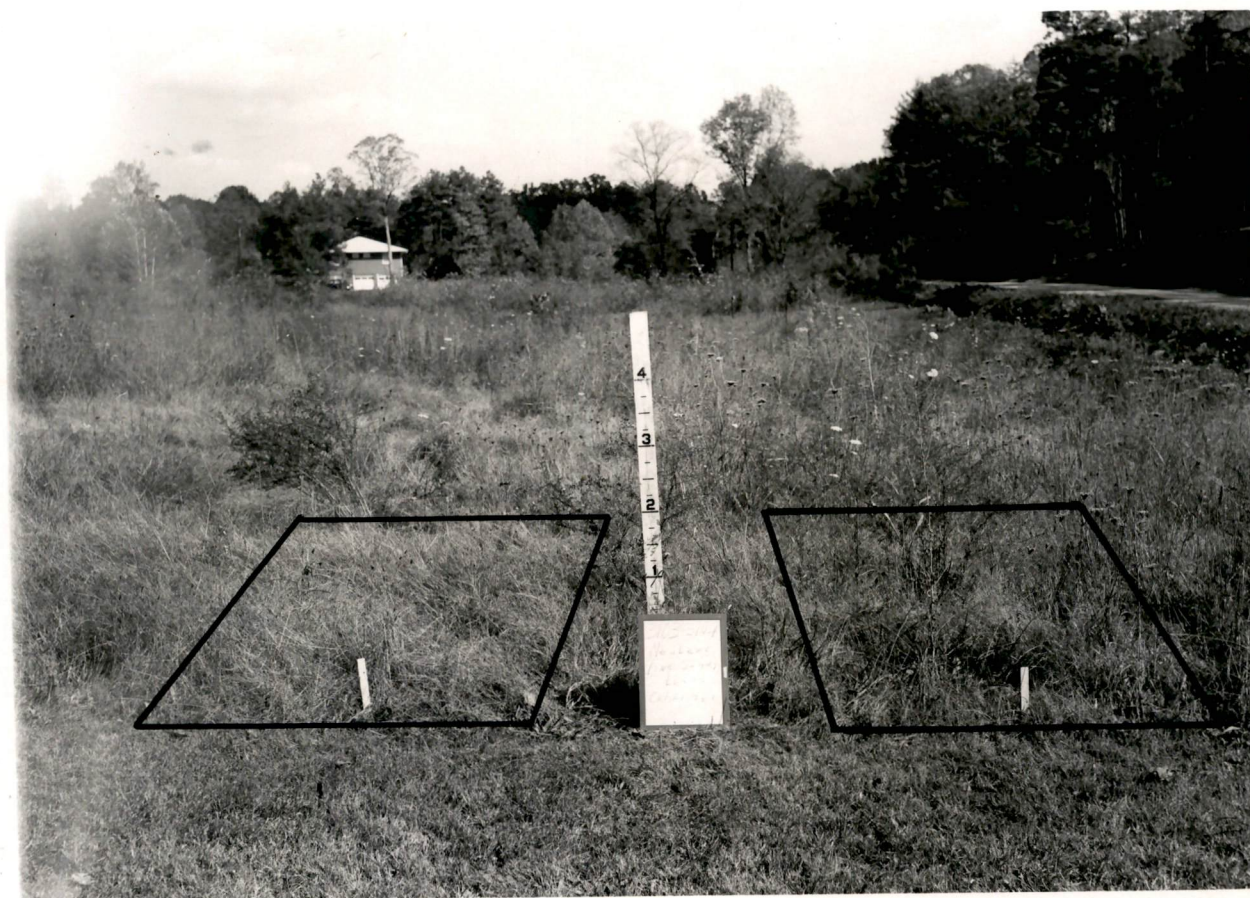


Fall treated

Spring treated

Figure 21--Photograph (October 28, 1958) of Tellico loam soil treated with the high rate of Sodium TCA.





Spring treated

Fall treated

Figure 22---Photograph (October 28, 1958) of Neubert fine sandy loam soil treated with the high rate of Sodium TCA.



As far as total vegetation control by soil sterilants and persistence of the herbicides, none rated high. Even the high rate, which was one-third more than the rate recommended by the manufacturer, failed to control all vegetation for as much as 1 year.

In June, 1958, a second survey was made of each plot, and a tabulation was made of the species not controlled by each treatment. The results are found in Appendix D. Some species of weeds and grasses were not killed by certain chemicals regardless of rate used. In other cases higher rates of certain herbicides gave better control than lower amounts of the same or other materials.

Herbicides that are slowly soluble are most often slowly leached, especially if applied at a heavy rate. Their remaining on the soil surface for a long period of time allows for at least partial removal by the lateral movement of surface water. Figure 23 shows the lateral movement of monuron from a plot treated at the heavy rate. This picture shows the most lateral movement of any of the materials used in this study.

### Greenhouse Results

A laboratory bioassay was conducted in order to determine the persistence of the herbicides at different soil depths. In May, following the application of chemicals, soil samples were taken from plots treated the previous fall at the high rate and from untreated adjacent areas. Plants were grown in pots filled with these soil samples, as described in the previous chapter. A photograph of indicator plants





Figure 23--Photograph (October 28, 1958) of plots treated with monuron at the high rate. Area to right of marker is outside the plot area. Control resulted from lateral movement of the herbicide. Etowah silty clay, 5% slope. Plot was treated March 15, 1958.



growing in treated and untreated soil is shown in figure 24. The plants showed apparent normal growth. There was no measurable residual toxicity revealed by this technique.





Figure 24--Photograph of Ogden soybeans and Martin milo as legume and grass indicators of persistence or leaching (July 15, 1958). Separate samples from 5 depths represent individual plots which had been treated with 5 different herbicides at the high rate. Plants in all treatments appeared normal. Plots were treated November 5, 1957; samples were taken May 20, and seeded May 25, 1958.



## CHAPTER V

### DISCUSSION OF RESULTS

More important than the degree of control of either broadleaf plants or grasses is whether a soil sterilant will give effective control of all vegetation long enough to be profitable. The longer a herbicide controls vegetation, the more valuable it becomes. If soil sterilants are to be profitable, residual control for a number of years is desirable. This would save the annual cost of labor and equipment.

In arid areas such as are found in parts of western United States, soil sterilant herbicides do not become inactivated for several years. Wiese (31) reported that either monuron applied at 60 pounds per acre or sodium chlorate applied at 800 pounds per acre would persist for 3 to 5 years in Texas.

It seems evident that certain factors as suggested by several research workers (8, 11, 23) are responsible for the rate of decomposition of herbicides in the soil. Perhaps microbial activity as influenced by temperature and moisture plays the more important part in decomposition. Other factors such as soil fertility, soil type, soil organic matter content, and soil pH as reviewed by Roberts (24) could affect the rate of inactivation. Or it may be that differences in materials allow for physical removal of part of the chemical by windblow or inactivation by ultra-violet light as suggested by Hill et al. (12). Perhaps some of these factors have greater influence on decomposition of herbicides, or maybe there is an interaction of the several factors which



determine whether a given chemical will kill shallow or deep rooted weeds, whether it will be temporary or relatively permanent and the rate required to give satisfactory results.

In this experiment, monuron was applied at the high rate of 100 pounds per acre and sodium chlorate at the high rate of 2400 pounds per acre. Neither controlled broadleaf and grass annuals and perennials for as long as 1 year. It was expected that other herbicides used at the high rate in this experiment would have persisted and prevented recurrence of growth, but all vegetation was not controlled.

Generally, time of application showed little effect as pertains to residual control since all materials lasted less than 1 year. Under the adverse climatic conditions found in East Tennessee, time of application could be important for seasonal control or for a specific purpose if used on a temporary soil sterilization basis. Parris (20) found better control from fall applications than from spring applications in Montana. In that arid area it seems reasonable.

The only difference in toxicity as affected by soil type in this experiment was observed on Neubert fine sandy loam, the coarsest textured soil of the three tested. The fall treated plots showed less control of vegetation than any of the other treatments. Several research workers (8, 23, 24) agree that herbicides are inactivated more rapidly in a coarser textured soil. There was not a wide difference in the textural grades of the soils studied which may account for the small difference noted.

"Chlorea" gave immediate control of annual and perennial grasses and broadleaf plants in this experiment. Monuron did not kill vegetation



as rapidly as did "Chlorea", but its delayed action was as effective, except that it failed to control Bermudagrass. Simazine gave control of annual weeds and grasses but did not control perennials such as Johnsongrass, Bermudagrass, and sericea. "Atracide" controlled broadleaf plants better than grasses and TCA controlled grasses better than broadleaf plants.

Weed species vary in their inherent tolerance of chemicals (8). Other research workers (23, 24) have reported that inherent toxicity, application rate, and formulation are important factors affecting residual toxicity.

Parris (20) reported no single herbicide available that would economically control all plant species found under the varied conditions throughout the United States. He favored the use of soil sterilant type material followed in succeeding years with contact killing herbicidal oils. On small areas infested with certain persistent perennials the use of certain soil sterilant chemicals resulted in a substantial saving. Certain combinations of soil sterilants provided the most effective results but were expensive.

From the results of this experiment it does not seem feasible to use a single soil sterilant for the control of all vegetation under the soil and climatic conditions prevailing in this area.



## CHAPTER VI

### SUMMARY AND CONCLUSIONS

To determine the possibilities for long-time vegetation control 5 selected soil sterilants were applied, at 3 different rates, on November 5, 1957, and March 15, 1958, to 3 soils of contrasting physical properties. Before treatments, a botanical survey was made to identify and record the species present on each of the three soil types to be treated. Control ratings were made in May, July, August, and October 1958. In June, 1958, a survey was made of each plot, and a tabulation made of the species not controlled by each treatment. In October, 1958, photographs were taken of the plots treated with the high rate.

Within 10 days after treatment all rates of all herbicides had apparently killed the vegetation of each plot. None of the soil sterilant treatments rated high in total control of vegetation by residual toxicity. Even the high rate, which was  $1/3$  more than the rate recommended by the manufacturer, did not control all vegetation for as much as 1 year. The general order of control was "Chlorea", monuron, simazine, "Atlacide", and TCA.

"Chlorea" gave immediate control of annual and perennial grasses and broadleaf plants. Monuron did not kill as rapidly as did "Chlorea" but its delayed action was as effective except that it failed to control Bermudagrass. Simazine gave control of annual weeds and grasses but did not control perennials, such as Johnsongrass, Bermudagrass and sericea. "Atlacide" controlled broadleaf plants better than grasses, while TCA controlled grasses better than broadleaf plants.



Generally, time of application of herbicides at soil sterilant rates showed little effect as pertains to residual control since all materials lasted less than 1 year. The only difference in toxicity as influenced by soil type was observed on Neubert fine sandy loam, the coarsest textured soil of the 3 tested. The fall treated plots on this soil showed less control of vegetation than any of the other treatments.

A laboratory bioassay, 7 1/2 months after treatment, failed to show any residual toxicity in the soil at any of 5 depths down to 30 inches. The indicator plants grew normally in samples of soil taken in May from plots treated the previous fall at the heavy rates of each herbicide and from adjacent areas. Either the herbicides had been decomposed, had leached deeper than the depths tested at the time soil samples were taken; or, the compositing and mixing of the soil samples destroyed the toxicity of the herbicides.



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## APPENDICES



# APPENDIX A

A tabulation of species found growing on the 3 soil types  
before herbicides were applied

Knoxville, Tennessee

September 9, 1957

| Scientific name                   | Common name          | Etowah<br>silty clay | Tellico<br>loam | Neubert<br>fine sandy<br>loam |
|-----------------------------------|----------------------|----------------------|-----------------|-------------------------------|
| <i>Acalypha rhomboidea</i>        | three-seeded mercury | * <sup>a</sup>       | *               | *                             |
| <i>Achillea millefolium</i>       | common yarrow        |                      |                 | *                             |
| <i>Albizia julibrissin</i>        | silk-tree            | *                    | *               |                               |
| <i>Allium vineale</i>             | wild garlic          | *                    | *               | *                             |
| <i>Amaranthus hybridus</i>        | green amaranth       | *                    |                 |                               |
| <i>Ambrosia bidentata</i>         | lanceleaf ragweed    | *                    | *               | *                             |
| <i>Ambrosia trifida</i>           | giant ragweed        | *                    |                 |                               |
| <i>Ampelimum albidus</i>          | climbing milkweed    | *                    |                 |                               |
| <i>Andropogon virginicus</i>      | broomsedge           | *                    | *               | *                             |
| <i>Apocynum cannabinum</i>        | Indian hemp          | *                    |                 |                               |
| <i>Arctium minus</i>              | common burdock       | *                    | *               |                               |
| <i>Asparagus officinalis</i>      | garden asparagus     |                      | *               |                               |
| <i>Asclepias purpurascens</i>     | purple milkweed      |                      |                 | *                             |
| <i>Asclepias syriaca</i>          | common milkweed      | *                    |                 |                               |
| <i>Aster ericoides</i>            | aster                |                      |                 | *                             |
| <i>Aster spp.</i>                 | aster                | *                    | *               |                               |
| <i>Bidens frondosa</i>            | devils beggarticks   |                      | *               |                               |
| <i>Brachyelytrum erectum</i>      | brachyelytrum        | *                    | *               |                               |
| <i>Bromus catharticus</i>         | rescuegrass          | *                    |                 |                               |
| <i>Campsis radicans</i>           | trumpet-creeper      |                      |                 | *                             |
| <i>Carex pensylvanica</i>         | sedge                |                      |                 | *                             |
| <i>Cassia fasciculata</i>         | partridgepea         |                      | *               |                               |
| <i>Cassia nictitans</i>           | wild sensitive plant |                      |                 | *                             |
| <i>Cassia tora</i>                | sicklepod            |                      |                 | *                             |
| <i>Celtis occidentalis</i>        | hackberry            | *                    | *               |                               |
| <i>Cercis canadensis</i>          | redbud               | *                    |                 | *                             |
| <i>Chenopodium album</i>          | common lambsquarters | *                    | *               |                               |
| <i>Chenopodium ambrosioides</i>   | Mexican tea          | *                    | *               |                               |
| <i>Chrysanthemum leucanthemum</i> | oxeye daisy          |                      | *               | *                             |
| <i>Cirsium altissimum</i>         | tall thistle         |                      | *               | *                             |
| <i>Cirsium discolor</i>           | common thistle       | *                    | *               | *                             |

<sup>a</sup>See footnote at end of table.



## APPENDIX A (continued)

| Scientific name                  | Common name          | Etowah<br>silty clay | Tallapoosa<br>loam | Neubert<br>fine sandy<br>loam |
|----------------------------------|----------------------|----------------------|--------------------|-------------------------------|
| <i>Convolvulus arvensis</i>      | field bindweed       |                      |                    | *                             |
| <i>Convolvulus sepium</i>        | hedge bindweed       | *                    |                    | *                             |
| <i>Crepis</i> sp.                | hawkbeard            |                      | *                  |                               |
| <i>Cynodon dactylon</i>          | Bermudagrass         | *                    | *                  |                               |
| <i>Cyperus retrofractus</i>      | galingale            |                      | *                  |                               |
| <i>Cyperus</i> sp.               | galingale            | *                    | *                  |                               |
| <i>Cyperus strigosus</i>         | galingale            |                      |                    | *                             |
| <i>Datura Stramonium</i>         | jimsonweed           | *                    |                    |                               |
| <i>Daucus Carota</i>             | wild carrot          |                      | *                  | *                             |
| <i>Desmodium canadense</i>       | Canada tick trefoil  | *                    | *                  | *                             |
| <i>Digitaria ischaemum</i>       | smooth crabgrass     |                      |                    | *                             |
| <i>Digitaria sanguinalis</i>     | large crabgrass      |                      | *                  | *                             |
| <i>Dioscorea batatas</i>         | Chinese yam          | *                    |                    |                               |
| <i>Diospyros virginiana</i>      | persimmon            | *                    | *                  | *                             |
| <i>Duchesnea indica</i>          | Indian strawberry    | *                    |                    |                               |
| <i>Elephantopus carolinianus</i> | elephant's-foot      | *                    | *                  |                               |
| <i>Eleusine indica</i>           | goosegrass           |                      | *                  |                               |
| <i>Erechtites hieracifolia</i>   | hawkweed             |                      | *                  |                               |
| <i>Erigeron canadensis</i>       | horseweed            |                      | *                  | *                             |
| <i>Erigeron</i> sp.              | fleabane             |                      | *                  |                               |
| <i>Eupatorium altissimum</i>     | thoroughwort         |                      | *                  |                               |
| <i>Euphorbia corollata</i>       | flowering spurge     |                      |                    | *                             |
| <i>Euphorbia maculata</i>        | spotted spurge       |                      | *                  | *                             |
| <i>Fragaria</i> sp.              | strawberry           |                      | *                  | *                             |
| <i>Gladiolus hortulanus</i>      | garden gladiolus     |                      | *                  |                               |
| <i>Gleditsia triacanthos</i>     | honey-suckle         | *                    |                    |                               |
| <i>Gnaphalium purpureum</i>      | purple cudweed       |                      | *                  | *                             |
| <i>Hypericum prolificum</i>      | St. John's-wort      |                      |                    | *                             |
| <i>Ipomoea hederacea</i>         | morningglory         |                      |                    | *                             |
| <i>Ipomoea lacunosa</i>          | ivyleaf morningglory | *                    |                    |                               |
| <i>Ipomoea purpurea</i>          | common morningglory  | *                    |                    |                               |
| <i>Juncus tenuis</i>             | slender rush         |                      | *                  |                               |
| <i>Lactuca canadensis</i>        | tall lettuce         |                      | *                  |                               |
| <i>Lactuca</i> sp.               | wild lettuce         |                      |                    | *                             |
| <i>Lespedeza cuneata</i>         | sericea              | *                    | *                  | *                             |
| <i>Ligustrum ovalifolium</i>     | California privet    | *                    | *                  |                               |
| <i>Liriodendron tulipifera</i>   | tulip-tree           |                      | *                  |                               |
| <i>Lonicera japonica</i>         | Japanese honeysuckle | *                    | *                  | *                             |



## APPENDIX A (continued)

| Scientific name                  | Common name             | Etowah<br>silty clay | Tellico<br>loam | Neibert<br>fine sandy<br>loam |
|----------------------------------|-------------------------|----------------------|-----------------|-------------------------------|
| <i>Maclura pomifera</i>          | osage orange            | *                    |                 |                               |
| <i>Menispermum canadense</i>     | moonseed                |                      |                 | *                             |
| <i>Morus alba</i>                | white mulberry          | *                    |                 |                               |
| <i>Muhlenbergia schreberi</i>    | nimblewill              |                      |                 | *                             |
| <i>Oxalis repens</i>             | sheep sorrel            |                      |                 | *                             |
| <i>Oxalis stricta</i>            | yellow woodsorrel       |                      | *               |                               |
| <i>Panicum anceps</i>            | panic-grass             |                      | *               | *                             |
| <i>Panicum meridionale</i>       | panic-grass             |                      | *               |                               |
| <i>Paspalum dilatatum</i>        | dallisgrass             |                      | *               |                               |
| <i>Paspalum pubescens</i>        | paspalum                | *                    |                 |                               |
| <i>Paspalum pubiflorum</i>       | paspalum                | *                    |                 |                               |
| <i>Passiflora incarnata</i>      | maypop passionflower    | *                    |                 |                               |
| <i>Passiflora lutea</i>          | yellow passionflower    | *                    |                 |                               |
| <i>Perilla frutescens</i>        | perilla                 | *                    |                 |                               |
| <i>Phlox paniculata</i>          | perennial phlox         | *                    |                 |                               |
| <i>Physalis longifolia</i>       | longleaf groundcherry   | *                    |                 |                               |
| <i>Phytolacca americana</i>      | pokeweed                | *                    | *               | *                             |
| <i>Plantago lanceolata</i>       | buckhorn plantain       | *                    | *               | *                             |
| <i>Plantago major</i>            | broadleaf plantain      |                      |                 | *                             |
| <i>Platanus occidentalis</i>     | sycamore                |                      |                 | *                             |
| <i>Poa pratensis</i>             | Kentucky bluegrass      | *                    |                 | *                             |
| <i>Polygonum aviculare</i>       | prostrate knotweed      |                      | *               |                               |
| <i>Polygonum hydropiperoides</i> | mild smartweed          | *                    |                 |                               |
| <i>Polygonum pennsylvanicum</i>  | Pennsylvania smartweed  | *                    | *               |                               |
| <i>Polymnia uvedalia</i>         | bearsfoot               | *                    |                 |                               |
| <i>Prunus persica</i>            | peach                   | *                    | *               |                               |
| <i>Prunus serotina</i>           | black cherry            | *                    | *               |                               |
| <i>Pueraria lobata</i>           | kudzu                   | *                    |                 |                               |
| <i>Pyrus malus</i>               | apple                   |                      | *               |                               |
| <i>Quercus alba</i>              | white oak               |                      | *               |                               |
| <i>Quercus falcata</i>           | Spanish oak             |                      | *               |                               |
| <i>Ranunculus abortivus</i>      | kidneyleaf buttercup    |                      |                 | *                             |
| <i>Ranunculus parviflorus</i>    | smallflowered buttercup | *                    |                 |                               |
| <i>Rhus glabra</i>               | smooth sumac            |                      | *               |                               |
| <i>Rhus radicans</i>             | poison ivy              | *                    | *               | *                             |
| <i>Rosa</i> sp.                  | rose                    |                      |                 | *                             |
| <i>Rubus hispidus</i>            | dewberry                |                      | *               | *                             |
| <i>Rubus</i> sp.                 | blackberry              | *                    | *               | *                             |
| <i>Rudbeckia hirta</i>           | black-eyed susan        |                      |                 | *                             |
| <i>Rumex obtusifolius</i>        | broadleaf dock          |                      |                 | *                             |



## APPENDIX A (continued)

| Scientific name               | Common name          | Etowah<br>silty clay | Tellico<br>loam | Neubert<br>fine sandy<br>loam |
|-------------------------------|----------------------|----------------------|-----------------|-------------------------------|
| <i>Salvia lyrata</i>          | lyre-leaved salvia   |                      |                 | *                             |
| <i>Sambucus canadensis</i>    | elderberry           | *                    |                 |                               |
| <i>Sassafras albidum</i>      | white sassafras      |                      | *               | *                             |
| <i>Senecio smallii</i>        | Small's ragwort      |                      | *               | *                             |
| <i>Silene</i> sp.             | catchfly             |                      | *               |                               |
| <i>Smilax rotundifolia</i>    | common greenbrier    |                      | *               | *                             |
| <i>Solanum carolinense</i>    | Carolina horsenettle | *                    | *               | *                             |
| <i>Solidago altissima</i>     | goldenrod            | *                    | *               | *                             |
| <i>Sorghum halapense</i>      | Johnsongrass         | *                    |                 | *                             |
| <i>Spiraea</i>                | spiraea              |                      |                 | *                             |
| <i>Taraxacum officinale</i>   | dandelion            | *                    |                 | *                             |
| <i>Trifolium pratensis</i>    | red clover           | *                    |                 | *                             |
| <i>Trifolium repens</i>       | white clover         | *                    |                 |                               |
| <i>Triodia flava</i>          | tall red-top         | *                    | *               | *                             |
| <i>Ulmus alata</i>            | winged elm           |                      |                 | *                             |
| <i>Ulmus americana</i>        | American elm         | *                    | *               |                               |
| <i>Urtica dioica</i>          | stinging nettle      | *                    |                 |                               |
| <i>Verbena urticifolia</i>    | white vervain        |                      |                 | *                             |
| <i>Verbesina occidentalis</i> | yellow wingstem      | *                    | *               | *                             |
| <i>Verbesina virginica</i>    | tickweed             | *                    |                 |                               |
| <i>Vernonia altissima</i>     | tall ironweed        | *                    |                 | *                             |
| <i>Vicia</i> sp.              | vetch                |                      | *               |                               |
| <i>Viola papilionacea</i>     | violet               | *                    |                 |                               |
| <i>Vitis aestivalis</i>       | summer grape         |                      |                 | *                             |
| <i>Vitis labruscana</i>       | foxgrape             |                      | *               |                               |

\*Asterisk indicates species present on soil type.



# APPENDIX B

Inches of daily and monthly precipitation, University of Tennessee  
Agricultural Experiment Station, Knoxville,  
November, 1957 through October, 1958

| Day   | Nov. | Dec. | Jan. | Feb. | March | April | May  | June | July | Aug. | Sept. | Oct. |
|-------|------|------|------|------|-------|-------|------|------|------|------|-------|------|
| 1     |      |      |      | .28  |       |       | .35  | .98  |      |      |       |      |
| 2     |      |      |      |      |       |       |      | .02  |      | .25  |       |      |
| 3     |      | .24  |      |      |       |       |      |      |      | .09  |       | .08  |
| 4     |      |      |      |      |       |       |      |      |      |      |       |      |
| 5     |      |      |      |      |       |       | .22  |      |      |      |       |      |
| 6     |      |      |      | .61  |       | .46   | .66  |      | .97  |      |       |      |
| 7     |      | 1.47 |      | .35  | .55   |       | 1.44 |      | .89  |      | .54   |      |
| 8     | .61  | .86  |      |      |       |       | .07  |      | .11  |      |       |      |
| 9     |      | .12  |      |      | .39   |       |      |      | .13  | .15  |       |      |
| 10    |      |      |      |      |       | .42   | .41  |      |      |      |       |      |
| 11    |      |      |      |      |       |       | .03  |      |      | .13  |       |      |
| 12    |      |      |      |      |       |       | .01  |      | .40  |      |       |      |
| 13    |      |      | .80  |      | .58   |       |      |      | .76  |      |       |      |
| 14    | .65  |      |      |      |       |       |      |      |      |      |       |      |
| 15    |      |      | .05  |      |       | .49   |      |      |      |      |       |      |
| 16    | 2.30 |      |      |      |       |       |      |      | .29  |      |       |      |
| 17    | .50  |      |      |      | .75   |       | .61  |      |      |      | .34   |      |
| 18    | 2.45 |      |      |      |       |       |      |      |      |      |       |      |
| 19    | .54  | .27  |      |      |       |       |      |      |      |      |       |      |
| 20    |      | 1.55 | .16  |      |       |       | .94  | .17  | 1.48 |      |       |      |
| 21    |      |      | .06  |      |       | 1.01  |      |      | .12  | .59  | 1.64  |      |
| 22    | .80  |      |      |      |       | .52   |      | .33  |      | .13  |       |      |
| 23    |      |      |      |      |       |       |      |      | .60  |      |       |      |
| 24    |      |      | .40  |      | .35   |       |      |      |      | .55  |       |      |
| 25    | .87  | .96  | .22  |      |       | 1.44  |      |      |      |      |       |      |
| 26    |      |      |      | .75  | .21   |       |      | .78  | .20  |      |       |      |
| 27    |      |      |      | .51  |       | .72   |      |      |      |      |       |      |
| 28    |      | .17  |      |      |       | .03   |      |      | .17  |      |       |      |
| 29    | .05  |      |      |      |       |       |      |      |      |      |       |      |
| 30    |      |      |      |      | .93   |       |      |      |      |      | .76   |      |
| 31    |      | .22  |      |      |       |       |      |      | .09  |      |       |      |
| Total | 8.77 | 5.86 | 1.69 | 2.50 | 3.76  | 5.09  | 4.74 | 2.28 | 6.21 | 1.89 | 3.28  | .08  |



# APPENDIX C

Daily maximum and minimum temperatures, degrees F., at the  
Tennessee Agricultural Experiment Station, Knoxville,  
November, 1957 through October, 1958

| Day | November |      | December |      | January |      | February |      | March |      | April |      |
|-----|----------|------|----------|------|---------|------|----------|------|-------|------|-------|------|
|     | Min.     | Max. | Min.     | Max. | Min.    | Max. | Min.     | Max. | Min.  | Max. | Min.  | Max. |
| 1   | 40       | 74   | 28       | 48   | 32      | 34   | 30       | 34   | 42    | 60   | 44    | 68   |
| 2   | 42       | 73   | 36       | 60   | 14      | 40   | 20       | 24   | 42    | 65   | 40    | 72   |
| 3   | 57       | 62   | 36       | 52   | 16      | 46   | 16       | 34   | 40    | 58   | 56    | 76   |
| 4   | 54       | 56   | 32       | 36   | 21      | 38   | 16       | 40   | 32    | 57   | 56    | 70   |
| 5   | 54       | 62   | 25       | 55   | 22      | 44   | 36       | 38   | 33    | 66   | 52    | 76   |
| 6   | 32       | 62   | 36       | 60   | 22      | 38   | 40       | 51   | 48    | 58   | 56    | 75   |
| 7   | 32       | 63   | 56       | 56   | 30      | 38   | 42       | 44   | 48    | 54   | 52    | 50   |
| 8   | 54       | 64   | 46       | 56   | 18      | 26   | 24       | 34   | 48    | 56   | 34    | 64   |
| 9   | 38       | 58   | 38       | 40   | 14      | 42   | 16       | 30   | 50    | 56   | 44    | 66   |
| 10  | 30       | 58   | 26       | 48   | 22      | 54   | 16       | 32   | 40    | 51   | 56    | 65   |
| 11  | 22       | 54   | 20       | 24   | 28      | 58   | 20       | 40   | 40    | 60   | 52    | 50   |
| 12  | 40       | 62   | 6        | 26   | 30      | 52   | 20       | 36   | 38    | 58   | 40    | 68   |
| 13  | 50       | 64   | 18       | 44   | 36      | 46   | 18       | 34   | 48    | 56   | 38    | 68   |
| 14  | 56       | 65   | 38       | 51   | 46      | 46   | 20       | 46   | 40    | 54   | 44    | 70   |
| 15  | 48       | 68   | 50       | 63   | 43      | 44   | 34       | 35   | 34    | 52   | 54    | 56   |
| 16  | 56       | 68   | 54       | 58   | 38      | 44   | 14       | 20   | 33    | 54   | 54    | 78   |
| 17  | 60       | 71   | 53       | 58   | 30      | 37   | 4        | 18   | 36    | 48   | 50    | 78   |
| 18  | 60       | 73   | 52       | 66   | 34      | 40   | 6        | 22   | 44    | 46   | 50    | 82   |
| 19  | 50       | 54   | 54       | 53   | 26      | 42   | 10       | 32   | 40    | 54   | 56    | 80   |
| 20  | 40       | 54   | 58       | 65   | 32      | 52   | 24       | 44   | 36    | 44   | 60    | 80   |
| 21  | 42       | 53   | 42       | 60   | 44      | 62   | 20       | 52   | 30    | 42   | 64    | 71   |
| 22  | 38       | 40   | 34       | 62   | 32      | 40   | 40       | 47   | 30    | 52   | 56    | 58   |
| 23  | 40       | 48   | 34       | 58   | 30      | 53   | 28       | 61   | 43    | 48   | 40    | 82   |
| 24  | 50       | 50   | 41       | 56   | 40      | 54   | 32       | 67   | 46    | 50   | 62    | 83   |
| 25  | 42       | 60   | 48       | 58   | 36      | 42   | 36       | 65   | 50    | 58   | 60    | 66   |
| 26  | 38       | 66   | 56       | 56   | 32      | 43   | 52       | 60   | 52    | 58   | 56    | 64   |
| 27  | 36       | 66   | 30       | 54   | 35      | 36   | 48       | 65   | 50    | 58   | 58    | 76   |
| 28  | 46       | 64   | 42       | 44   | 36      | 36   | 52       | 65   | 50    | 52   | 60    | 75   |
| 29  | 54       | 66   | 34       | 50   | 26      | 38   |          |      | 36    | 60   | 64    | 68   |
| 30  | 40       | 42   | 27       | 54   | 30      | 51   |          |      | 50    | 58   | 50    | 72   |
| 31  |          |      | 32       | 42   | 42      | 56   |          |      | 56    | 60   |       |      |



## APPENDIX C (continued)

| Day | May  |      | June |      | July |      | August |      | September |      | October |      |
|-----|------|------|------|------|------|------|--------|------|-----------|------|---------|------|
|     | Min. | Max. | Min. | Max. | Min. | Max. | Min.   | Max. | Min.      | Max. | Min.    | Max. |
| 1   | 62   | 68   | 66   | 88   | 66   | 90   | 76     | 84   | 70        | 88   | 54      | 58   |
| 2   | 64   | 78   | 68   | 86   | 66   | 94   | 72     | 84   | 60        | 88   | 52      | 60   |
| 3   | 66   | 82   | 62   | 88   | 68   | 95   | 72     | 84   | 64        | 91   | 54      | 60   |
| 4   | 66   | 81   | 70   | 86   | 70   | 90   | 70     | 90   | 68        | 90   | 56      | 72   |
| 5   | 66   | 82   | 72   | 86   | 70   | 86   | 70     | 90   | 68        | 92   | 54      | 80   |
| 6   | 62   | 56   | 70   | 85   | 70   | 88   | 68     | 92   | 68        | 92   | 56      | 82   |
| 7   | 40   | 48   | 62   | 90   | 72   | 88   | 70     | 90   | 64        | 90   | 54      | 78   |
| 8   | 44   | 66   | 66   | 84   | 72   | 76   | 72     | 88   | 62        | 86   | 50      | 78   |
| 9   | 52   | 58   | 70   | 86   | 70   | 84   | 72     | 86   | 56        | 84   | 55      | 76   |
| 10  | 56   | 75   | 68   | 90   | 70   | 86   | 70     | 90   | 58        | 86   | 62      | 76   |
| 11  | 61   | 80   | 68   | 86   | 72   | 86   | 72     | 90   | 70        | 83   | 44      | 72   |
| 12  | 60   | 82   | 65   | 89   | 74   | 80   | 72     | 90   | 66        | 74   | 42      | 72   |
| 13  | 56   | 80   | 68   | 94   | 70   | 86   | 74     | 88   | 66        | 84   | 44      | 78   |
| 14  | 50   | 84   | 72   | 94   | 70   | 86   | 74     | 88   | 60        | 90   | 50      | 82   |
| 15  | 60   | 85   | 73   | 92   | 72   | 88   | 74     | 90   | 64        | 86   | 58      | 86   |
| 16  | 60   | 86   | 68   | 84   | 76   | 86   | 72     | 89   | 74        | 88   | 56      | 80   |
| 17  | 62   | 88   | 62   | 84   | 70   | 86   | 70     | 88   | 72        | 86   | 58      | 80   |
| 18  | 64   | 80   | 62   | 88   | 72   | 90   | 64     | 86   | 60        | 80   | 56      | 84   |
| 19  | 63   | 70   | 62   | 86   | 74   | 92   | 64     | 90   | 54        | 80   | 55      | 80   |
| 20  | 64   | 78   | 72   | 90   | 72   | 90   | 68     | 91   | 64        | 84   | 50      | 78   |
| 21  | 56   | 84   | 66   | 88   | 70   | 85   | 72     | 88   | 64        | 74   | 46      | 78   |
| 22  | 53   | 83   | 68   | 80   | 72   | 84   | 72     | 88   | 68        | 86   | 56      | 73   |
| 23  | 60   | 88   | 56   | 82   | 74   | 85   | 74     | 84   | 64        | 92   | 54      | 74   |
| 24  | 64   | 90   | 62   | 85   | 70   | 78   | 72     | 80   | 64        | 88   | 46      | 74   |
| 25  | 66   | 82   | 62   | 90   | 66   | 86   | 68     | 84   | 66        | 88   | 46      | 64   |
| 26  | 64   | 86   | 72   | 80   | 72   | 92   | 62     | 86   | 68        | 88   | 48      | 56   |
| 27  | 62   | 84   | 60   | 80   | 72   | 90   | 64     | 84   | 70        | 80   | 46      | 55   |
| 28  | 64   | 86   | 60   | 84   | 78   | 90   | 62     | 86   | 54        | 77   | 42      | 66   |
| 29  | 56   | 80   | 60   | 88   | 76   | 92   | 64     | 88   | 54        | 78   | 36      | 70   |
| 30  | 56   | 86   | 64   | 90   | 70   | 94   | 66     | 90   | 56        | 70   | 40      | 70   |
| 31  | 66   | 88   |      |      | 71   | 86   | 70     | 90   |           |      | 40      | 74   |



# APPENDIX D

A tabulation in June, 1958, of species not controlled on plots treated with selected herbicides, Knoxville, Tennessee.

| Botanical name        | Common name          | Time of treatment and material |           |          |           |           |     |   |
|-----------------------|----------------------|--------------------------------|-----------|----------|-----------|-----------|-----|---|
|                       |                      | Fall                           |           |          | Spring    |           |     |   |
|                       |                      | Chl. a/                        | Mon. Sim. | Atl. TCA | Chl. Mon. | Sim. Atl. | TCA |   |
|                       |                      | Lb/                            |           |          |           |           |     |   |
| Acalyph rhomboidea    | three-seeded mercury |                                |           | H        |           |           |     | H |
| Acer negundo          | box-elder            |                                |           |          |           |           |     | H |
| Achillea millefolium  | common yarrow        | M                              | L         |          |           |           |     | M |
| Albizia julibrissin   | silk-tree            | H                              | M         |          |           |           |     |   |
| Allium vineale        | wild garlic          | M                              | M         | H        |           |           |     | H |
| Ambrosia bidentata    | lanceleaf ragweed    | M                              | M         | H        |           |           |     | H |
| Ambrosia sp.          | ragweed              |                                | M         |          |           |           |     |   |
| Ambrosia trifida      | great ragweed        |                                |           |          |           |           |     |   |
| Ampelamus albidus     | climbing milkweed    | L                              | H         |          |           |           |     | H |
| Ampelopsis cordata    | ampelopsis           |                                |           |          |           |           |     | L |
| Andropogon sp.        | beardgrass           |                                |           |          |           |           |     |   |
| Andropogon virginicus | broomsedge           | L                              | L         |          |           |           |     | H |
| Apocynum cannabinum   | Indian hemp          | M                              | M         |          |           |           |     | M |
| Arctium minus         | common burdock       |                                |           |          |           |           |     |   |
| Arctium sp.           | burdock              |                                | L         |          |           |           |     | L |
| Aristida sp.          | triple-awned grass   |                                |           |          |           |           |     |   |
| Asclepias syriaca     | common milkweed      | L                              | H         |          |           |           |     | H |
| Asparagus officinalis | garden asparagus     |                                |           |          |           |           |     |   |
| Aster sp.             | aster                |                                | L         |          |           |           |     |   |
| Bidens frondosa       | devils beggarticks   |                                |           |          |           |           |     |   |
| Brachyelytrum erectum | brachyelytrum        |                                |           |          |           |           |     |   |
| Bromus japonicus      | Japanese brome       |                                | H         |          |           |           |     |   |
| Campsis radicans      | trumpet-creeper      | H                              | H         |          |           |           |     |   |
| Carex cephalophora    | sedge                |                                |           |          |           |           |     |   |
| Carex granularis      | sedge                |                                |           |          |           |           |     |   |
| Carex leavenworthii   | sedge                |                                |           |          |           |           |     |   |
| Carex retroflexa      | sedge                | L                              | L         |          |           |           |     |   |

a/ b/ See footnotes at end of table.



APPENDIX D (continued)

| Botanical name             | Common name            | Time of treatment and material |      |      |      |        |      |      |      |      |     |
|----------------------------|------------------------|--------------------------------|------|------|------|--------|------|------|------|------|-----|
|                            |                        | Fall                           |      |      |      | Spring |      |      |      |      |     |
|                            |                        | Chl.                           | Mon. | Sim. | Atl. | TCA    | Chl. | Mon. | Sim. | Atl. | TCA |
| Carex sp.                  | sedge                  | H                              | M    | M    | H    | H      |      | M    | H    | H    | H   |
| Cassia tora                | sicklepod              |                                |      |      |      |        |      |      |      |      |     |
| Celtis occidentalis        | hackberry              |                                | M    | M    | L    |        |      | L    | M    | H    | M   |
| Cerastium viscosum         | mouse-ear chickweed    |                                |      |      |      |        |      |      |      |      |     |
| Chenopodium album          | common lambsquarters   |                                |      | M    | L    | H      | H    |      | M    | H    | M   |
| Chenopodium ambrosioides   | Mexican tea            |                                |      |      |      | H      | H    |      |      |      |     |
| Chrysanthemum leucanthemum | oxeye daisy            |                                |      |      |      | H      | H    |      |      |      |     |
| Circaea sp.                | enchanter's nightshade |                                |      |      |      | L      | L    |      |      |      |     |
| Cirsium altissimum         | tall thistle           |                                |      |      |      | L      | L    |      |      |      |     |
| Cirsium discolor           | common thistle         |                                |      |      |      | L      | L    |      |      |      |     |
| Cirsium sp.                | thistle                |                                |      |      |      | L      | L    |      |      |      |     |
| Convolvulus sepium         | hedge bindweed         |                                | H    |      |      | M      | M    |      | M    | H    | H   |
| Crepis pulchra             | hawksbeard             |                                |      |      |      |        |      |      |      |      |     |
| Cuscuta sp.                | dodder                 |                                |      |      |      |        |      |      |      |      |     |
| Cynodon dactylon           | bermudagrass           | H                              | H    |      |      | M      | M    |      |      |      |     |
| Cyperus esculentus         | yellow nutsedge        |                                |      |      |      | L      | L    |      | H    | H    |     |
| Cyperus ovularis           | sedge                  |                                |      |      |      | M      | M    |      |      |      |     |
| Cyperus sp.                | sedge                  |                                |      |      |      |        |      |      |      |      |     |
| Datura stramonium          | Jimsonweed             |                                |      |      |      |        |      |      |      |      |     |
| Daucus carota              | wild carrot            |                                |      |      |      | H      | H    |      | H    | H    | H   |
| Desmodium canadense        | Canada tick trefoil    |                                |      |      |      |        |      |      |      |      |     |
| Desmodium rotundifolium    | tick trefoil           |                                |      |      |      |        |      |      |      |      |     |
| Digitaria ischaemum        | small crabgrass        |                                |      |      |      |        |      |      |      |      |     |
| Digitaria sanguinalis      | large crabgrass        |                                |      |      |      |        |      |      |      |      |     |
| Digitaria sp.              | crabgrass              |                                |      |      |      |        |      |      |      |      |     |
| Dioscorea batatas          | Chinese yam            |                                |      |      |      |        |      |      |      |      |     |
| Diospyros virginiana       | persimmon              |                                |      |      |      |        |      |      |      |      |     |
| Duchesnea indica           | Indian strawberry      |                                |      |      |      |        |      |      |      |      |     |



APPENDIX D (continued)

| Botanical name           | Common name           | Time of treatment and material |                    |        |                    |             |
|--------------------------|-----------------------|--------------------------------|--------------------|--------|--------------------|-------------|
|                          |                       | Fall                           |                    | Spring |                    |             |
|                          |                       | Chl.                           | Mon. Sim. Atl. TCA | Chl.   | Mon. Sim. Atl. TCA |             |
| Eleusine indica          | goosegrass            |                                |                    |        |                    | M           |
| Eriogonum sp.            | fleabane              | M                              |                    |        |                    | H H M M L L |
| Eupatorium rotundifolium | composite             | L                              |                    |        |                    |             |
| Eupatorium sp.           | thoroughwort          |                                |                    |        |                    |             |
| Euphorbia corollata      | flowering spurge      |                                |                    |        |                    |             |
| Euphorbia dentata        | spurge                | H                              |                    |        |                    | H M         |
| Euphorbia maculata       | spotted spurge        | H                              |                    |        |                    |             |
| Fragaria sp.             | strawberry            |                                | L L                |        |                    |             |
| Galinisoga parviflora    | smallflower galinsoga |                                |                    |        |                    |             |
| Geranium carolinianum    | Carolina geranium     |                                |                    |        |                    |             |
| Geum canadense           | rose                  |                                |                    |        |                    |             |
| Geum virginicum          | spurge                |                                |                    |        |                    | L H         |
| Gnaphalium purpureum     | purple cudweed        |                                |                    |        |                    |             |
| Hordeum pusillum         | little barley         |                                |                    |        |                    |             |
| Houstonia sp.            | madder                |                                |                    |        |                    |             |
| Ipomoea pandurata        | bigroot morningglory  |                                |                    |        |                    |             |
| Ipomoea purpurea         | common morningglory   |                                |                    |        |                    |             |
| Juncus biflorus          | rush                  |                                |                    |        |                    |             |
| Juncus tenuis            | slender rush          |                                |                    |        |                    |             |
| Lactuca scariola         | prickly lettuce       |                                |                    |        |                    |             |
| Lactuca sp.              | lettuce               |                                |                    |        |                    |             |
| Lepidium virginicum      | Virginia pepperweed   |                                |                    |        |                    |             |
| Lespedeza cuneata        | sericea               |                                |                    |        |                    |             |
| Lespedeza stipulacea     | Korean clover         |                                |                    |        |                    |             |
| Lespedeza striata        | Japanses clover       |                                |                    |        |                    |             |
| Liriodendron tulipifera  | tulip-tree            |                                |                    |        |                    |             |
| Lithospermum officinalis | growwell              |                                |                    |        |                    |             |



APPENDIX D (continued)

| Botanical name         | Common name             | Time of treatment and material |           |     |           |           |     |
|------------------------|-------------------------|--------------------------------|-----------|-----|-----------|-----------|-----|
|                        |                         | Fall                           |           |     | Spring    |           |     |
|                        |                         | Chl. Mon.                      | Sim. Atl. | TCA | Chl. Mon. | Sim. Atl. | TCA |
| Lobelia siphilitica    | great lobelia           | M                              |           |     |           |           | H   |
| Lonicera japonica      | japanes honeysuckle     |                                |           |     |           |           | H   |
| Lychnis alba           | white cockle            |                                | H         |     |           | L         | L   |
| Melilotus sp.          | sweet clover            |                                |           |     |           |           | H   |
| Menispermum canadense  | moonseed                |                                | H         |     |           | H         | M   |
| Mollugo verticillata   | carpetweed              |                                |           |     |           |           |     |
| Monarda fistulosa      | wild bergamot           |                                |           |     |           |           | H   |
| Morus rubra            | red mulberry            |                                |           |     |           |           | L   |
| Tillandsia             | moss                    |                                |           |     |           |           |     |
| Muhlenbergia schreberi | nimblewill              | L                              | M         |     |           |           | M   |
| Oenothera biennis      | common evening primrose |                                |           |     |           |           | M   |
| Oxalis sp.             | wood-sorrel             |                                | L         |     |           |           | M   |
| Panicum anceps         | panic-grass             |                                | H         |     |           |           | H   |
| Panicum dichotomum     | panicum                 |                                | H         |     |           |           | H   |
| Panicum lanuginosum    | panic-grass             |                                | L         |     |           |           |     |
| Panicum sp.            | panic-grass             |                                | L         |     |           |           |     |
| Paspalum sp.           | watergrass              | L                              | H         |     |           |           | H   |
| Passiflora incarnata   | maypop passionflower    | L                              | M         |     |           |           | H   |
| Penstemon sp.          | beard-tongue            | H                              |           |     |           |           | H   |
| Perilla frutescens     | nightshade              |                                |           |     |           |           |     |
| Phaseolus polystachios | kidney-bean             |                                |           |     |           |           |     |
| Phleum pratense        | timothy                 | M                              |           |     |           |           |     |
| Physalis sp.           | ground-cherry           | M                              | L         |     |           |           | L   |
| Phytolacca americana   | pokeweed                |                                | M         |     |           |           | M   |
| Plantago aristata      | bracted plantain        |                                |           |     |           |           | H   |
| Plantago lanceolata    | buckhorn plantain       | M                              |           |     |           |           | H   |
| Plantago major         | broadleaf plantain      | H                              |           |     |           |           | L   |



APPENDIX D (continued)

| Botanical name           | Common name           | Time of treatment and material |      |      |      |     |        |      |      |      |     |   |   |
|--------------------------|-----------------------|--------------------------------|------|------|------|-----|--------|------|------|------|-----|---|---|
|                          |                       | Fall                           |      |      |      |     | Spring |      |      |      |     |   |   |
|                          |                       | Chl.                           | Mon. | Sim. | Atl. | TCA | Chl.   | Mon. | Sim. | Atl. | TCA |   |   |
| Plantago sp.             | plantain              | H                              | H    |      |      |     | M      | H    |      |      | L   | H | L |
| Plantago virginica       | pale-seed-plantain    |                                |      |      |      |     | M      |      |      |      | L   | H | L |
| Poa pratensis            | Kentucky bluegrass    |                                |      |      |      |     | M      |      |      |      |     | H | H |
| Polygonum aviculare      | prostrate knotweed    |                                |      |      |      |     | M      |      |      |      |     |   |   |
| Polygonum sp.            | knotweed              |                                |      |      |      |     |        |      |      |      |     |   |   |
| Prunus serotina          | black cherry          |                                |      |      |      |     | H      |      |      |      |     | H | H |
| Pyrhopaprus carolinianus | false dandelion       |                                |      |      |      |     | M      |      |      |      |     |   | M |
| Pyrus malus              | apple                 |                                |      |      |      |     |        |      |      |      |     |   |   |
| Quercus sp.              | oak                   |                                |      |      |      |     | H      |      |      |      |     |   |   |
| Ranunculus abortivus     | smallflower buttercup |                                |      |      |      |     | M      |      |      |      |     | M | L |
| Ranunculus parviflorus   | kidneyleaf buttercup  |                                |      |      |      |     |        |      |      |      |     | H | H |
| Rhus copallina           | dwarf sumac           |                                |      |      |      |     |        |      |      |      |     |   |   |
| Rhus glabra              | smooth sumac          |                                |      |      |      |     | M      |      |      |      |     |   |   |
| Rhus radicans            | poison ivy            |                                |      |      |      |     |        |      |      |      |     |   |   |
| Rosa sp.                 | rose                  |                                |      |      |      |     |        |      |      |      |     |   |   |
| Rubus allegheniensis     | sow-teat blackberry   |                                |      |      |      |     |        |      |      |      |     |   |   |
| Rubus hispidus           | dewberry              |                                |      |      |      |     | H      |      |      |      |     |   |   |
| Rudbeckia hirta          | black-eyed susan      |                                |      |      |      |     | M      |      |      |      |     |   |   |
| Rumex obtusifolius       | broadleaf dock        |                                |      |      |      |     |        |      |      |      |     |   |   |
| Sassafras albidum        | white sassafras       |                                |      |      |      |     |        |      |      |      |     |   |   |
| Senecio smallii          | Small's ragwort       |                                |      |      |      |     | L      |      |      |      |     |   |   |
| Setaria sp.              | bristly foxtail       |                                |      |      |      |     | M      |      |      |      |     |   |   |
| Setaria viridis          | green foxtail         |                                |      |      |      |     |        |      |      |      |     |   |   |
| Sida spinosa             | prickly sida          |                                |      |      |      |     |        |      |      |      |     |   |   |
| Silene antirrhina        | sleepy catchfly       |                                |      |      |      |     |        |      |      |      |     |   |   |
| Sisyrinchium albidum     | blue-eyed grass       |                                |      |      |      |     |        |      |      |      |     |   |   |
| Sisymbrium officinale    | hedge mustard         |                                |      |      |      |     |        |      |      |      |     |   |   |



APPENDIX D (continued)

| Botanical name        | Common name          | Time of treatment and material |      |      |      |     |        |      |      |      |     |
|-----------------------|----------------------|--------------------------------|------|------|------|-----|--------|------|------|------|-----|
|                       |                      | Fall                           |      |      |      |     | Spring |      |      |      |     |
|                       |                      | Chl.                           | Mon. | Sim. | Atl. | TCA | Chl.   | Mon. | Sim. | Atl. | TCA |
| Smilax rotundifolia   | common greenbrier    |                                | M    |      |      | H   |        | H    | M    | L    | L   |
| Solanum carolinense   | Carolina horsenettle | H                              | M    |      |      | M   |        | H    | M    | H    | H   |
| Solanum nigrum        | black nightshade     |                                |      |      |      |     |        |      |      | L    |     |
| Solanum sp.           | nightshade           |                                |      |      |      |     |        |      |      |      |     |
| Solidago sp.          | goldenrod            |                                | M    | H    | H    |     |        | L    | M    | H    | H   |
| Sorghum halepense     | Johnsongrass         |                                | M    | H    | H    |     |        | H    | H    |      |     |
| Specularia perfoliata | venus lookingglass   |                                |      |      |      |     |        |      |      |      |     |
| Stellaria media       | common chickweed     | L                              |      |      |      |     |        |      |      |      |     |
| Taraxacum officinale  | dandelion            |                                | M    |      |      |     |        |      | H    |      |     |
| Trifolium campestre   | large hop clover     |                                |      |      |      |     |        |      |      |      |     |
| Trifolium dubium      | clover               |                                |      |      |      |     |        |      |      |      |     |
| Trifolium pratense    | red clover           |                                |      |      |      |     |        |      |      |      |     |
| Trifolium repens      | white clover         |                                |      |      |      |     |        |      |      |      |     |
| Triodia flava         | tall red-top         |                                | M    |      |      |     |        |      | H    | H    | H   |
| Ulmus alata           | winged elm           |                                |      |      |      |     |        |      | H    | H    | L   |
| Ulmus americana       | American elm         |                                |      |      |      |     |        |      |      |      |     |
| Ulmus sp.             | elm                  | L                              |      |      |      |     |        |      |      |      |     |
| Verbascum blattaria   | moth mullein         |                                |      |      |      |     |        |      |      |      |     |
| Verbascum thapsus     | common mullein       | M                              |      |      |      |     |        |      |      |      |     |
| Verbena scabra        | vervain              |                                |      |      |      |     |        |      |      |      |     |
| Verbesina sp.         | crowbeard            |                                |      |      |      |     |        |      |      |      |     |
| Vernonia altissima    | ironweed             |                                |      |      |      |     |        |      |      |      |     |
| Veronica arvensis     | corn speedwell       |                                | H    | L    |      |     |        |      |      |      |     |
| Veronica peregrina    | purslane speedwell   |                                | L    |      |      |     |        |      |      |      |     |
| Vicia grandiflora     | vetch                |                                |      |      |      |     |        |      |      |      |     |
| Vicia sativa          | common vetch         |                                |      |      |      |     |        |      |      |      |     |
| Viola papilionacea    | violet               |                                |      |      |      |     |        |      |      |      |     |
| Vitis sp.             | grape                |                                |      |      |      |     |        |      |      |      |     |



## APPENDIX D (continued)

a/Chl. (Chlorea), Mon. (Monuron), Sim. (Simazine), Atl. (Atalacide), and TCA (Sodium TCA).

b/Letters "L", "M", and "H" refer to low, medium and high rates of application. Where "L" is shown the species was found only at the low rate of application, where "M" is shown the species was found at the medium and low rates, and where "H" is shown, the species was found at all rates. Where no letter is listed the species was not present on that treatment and was either controlled by all rates or had not been present on that plot.