TECHNIQUES INVOLVED IN THE USE OF CHEMICALS IN AN ATTEMPT TO ESTABLISH WILDLIFE CLEARINGS

by

Harold Alfred Trumbo

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INTRODUCTION

The use of chemicals for the control of woody plants joined the parade of "multiple uses of chemicals" shortly after World War II. A great number was tested prior to that period but were not entirely satisfactory because of ineffectiveness, toxic to users, or because of their high cost (Chaiken, 1951:2). With the development of new or combined chemicals that most nearly produced the desired results, a greater interest in herbicides was awakened.

Probably the forerunners in the use of chemicals to control woody plant growth were utility companies and highway departments. The great number of rights-of-way under their supervision necessitated immediate and extensive research programs. Fortunately, these programs and results were carried over into allied fields.

Interest in herbicides developed in forestry because easier and less costly methods of removing weed trees were desired; not only the occasional "wolf" tree but stand improvements as well which occupied many acres. Experiments of significance got underway about 1950. A number of herbicides were tested on a limited scale but most were rejected. Detailed herbicide research had to be conducted with those chemicals which held greatest promise because many problems were encountered. New methods of application were a necessity.

As far as wildlife is concerned, probably the earliest testings of herbicides were detrimental rather than beneficial. Although not toxic, or of low toxicity to the user and most forms of wildlife, a number of herbicides used indescriminately had the potential to destroy wildlife foods and cover. With a growing concern for wildlife food and cover, greater care was exercised in the use of herbicides. It was also recognized that these chemicals could be used as a game management tool; cover and food producing plants could be released, trails and roadsides could be maintained at a lower cost and for extended periods of time and forest openings could be created. It was in this last segment of game management that herbicides seemed to hold greatest new possibilities.

The value to forest game of interspersed forest types is well known and openings in the forest appear to be essential to most wildlife species. Clearings are utilized by animals regardless of the intended purpose or the technique of establishment. It does not appear to matter whether clearings are natural, hand-cleared, bulldozed, established by herbicides, or created through normal forestry operations. Perhaps different clearing establishment practices will continue to be used by land managers because of the desirable results inherent in each.

Aware of the value of forest openings to wildlife species and with the knowledge that herbicides had been successfully used to control woody plants, the Virginia Cooperative Wildlife Research Unit and Department of Plant Pathology and Physiology of Virginia Polytechnic Institute proposed a study on the Broad Run Game Management Unit, Craig County, Virginia. This investigation emenated from the cooperative proposal and attempted the following evaluations:

1. The effectiveness of herbicide treatment as a method of establishing wildlife clearings.

2. Comparison of cost of this herbicide method to that of bulldozing and manual labor.

3. Game species utilization of clearings created by use of herbicides.

The study area used was selected because it adjoined an experimental area established to evaluate various methods of habitat manipulation. The present investigation site was incorporated into the entire Broad Run Research Area and assigned compartment E.

Cooperating agencies concerned in the investigation were the Virginia Cooperative Wildlife Research Unit, Department of Biology, Department of Plant Pathology and Physiology, Virginia Commission of Game and Inland Fisheries, Jefferson National Forest and E. I. DuPont de Nemours and Company which supplied part of the herbicides for experimental purposes.

REVIEW OF LITERATURE

The increased demand for forest, range, and agricultural products since World War II has focused greater attention upon ways of making more efficient use of the lands (Goodman and Reid, 1957). In striving for this goal, herbicides have played an important part in eliminating undesirable plant growth or "weed" species. Logically this land management tool developed into a highly controversial issue; new approaches to the use of herbicides in the control of plant growth were required.

Stoeckeler (1951), reported that manpower and money required to control woody growth along telephone rights-of-way were reduced with chemical sprays, according to studies made in 1948 and 1949 on the Nicolet National Forest in northeastern Wisconsin. A big factor in this economy was the increased number of years between maintenance treatments. Kaufman (1948) stated that 2,4 dichlorophenoxyacetic acid (2,4-D) appeared to be an effective herbicide to control most woody plant species after a 50% to 60% cross-section kill was obtained, but more satisfactory methods of application of the chemical were needed. In Kaufman's experiment, as with most others, water was used as a carrier. Southwick (1948) pointed out the advantage of a 2,4-D herbicide spray program in the maintenance of public utility rights-of-way, roadsides, and ditches. A new herbicide, 2,4,5-Trichlorophenoxyacetic acid, (2,4,5-T) was found to be as effective as 2,4-D on some plant species and was likewise effective on species that were resistant to 2,4-D. Experiments were conducted with diesel fuel as a carrier along with applications in different seasons and with different methods of application. Coulter (1951) found that 2,4-D and 2,4,5-T combined and when used as a basal treatment on Osage Orange (Maclura pomifera), produced a good control of that species. Darrow and McCully (1951) experimented with aerial applications of 2,4,5-T on pole-sized to mature Post Oak (Quercus stellata) and Black Jack Oak (Q. marilandicus). Kills of less than 60% on Post Oak and less than 18% on Black Jack Oak were obtained. When the same rates were applied to the same species less than 6 feet in height, a 90% kill was produced.

Not all control tests were successful. Upon discovering new and effective herbicides, experiments concerned with levels of the chemical concentrations had to be conducted to determine the most effective and economical quantities of herbicides to be used. Elwell, Coulter, and Gibson (1951) stated that in tests using low rates of 2,4-D and 2,4,5-T separately and in combinations, an effective control was not obtained but good results were realized at higher and varied levels of concentrations.

Grove (1955) reported that basal spraying was used successfully in the maintenance of a cleared portion of rights-of-way on the Pennsylvania Power and Light Company utility line in central Pennsylvania. The Missouri Department of Highways obtained satisfactory results from the use of herbicides as a replacement for normal practices of mowing and cutting (Bruto, 1950).

At approximately this same time, the effectiveness of the herbicides, 2,4-D and 2,4,5-T, was being tested on mature trees. A large portion of this work was done for forest management purposes where individual tree species were to be removed for unproductiveness, fire hazards, growth competition and/or a combination of these factors. Various methods of eliminating individual stems were tested. Several tests were successful, depending upon the species tested, season used, and the concentration of the herbicides. Chaiken (1951) used herbicides with satisfactory results in removing inferior trees in the management of Loblolly Pine (Pinus Taeda). Carvell (1955) reported that a number of methods utilizing herbicides for controlling weed trees proved successful in West Virginia. This latter investigator found that liquid herbicides could be applied as a foliage spray in spring or summer to low growing specimens or as a basal spray in the dormant season.

In treating larger stems too high to spray, over-lapping cuts were made at a convenient chopping height and a liquid herbicide was applied until the cut overflowed. Solid herbicides such as Ammonium Sulfamate crystals were packed into notches cut at specific intervals around the base of the stems. Arend (1955) stated that from June to October satisfactory results were obtained in most species when a single continuous ax cut was made around the base of a stem and a 1% mixture of 2,4,5-T ester in fuel oil was added to the frill. According to Groth (1957), notch girdling killed most large trees but only about half of the small pole-sized trees; he concluded that White Oak (Q. alba) was the easiest to kill and Black Gum (Nyssa sylvatica) was the most difficult among species with which he worked.

Stump treatment has been recommended as a method of controlling regrowth in some species. Martin (1957) reported that sprouting of small Post Oak could greatly be reduced if a solution of 4 lbs. of Ammonium Sulfamate crystals per gallon of water was applied to freshly cut stumps in the dormant season. He recommended that if cutting is done in summer, one teaspoon of this chemical per inch of diameter should be applied. McQuilkin (1957), in his experiments, effectively killed northern hardwoods by placing 2,4-D and 2,4,5-T in frills.

Aerial applications of herbicides were used to control woody growth on certain rights-of-way, in release of pine seedlings, and in site preparation for planting pines. Ralston (1954) in Michigan, obtained satisfactory results in aerial spraying scrub oaks for the release of Red Pine (P. resinosa). The results showed no apparent effect on the pine. Arend (1955) in lower Michigan found that damage to conifers resulted when the material was applied during the active growing season, but there was no apparent damage after new growth had winter hardened.

Experiments are being conducted on site preparation for planting White Pine (P. strobus) through herbicide aerial applications. Herbicides are being used extensively in the release of pine seedlings, particularly in the South where pines are of greater commercial value than many of the hardwoods which form the overstory canopy. Releases are made by airplane applications and by individual stem releases. These investigations indicate that herbicides have a direct and indirect effect on wildlife, some favorable and others unfavorable. Although 2,4-D and 2,4,5-T herbicides are non-toxic to animals and humans (Krefting, Hansen, and Stenlund, 1956), they can have a detrimental effect on wildlife habitat when used indiscriminately. Many of the "weed" species are of value to wildlife (Goodrum and Vincent, 1956), for example, Martin, Zim, and Nelson, (1951) list 96 species of animals which have been reported using oaks as a source of food.

Various reactions concerning the use of herbicides were to be expected, depending upon the concepts of land use; different groups often expressed conflicting values according to Egler (1957). Grove (1956) was of the opinion that the use of herbicides on rights-of-way concerned not only officials of the utility companies, but everyone interested in the ecological, esthetic, and conservation problems. In some cases policies were outlined for the maintenance of vegetation of rights-of-way, (Goddard, 1955); for example, the United States Forest Service.

It was apparent that herbicides had entered the "chemical control" picture permanently, therefore cooperation and compromises were necessary between the divergent opinion groups. It was recognized by game biologists that approved herbicides could be very useful tools in the management of wildlife, if used properly. Egler (1954) suggested that selective spraying of rights-of-way would provide more hunting areas, if low growing shrubs were left in the center and a higher growth along the edges. Egler also pointed out that the two most common methods of application were summer-foliage blanket spray and a dormant basal spray (1958). Grove (1956) recommended the selective method of application on rights-of-way, where practical, because this method could benefit maintenance of the cleared strip as well as benefit wildlife. Bramble and Byrnes (1958) conducted a study of wildlife use of a power line right-of-way after broadcast and basal spraying methods were used. Where the basal spray was used, only the treated species and vegetation in the immediate area around the stem were killed, low growing shrubs such as huckleberries were unharmed. Using the broadcast method, low growing shrubs were killed along with the unwanted species. Where the broadcast method was used, 10% of the total ground area was covered by living plants, however, this left adequate room for wind disseminated and animal-borne seeds to propogate. Sweet fern (Comptonia peregrina), which is used by deer in winter in Pennsylvania, became abundant in these areas. The use of these treated areas by wildlife varied, depending upon the game species, the season, and weather conditions.

These new herbicides were recognized as a maintenance tool in the wildlife field and the Virginia Commission of Game and Inland Fisheries adopted their use. Phelps (1955) stated that herbicides would permanently control hardwood sprouting on established wildlife clearings; 75% of the sprouts could be killed; the remainder could be removed by power equipment.

In some areas where desired wildlife food plants have decreased due to competition and plant succession, herbicides have been used to stimulate regrowth of the desired species and to control the undesirable. Page (1956) found that in spraying an area lightly stocked with aspen in southern Michigan, the amount of deer browse was about doubled due to resprouting.

Gysel (1957) studied the effects on wildlife food and cover of different methods of releasing pines. In two areas where 2,4,5-T was used in frills and 2,4-D and 2,4,5-T were combined and used as a basal treatment, crowns of the hardwoods were killed and pines responded with stimulated growth. A complete kill of the overstory was not obtained due to the small amount of chemical used, however, there was an increase in the quantity of browse. Pines were released and a great amount of sprouting resulted in areas where the hardwoods were cut or girdled. In the use of aerial applications, the oak overstory was killed and pines were released but there was very little sprouting of the oaks. A good ground cover remained. The use of herbicides to increase food and cover for game was not limited to woody species.

Beck (1957) effectively controlled a solid stand of Phragmites (Phragmites communis) along the Chesapeake and Delaware Canal by the use of 2.2 dichloropropionic acid. Valuable wildlife food plants invaded the treated areas. Due to the invasion of these plants, game species such as quail, dove, and pheasants followed.

This is far from being the end of the "new era" in the chemical control of plant growth. New herbicides are being developed, new methods of application are being tested, and more uses are being discovered for those chemicals which have proven satisfactory. It is through the tireless efforts of research that satisfying results are being realized.

DESCRIPTION OF AREA

Location

The study area lies on North Mountain along the southeastern border of Craig County, Virginia. This mountain forms a boundary between Craig County to the northwest and Roanoke and Botetourt Counties to the southeast. It is north of route U. S. 311, approximately 15 miles southeast of New Castle, Virginia and 30 miles northwest of Roanoke, Virginia.

History

Due to extremely heavy timber cuttings on this area shortly after the turn of the century and to the lack of fire protection, fires were commonplace and sections of the area were frequently burned. It was not until the area came under the jurisdiction of the U. S. Forest Service in 1935 that forest management and fire control measures were imposed. From that time until the present, the number of fires and the acreage burned have been greatly reduced. Forest management practices are helping to restore the Broad Run Research Area to a more productive site.

Geology

Basic Devonian rock in this area was the parent material for Brallier shale on the lower elevations and Chemung shale on the higher slopes. In a large portion of the area these shales are completely exposed or are overlain by only a thin layer of top soil.

Soil

In relation to physiography and the geologic rock formations over which the soils have been developed, the soils of Virginia may be divided into four provinces: Coastal Plains, Piedmont Plateau, Blue Ridge Mountains and the Appalachian Province comprising the Limestone Valleys, Mountains and Plateaus (Virginia Academy of Science, 1950:350). The underlying rocks of the Appalachian Province are shales and sandstone or a combination of the two and usually of the Muskingum, Montevallo and Jefferson series. The topography is steep and the soils are shallow, poorly developed and of low fertility. This is particularly true on slopes having a western or southwestern exposure.

Ecology

The intense timber harvest operations, fires, and thin infertile soils have had a detrimental effect on the vegetation of the area. Due to removal of the woody and herbaceous plants by various causes, the soils became badly eroded. The elevations which vary from 1500 to 3100 feet above sea level indicate the steepness of the ridge, thus much of the area is susceptible to erosion.

The main ridges in the southern Appalachians generally run in a northeast to southwest direction and the secondary ridges, which are perpendicular to the main ridges, in a northwest to southeast direction. The westerly exposures receive the afternoon sun and prevailing westerly winds; they have a thin soil subject to low relative humidity. The easterly slope~ receive the morning sun but not the dry westerly winds, thus have denser vegetation, a thicker soil, and a higher relative humidity. The westerly exposures, with relatively low pH values, support a growth of ericaceous plants (*Kalmia latifolia*, *Vaccinium* spp., *Gaylussacia* spp.). Table mountain pine (*P. pungens*), Virginia pine

(*P. virginiana*), and bear oak (*Q. ilicifolia*) make up the overstory on these dry slopes. The more moist easterly slopes support an overstory of scarlet oak (*Q. coccinea*), white oak (*Q. alba*), chestnut oak (*Q. prinus*), pitch pine (*P. rigida*) and Virginia pine; the understory is mainly dogwood (*Cornus florida*) and witch hazel (*Hamamelis virginiana*).

The ravines, with poorer soils, support an overstory of chestnut oak, scarlet oak, white oak, and hickories (*Carya* spp.). Coves are composed of an overstory of white oak, hickories, white pine (*P. strobus*), yellow poplar (*Liriodendron tulipifera*), and northern red oak (*Q. rubra borealis*). In both ravines and coves the understory is mainly greenbriars (*Smilax* spp.), grapes (*Vitis* spp.), witch hazel, and dogwood. Level areas or flats are generally mesic and support white oak and mixed oaks.

Climate

The nearest weather station is Blacksburg, 20 miles from the study area, which reports a 51-year mean annual precipitation of 42.9 inches and an average temperature of 52.4°F.

PROCEDURES AND TECHNIQUES

Selection of Study Area

The area selected for study consisted of a 1500 acre compartment adjoining the 8,000 acre Broad Run Research Area. The Broad Run Research Area proper is divided into 4 compartments of approximately 2,000 acres each. These compartments were designated as Compartments A, B, C, and D, and were designed to study the effect of forestry (timber harvest and T.S.I.) and wildlife management practices (agricultural clearings and water holes) on indigenous game species. Agricultural type clearings are an important segment of Virginia's forest game management program. The study area selected for the herbicide investigations was incorporated into the Broad Run Study and designated Compartment E (Figure 1). This compartment was ideally located because of its proximity to established agricultural type clearings. This arrangement was designed to permit long range comparisons of the success between chemical and mechanical methods of establishing clearings.

Selection of Proposed Clearing Sites

In order to keep the entire Broad Run investigation as homogeneous in scope as possible, the areas to receive herbicide treatments within Compartment E were selected by the criteria used for locating the agricultural areas in the adjoining compartments. Areas of approximately 1 acre in size appeared to be optimum for wildlife clearings. The scarcity of sites suitable for agricultural development was a limiting factor, thus making it necessary to select some areas smaller than the desired size and others larger. In selecting

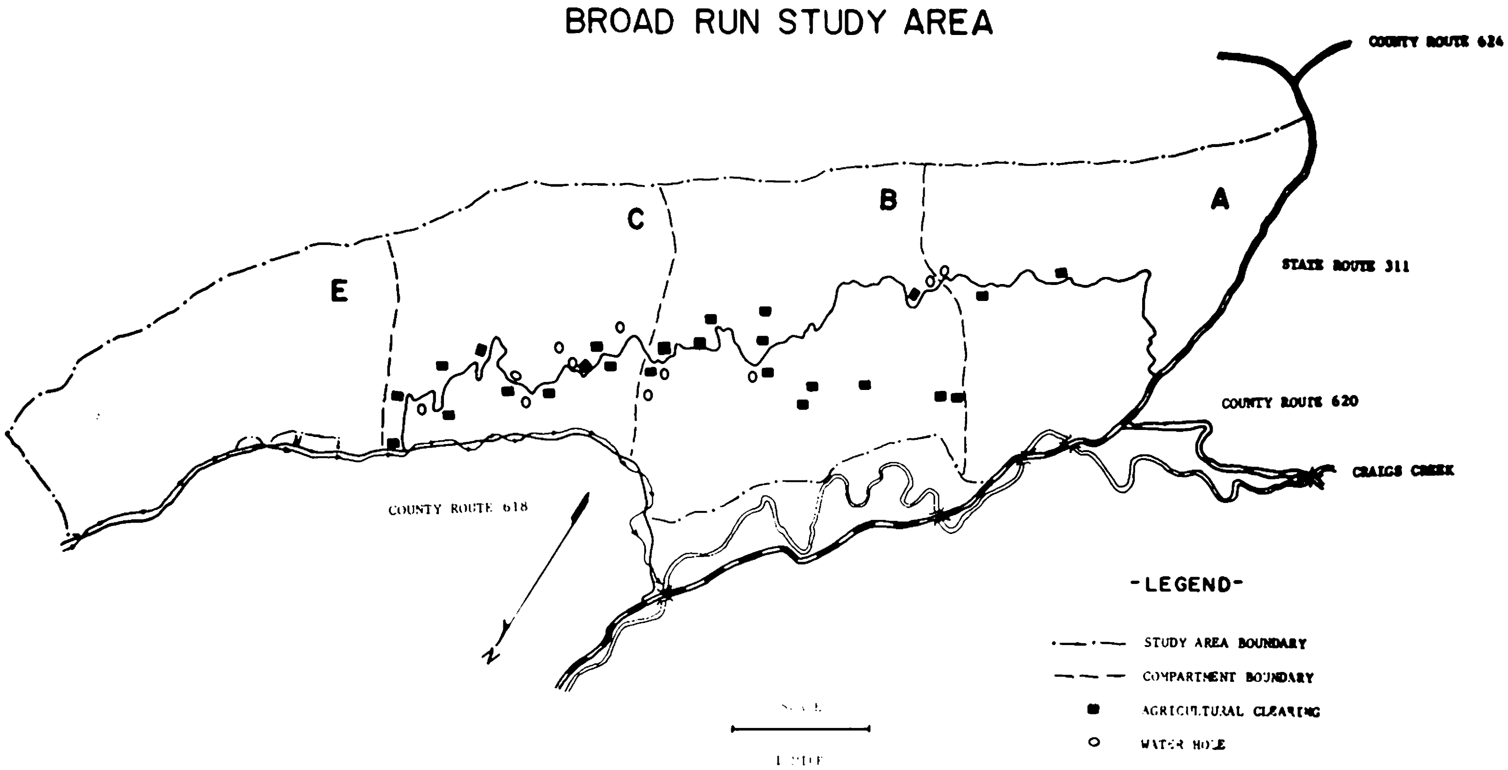

Figure 1. Broad Run Research Area, Craig County, Virginia, Compartment E was selected for herbicide investigation.

areas for treatment, the degree of slope was the first consideration. Due to the ruggedness of the terrain, typical of western Virginia, areas level enough to warrant consideration were first located then other factors were considered, i.e., rockiness, depth of soil, vegetation, exposure, and proximity to areas already selected. An employee of the Virginia Commission of Game and Inland Fisheries who located andestablished the agricultural areas was a member of the group which selected the proposed herbicide treatment sites. Twelve sites were selected but 2 were abandoned; Number 1 because of its size and location and Number 3 because of its potential value as an undisturbed area. A total of 10 areas were used in this study (Figure 2).

Topographical Features

The topography of the selected areas was as varied as that of the entire compartment. The 10 sites chosen ranged from relatively flat areas to ridge tops; some had both features. Area Number 2 lies entirely on a 12% slope with a southern exposure; areas Number 4 and Number 5 lie at opposite ends of a modified ridge; Number 4 has some characteristics of a cove and Number 5 being more exposed, has ridge-top features. Areas Number 6 and Number 9 are located on benches; one has a southwestern exposure and the other has a northeastern exposure. Areas Number 7 and Number 8 are in cove areas with part of Number 8 extending up a ridge of northeast exposure. Areas Number 10 and 11 are located on a ridge; most of Number 10 has a northeastern exposure while Number 11 is entirely on the ridge top. Area Number 12 has relatively little slope; the vegetation on

COMPARTMENT E

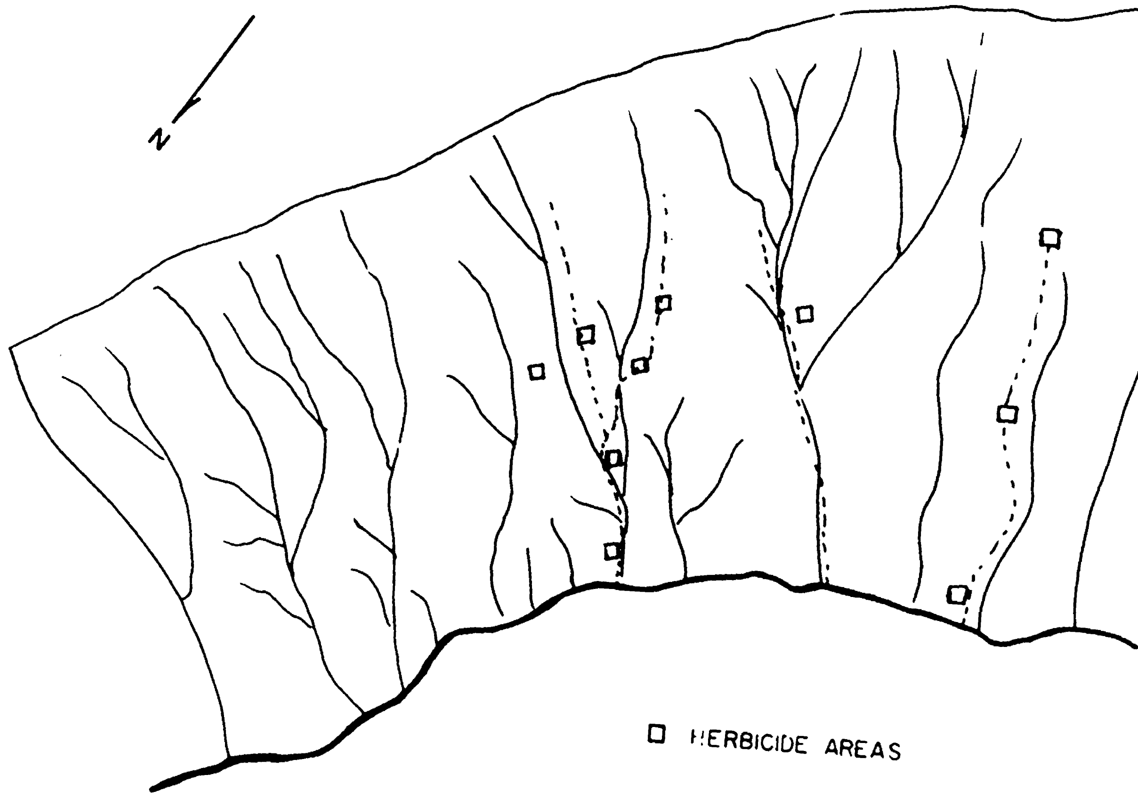

Figure 2. Location of herbicide areas, Broad Run Study Area, Craig County, Virginia

sections of it gives a swampy appearance.

Design of Proposed Clearings for Herbicide Treatments

After the decision was made to test 4 different herbicides, the most practical design appeared to be a square. The proposed treatment sites were checked closely to determine how a square design would best fit into each particular area. A corner was then established by driving a stake into the ground. After taking a bearing by the use of a compass and Jacob's staff, the first side of the square was chained as far as practical and a second corner was established and staked. At this point, a 90 degree angle was turned. The second side of the square was chained to the exact length of the first and at this point a third corner was established. This same procedure continued until the perimeter was established. Each of the 10 areas was divided into 4 equal parts (Fig. 3), thus making it possible to use 4 herbicides in each area; 1 per quarter section. Each herbicide treatment was then replicated 10 times. The 10 investigational areas varied in size from 0.27 to 1.60 acres.

Herbicide Aspect

It was pointed out that one of the primary objectives of the study was to determine whether or not herbicides could be used successfully in creating forest openings which would be beneficial to wildlife. A number of herbicides had been used successfully in various phases of woody plant control and wildlife clearings had been successfully established by various methods, but the investigator could not find literature references on this specific problem.

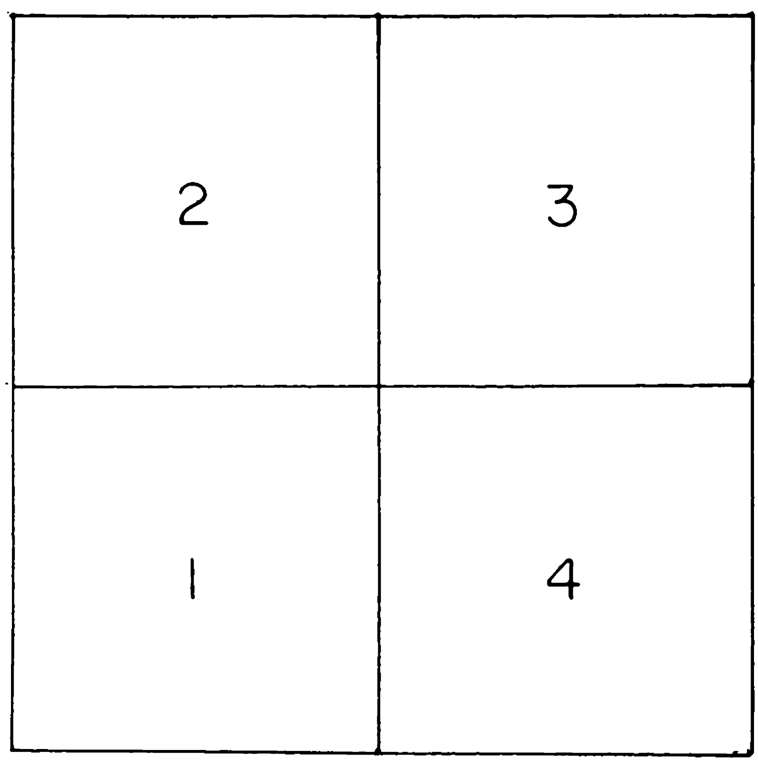

Figure 3. Design of herbicide clearings, Broad Run Research Area, Craig County, Virginia.

Selection of Herbicides

Two of the 4 herbicides, 2,4,5-T ester and ammonium sulfamate were selected because they had been used with success in the control of most woody species under certain conditions and applications and were being used extensively in various industries. Also, they could be transported to remote areas with little difficulty.

Fenuron in clay pellets and Monuron on a vermiculite carrier were selected because they had shown promise in results obtained from experiments conducted at V. P. I. (Chappell, *pers. comm.*). These herbicides could also be easily transported into areas inaccessible to vehicles.

The herbicide to be applied to a particular quarter-section on each proposed clearing was randomly selected. The quarter-sections of each proposed clearing were numbered consecutively, beginning at the lower left corner of the design. Numbers 1 through 4, representing the four herbicides to be used, were placed in a box. The first number drawn represented the herbicide to be used on quarter-section Number 1. Thus, a herbicide was selected for each quarter-section. This was done for each of the 10 proposed clearings.

Application Methods and Equipment

2,4,5-T and Ammonium Sulfamate. After it was decided that the stems on the selected areas would not be cut, the most practical and uniform method of treating with 2,4,5-T and ammonium sulfamate appeared to be by frilling the stems and placing the herbicides into these frills.

For 1 day, 7 men assisted in this work, 4 frilling the stems and 3 applying the herbicides. For the remainder of the time a crew of 5 men did the work; 3 making the frills and 2 applying the herbicides. All frills were made by a downward ax cut at a convenient chopping height, approximately waist high.

In quarter-sections selected to receive 2,4,5-T, ax cuts were made at 4-inch intervals around stems with a d.b.h. of 4-inches and larger. Stems with a d.b.h. of 1- to 4-inches were cut on two opposing sides. Then 2,4,5-T mixed with No. 2 diesel fuel at a concentration of 12-lbs. acid equivalent per 100-gals. of oil, was applied to these ax cuts by the use of 2-gallon garden sprayers with a spray nozzle. Ax cuts were filled to overflowing. The foliage of stems less than 1-inch d.b.h. and shrubs were blanket-sprayed (to dripping) with the same mixture.

The frill design was different for the ammonium sulfamate treatments in that the ax cuts were overlapping. A solution consisting of 7-lbs. of ammonium sulfamate crystals dissolved in 2-gals. of water was applied to the ax cuts by the same technique and sprayers used in the 2,4,5-T treatment. Shrubs and tree species under 1-inch d.b.h. were not treated. The garden sprayers were washed thoroughly after each treatment.

The supply of herbicides, oil, water, and equipment was hauled on a 4-wheel drive Jeep pick-up. This made it possible to haul the materials beyond the limits of a conventional vehicle; in some cases vehicular travel was possible to the treatment sites.

Monruon and Fenuron. These two herbicides (Fenuron 25% active; Monuron 40% active) were applied at a rate 5- and 10-grams of active ingredient per stem; stems 0 to 5.0 inches d.b.h. received 5-grams and those above 5-inches received 10-grams. After 5 and 10-gram amounts had been determined, measuring cups were marked, showing these two quantities. Buckets having a 2-gallon capacity were used to carry the herbicides during treatments. These were also marked to exact levels indicating a definite number of pounds. A record was maintained of the number of pounds applied to each quarter-section. In making the application, the measuring cups were filled to the desired level, then the contents were scattered around the base of the stem, approximately 6-inches from the stem. Stems arranged in clumps were treated as single stems. A gague to determine the amount of chemical to be applied was constructed from a 4-inch wide board cut into sections 7-inches long, with notches 5-inches wide cut into one side. These gagues were used to determine whether a stem should receive a 5 or 10-gram treatment. As the treatment progressed, the gagues were used less frequently with experience in diameter estimation.

The herbicides were transported as close as possible to the treatment area in vehicles, then carried the rest of the way in back packs. After several sections had been treated, a close estimation would reveal the amount needed on the next area.

Seasons

Most of the literature reviewed revealed that best results from frill treatments were obtained in late summer and/or early fall, prior to the dormant season. Treatments of 2,4,5-T and ammonium sulfamate by this method were begun and were completed in the month of August, 1958.

Monuron had been tested in fall, winter, and summer months. Although good results were obtained by applying this chemical in October and December, the summer season was selected since weather conditions and commitments prevented an earlier application (Chappell, pers. comm.). The first application was made June 9, 1958 and the final one August 6, 1958.

Vegetative Counts

Total woody vegetation counts, by species, were made on all the tested areas. The first count was to determine the number of stems treated and a second to obtain the number of treated stems that survived.

Counts were made on sample plots in each quarter-section of 4 representative proposed clearings. All vegetative species in these plots were counted.

Entire Clearings

Stem counts were made on each quarter-section of each clearing site. The first count was made in the fall of 1958, following the applications of herbicides. This count was made to obtain the number of living stems on each area. Before the count began, a clothesline cord was stretched across the treated area, dividing the section into narrow strips in order to facilitate counting. The width of these strips depended upon the density of the vegetation. The person making the count walked through each strip calling out to a recorder the species and number of each in 0 to 4.9-inch and 5.0-inch and larger d.b.h. categories. The total number of living stems, by species, was recorded for each quarter-section of each treatment site.

The second count was made in the late summer of 1959 after one complete growing season. This count was made to determine the number of stems uneffected or recovering from each respective herbicide treatment. These counts were conducted in the same manner as the original; the cord was again used to bisect each area.

On the Monuron and Fenuron treated areas the stem count was classed into two categories; stems showing resurgance above the ground and those sprouting at the foot collar. Although the treatments were made on the basis of stem size (0 to 4.9-inch and 5.0 plus inches d.b.h.), the count was not made on the same basis. Pre-count examination of the areas indicated there were no apparent differences between the effectiveness of the 5-gram and 10-gram treatments.

In areas treated with ammonium sulfamate, a majority of the crowns appeared to be dead, therefore the count was categoried according to the number of living stems, and those that were dead but were sprouting at ground level.

The technique of spacing axe cuts used in the application of 2,4,5-T appeared to be ineffective; few stems were killed. The number of dead stems was counted and recorded instead of living stems. The foliage-basal treatment of 2,4,5-T to stems under 1-inch d.b.h. looked promising and in that count, the number of living stems was recorded.

<u>One-hundredth Acre Sample Plots</u>

Permanent 1/100-acre vegetative sample plots (11.7' radius) were established in 4 of the clearings as a means of studying vegetative changes which resulted from use of the herbicides. These clearings were selected on the basis of topographical features: ridge top, slope, ridge top + slope and cove. Two of these 1/100-acre circular plots were established in each quarter-section of the selected clearings. After the center of the clearing was located, 40' measurements were taken diagonally toward the center of each quarter-section at which point treated stakes were driven into the ground. This established the center of the four sample plots. These were assigned plot Number 1 for each quarter-section. Forty foot measurements were then made from each corner of the clearing diagonally toward the center. Treated stakes were driven into the ground at these points; thus establishing the center of sample plots Number 2 in each quarter-section (Figure 4).

The first vegetative count was made in December 1958. All stems, woody and herbaceous, were counted. This was done by using a rope 23.4' long and placing the middle of it on the stake in the center of the plot. The two sections (11.7') were then extended to their maximum length away from the stake, forming a wedge. The distance between these two ropes depended upon the vegetation density, the amount that could readily be counted. When the stems within the wedge were counted, one rope was left in place and the other crossed over, forming a new wedge. This was done until the entire circle was completed. A second count was made in the winter of 1960.

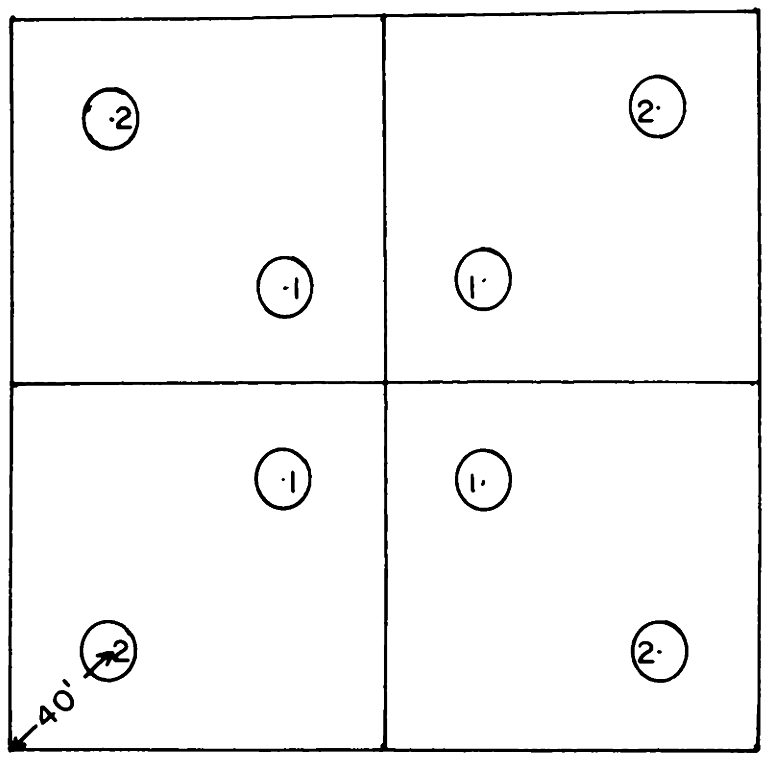

Figure 4. Herbaceous vegetation sample plots, 1/100 acre, installed mechanically in 4 herbicide test areas, Broad Run Research Area, Craig County, Virginia.

RESULTS

Effects of Herbicides on Major Tree Species

In the results obtained from the herbicide applications, a considerable difference was noted between the effectiveness of each herbicide on major tree species. This was not entirely due to the properties of each respective herbicide but was also related to the application techniques involved in some treatments. However, it was clearly indicated that some herbicides were more effective than others. Reports indicate that 2,4,5-T has been used successfully in other fields to control numerous woody plant species but in this study the results of 2,4,5-T were unsatisfactory. Undoubtedly this was due to the technique employed of spacing ax cuts around the stem. Ammonium sulfamate used in frills completely opened the canopy but the sprout growth from root collars was very pronounced. Had the application been made closer to the ground, a more complete kill would no doubt have resulted.

There appeared to be little difference between the results obtained from the Monuron and Fenuron treatments; both were very effective. Fenuron showed quicker action. It was observed on June 27, 12 days after application, that a "browning" condition had taken place on Fenuron treated areas. The following summer there was no resurgence of stems, only root sprouting by some species. The reverse of this action was noted on Monuron treated areas. A "browning" condition was first observed July 30, 55 days after the first application. There was a considerable amount of leaf resurgence the summer following application but the leaves were abnormal in size and shape. In a Bath County, Virginia experiment, treated stems showed a resurging-dying tendency 2 and 3 years after treatment. Table 1 shows the acreage per quarter-section and the amount of herbicide used in each quarter-section application.

Red Maple (Acer rubrum), Sourwood (Oxydendrum arboreum), Sassafras (Sassafras albidum) and Black Gum (Nyssa sylvatica) exhibited the greatest resistance to all treatments. Most of the other species were susceptible to Monuron and Fenuron, especially the oaks and pines. The effectiveness of each herbicide treatment on the Broad Run Project is shown in Tables 2 through 5. The results of the 1/100-acre samples are reported in Tables 6 through 9.

Cost Comparisons

Cost comparisons shown in this study are related to the actual work involved in applying the herbicides and the cost of materials used. The amount of time required for preparations and travel from V. P. I. to the work area, which is approximately 50 miles, is not included.

Between Herbicides

Cost figures for herbicide applications varied in amounts from $27.96 to $149.10 per acre as shown in Table 10. In the application of liquids, 2,4,5-T and ammonium sulfamate, the labor cost exceeded or nearly equaled the cost of the chemicals, while in the granular herbicides, Fenuron and Monuron, the cehmicals were by far the greater cost.

As was pointed out previously, the cost figures were based on the essential materials and the amount of time required for application.

Table 1. Acreage per clearing and amount of herbicides applied per quarter clearing, Broad Run Wildlife Research Area, Craig County, Virginia

Clearing Number	Acreage cl.	Acreage qr.	Total amount herbicides/quarter clearing 2,4,5-T 12#/100 gal.	Ammonium sulfamate 3.5#/gal.	Fenuron 25%*	Monuron 40%*
2	0.63	.16	3.0	2.5	12	3.5
4	1.60	.40	7.0	9.0	36	13.5
5	1.09	.27	3.5	3.0	20	12.0
6	0.63	.16	4.0	3.0	12	7.0
7	0.27	.07	1.0	1.0	10	3.5
8	1.09	.27	2.0	1.5	19	21.5
9	0.90	.23	2.5	2.0	44	24.0
10	1.09	.27	6.0	10.0	24	12.0
11	1.09	.27	12.0	10.0	15	7.0
12	1.52	.38	16.5	14.0	36	16.0
Total	9.91	2.48	57.5**	56.0	228	120.0

*Active ingredient
**Includes 1.75 gal. herbicide

Table 2. Effect of Fenuron* on all woody species, on 10 clearings, Broad Run Wildlife Management Area, Craig County, Virginia, June, 1958

Species	Total stems	Survival		Per cent killed
		Root sprouting	Stem resurging	
Red Oak	736	8	12	97
White Oak	471	0	4	99
Chestnut Oak	298	5	16	93
Chestnut	0	0	0	0
Sassafras	62	10	3	79
Black Gum	763	28	110	82
Dogwood	204	7	38	78
Black Locust	3	0	0	100
Red Maple	1621	73	223	82
Hickory	71	0	11	85
Pine	194	0	0	100
Yellow Poplar	0	0	0	0
Hawthorn	4	0	0	100
Serviceberry	125	2	16	86
Sourwood	289	62	32	66
Witchazel	440	27	63	80
Total	5280	222	528	86

*5 grams/stem up to 5" d.b.h.; 10 grams/stem 5" d.b.h. and above

Table 3. Effect of Monuron* on all woody species on 10 clearings, Broad Run Wildlife Management Area, Craig County, Virginia, June, 1958

Species	Total stems	Survival Root sprouting	Survival Stem resurging	Per cent killed
Red Oak	802	16	62	90
White Oak	361	2	54	90
Chestnut Oak	217	1	19	91
Chestnut	6	0	0	100
Sassafras	66	3	28	54
Black Gum	736	12	282	60
Dogwood	264	1	24	91
Black Locust	71	0	15	79
Red Maple	1354	40	500	63
Hickory	80	1	25	67
Pine	302	0	4	99
Yellow Poplar	0	0	0	0
Hawthorn	0	0	0	0
Serviceberry	167	6	102	35
Sourwood	277	14	144	43
Witchhazel	927	47	386	53
Total	5630	143	1645	68

*5 grams/stem up to 5" d.b.h.; 10 grams/stem 5" d.b.h. and above

Table 4. Effect of 2,4,5-T* on frills and basal-foliage treatments on all woody species on 10 clearings, Broad Run Wildlife Management Area, Craig County, Virginia, August, 1958

Species	Frilled Total stems	Frilled No. dead stems d.b.h. 1" and up	Frilled Per cent killed	Basal-foliage spray Total stems	Basal-foliage spray Stems killed	Basal-foliage spray Per cent killed
Red Oak	777	22	3	1284	1204	94
White Oak	430	11	3	36	35	97
Chestnut Oak	243	9	4	85	83	98
Chestnut	0	0	0	11	11	100
Sassafras	56	18	32**	657	653	97
Black Gum	651	116	18**	409	287	30
Dogwood	203	35	17**	36	32	89
Black Locust	6	0	0	4	4	100
Red Maple	1160	203	17**	443	403	91
Hickory	61	3	5	24	23	96
Pine	205	12	6	7	6	86
Yellow Poplar	0	0	0	0	0	0
Hawthorne	0	0	0	1	1	100
Serviceberry	155	88	62**	60	50	83
Sourwood	192	8	4	18	16	89
Witchhazel	412	198	38**	538	492	91
Total	4551	723	15	3613	3300	91

*12 lbs./100 gal. No. 2 diesel fuel.
**A number of these stems were small and ax cuts may have caused crown kill.

Table 5. Effect of ammonium sulfamate* in frills on all woody species on 10 clearings, Broad Run Wildlife Management Area, Craig County, Virginia, August, 1958

Species	Total stems	Stems crown-killed	Per cent crown-killed	No. crown-killed stems resprouting	Per cent stems resprouting
Red Oak	839	749	89	658	88
White Oak	460	433	94	314	72
Chestnut Oak	169	151	89	134	89
Chestnut	1	1	100	1	100
Sassafras	32	28	88	10	36
Black Gum	575	553	96	318	56
Dogwood	192	174	91	73	43
Black Locust	8	8	100	6	75
Red Maple	1779	1511	85	1126	75
Hickory	60	49	82	10	20
Pine	239	201	84	1	5
Yellow Poplar	0	0	0	0	0
Hawthorn	0	0	0	0	0
Serviceberry	117	98	84	62	63
Sourwood	334	292	87	235	80
Witchhazel	393	385	98	92	24
Total	5198	4633	89	3040	66

*Applied at a rate of 7 lbs./2 gal. water.

Table 6. Average number of stems by species on 2 sample plots (1/100 acre) from 4 clearings treated with Fenuron. Each clearing was selected to represent one of 4 topographical features, Broad Run Research Area, Craig County, Virginia

Species	Ridge top		Slope		Ridge top + slope		Cove	
	No. stems at treatment	No. stems after one year	No. stems at treatment	No. stems after one year	No. stems at treatment	No. stems after one year	No. stems at treatment	No. stems after one year
Cinquefoil	0	0	0	4	0	0	0	0
Smilax	1	0	8	11	7	10	2	5
Teaberry	36	176	13	53	106	147	45	117
Pipsissewa	0	0	11	5	0	0	0	0
Huckleberry	137	252	374	454	30	49	25	114
Mt. Laurel	78	80	0	0	2	7	17	28
Azalea	0	0	0	0	4	11	0	0
Arbutus	1	10	0	0	12	20	7	19
Ferns	1	12	0	0	0	0	0	6
Grapes	0	0	0	0	1	0	0	2
Galax	0	0	3	4	225	266	115	234
Total	252	530	408	530	386	508	210	524

Table 7. Average number of stems by species on 2 sample plots (1/100 acre) from 4 clearings treated with Monuron. Each clearing was selected to represent one of 4 topographical features, Broad Run Research Area, Craig County, Virginia

Species	Ridge top		Slope		Ridge top + slope		Cove	
	No. stems at treatment	No. stems after one year	No. stems at treatment	No. stems after one year	No. stems at treatment	No. stems after one year	No. stems at treatment	No. stems after one year
Cinquefoil	0	0	1	0	0	0	0	0
Smilax	1	3	11	18	3	4	4	7
Teaberry	114	316	63	121	151	249	39	107
Pipsissewa	0	0	15	11	0	0	0	0
Huckleberry	346	410	118	276	184	324	301	415
Mt. Laurel	124	119	0	0	64	53	61	60
Azalea	0	0	0	0	7	21	17	18
Arbutus	0	0	0	0	19	37	22	28
Ferns	0	8	1	6	0	0	2	8
Grapes	0	0	2	2	0	3	0	0
Galax	0	0	0	0	0	0	16	31
Total	584	854	209	433	441	694	455	673

Table 8. Average number of stems by species on 2 sample plots (1/100 acre) from 4 clearings treated with 2,4,5-T. Each clearing was selected to represent one of 4 topographical features, Broad Run Research Area, Craig County, Virginia

Species	Ridge top		Slope		Ridge top + slope		Cove	
	No. stems at treatment	No. stems after one year	No. stems at treatment	No. stems after one year	No. stems at treatment	No. stems after one year	No. stems at treatment	No. stems after one year
Cinquefoil	1	0	0	0	0	0	0	0
Smilax	0	18	8	7	5	6	3	3
Teaberry	46	0	14	31	61	94	0	0
Pipsissewa	0	0	4	4	1	0	0	0
Huckleberry	423	607	317	428	119	126	47	72
Mt. Laurel	115	50	0	0	34	28	2	5
Azalea	0	0	0	0	0	0	0	0
Arbutus	0	7	0	0	33	49	0	0
Ferns	3	7	2	2	0	0	0	0
Grapes	0	0	2	2	0	0	0	0
Galax	0	0	0	0	33	30	38	41
Total	546	729	347	473	284	337	89	120

Table 9. Average number of stems by species on 2 sample plots (1/100 acre) from 4 clearings treated with ammonium sulfamate. Each clearing was selected to represent one of 4 topographical features, Broad Run Research Area, Craig County, Virginia

Species	Ridge top		Slope		Ridge top + slope		Cove	
	No. stems at treatment	No. stems after one year	No. stems at treatment	No. stems after one year	No. stems at treatment	No. stems after one year	No. stems at treatment	No. stems after one year
Cinquefoil	2	4	0	0	0	0	0	0
Smilax	8	9	2	0	4	5	3	6
Teaberry	101	190	10	55	327	249	149	211
Pipsissewa	17	26	1	1	0	0	0	0
Huckleberry	120	203	208	363	89	85	74	103
Mt. Laurel	1	2	65	59	39	49	2	3
Azalea	0	0	0	0	6	10	0	0
Arbutus	0	0	0	0	3	22	0	0
Ferns	0	0	0	1	0	0	0	2
Grapes	0	0	0	0	0	0	0	0
Galax	0	0	0	0	0	18	0	0
Total	248	433	385	378	467	487	227	323

Table 10. Average cost per acre for treating 10 proposed wildlife clearings with Fenuron, Monuron, 2,4,5-T, and ammonium sulfamate, Broad Run Research Area, Craig County, Virginia, June, July, August, 1958

Herbicide	Chemicals						Labor		Total cost
	Lbs./acre	Cost/lb.	Gals./acre		Cost/gal.				
			Chem.	oil	Chem.	oil	Hours	Cost*	
Fenuron	$92.00	$1.50	--	--	--	--	11.1	$11.10	$149.10
Monuron	$48.40	$1.50	--	--	--	--	10.3	$10.30	$ 82.90
2,4,5-T	--	--	$0.71	$22.48	$10.30	$0.18	16.6	$16.60	$ 27.96
Ammonium sulfamate	$79.03**	$0.32	--	--	--	--	17.2	$17.20	$ 42.49

*Hourly wage rate $1.00
**Chemical dissolved in water; 3.5 lbs./gal.

Had the time required for application preparation been considered in the 2,4,5-T and ammonium sulfamate treatments, the total cost for these two chemicals would have probably doubled. However, these figures would have been lower or as low as the cost figures for Monuron and Fenuron. A majority of the areas treated were accessible to a 4-wheeled-drive vehicle; the others were within easy walking distance. This was an important factor in making an economical application of the liquid herbicides by the selected techniques.

The fact was indicated in a later experiment that an excessive amount of Fenuron was used on the Broad Run Project. An application of 5 or 10-grams per stem was used in Broad Run while 1-gram per stem proved effective in a subsequent test conducted in Roanoke County, Virginia. An average of 8 grams was applied to each stem in the Broad Run study; had a 1-gram application been made, approximately 11.5 pounds of Fenuron per acre would have been applied at a per acre chemical cost of $17.25 as compared to the actual cost of $138.00. With labor cost included, the total per acre cost would have been $28.35 instead of $149.10.

Monuron also was applied at a rate of 5 or 10-grams per stem. There was no apparent difference in the effectiveness of these two rates of application. Again assuming that an average of 8 grams were applied to each stem, and that 5 grams would have been sufficient, the chemical cost per acre would have been $45.38 as compared to $72.60, and a total per acre cost (including labor) of $51.81 as compared to the actual cost of $82.90. Treatments of less than 5 grams of Monuron per stem were not made.

Herbicides vs. Bulldozing

Several important factors are considered when agricultural type clearings are to be established by bulldozing: (1) areas suitable to development in relation to slope, fertility, and rockiness; (2) access to the area to be developed; and (3) general location of area. These factors influence the cost of development. Depending upon the operator, the condition of his equipment, and the selected work area, a 1-acre area generally can be cleared of vegetation in 1 day.

In the Broad Run Wildlife Research Area, 24 such clearings were established in 1957 in conjunction with a 9 1/4 mile access road. This was a contracted project, covering both access road and clearing development, at an hourly rate of $9.50.

In consideration of the foregoing statements, the cost of removing the vegetation from a 1-acre area in Broad Run was approximately $90.00. This figure does not include an additional amount of labor necessary to prepare the area for tillage.

In the herbicide areas, only the cost of chemicals and labor are considered as a comparison to the cost of bulldozing (Table 11). All vegetative materials were left standing in these areas treated with herbicides.

Herbicides vs. Hand Clearing

Open areas were not created in the Broad Run Project by hand-clearing methods, or in the adjoining management areas in recent years. As management techniques became more mechanized and deer populations increased, the method of hand-clearing establishment

Table 11. Cost comparisons per acre of the four study herbicides, bulldozing and hand-clearing* used on the Broad Run Research Area, Craig County, Virginia

	Fenuron	Monuron	2,4,5-T	Ammonium sulfamate	Bulldozing	Hand-clearing
Labor**	$ 11.10	$10.30	$16.60	$17.20	--	$32.00
Chemicals	$138.00	$72.60	$ 7.31	$25.29	--	--
Oil	--	--	$ 4.05	--	--	--
Dozer-operator	--	--	--	--	$90.00	--
Total	$149.10***	$82.90	$27.96	$42.49	$90.00****	$32.00

*Hand-clearing was not done on the Broad Run Project but has been done elsewhere as a method of establishing clearings. It is shown here only as a comparison.

**Labor @ $1.00/hr.

***Cost shown is based on 5 and 10 gms/stem. It is shown elsewhere that 1 gm/stem is sufficient to control most woody species. On this basis the cost per acre would be approximately $28.00

****The cost of each bulldozed clearing in the adjoining compartments was about $90.00. This is an approximation because 9 1/4 miles of access road were constructed in the same project. It does not include time spent by resident Game Manager on hand clean-up work necessary to condition areas for tilling.

became less practicable. However, there are some instances where this technique is desirable and worth consideration. One example is in releasing desired tree or shrub species from competing vegetation. It is conceivable that a 1-acre area could be cleared in a 2-day period by 2 men in western Virginia. This, as with other methods, would depend upon the density and size of the vegetation. The cost of this method as compared to herbicides and bulldozing is presented in Table 11.

Incidental Experiments and Results

Additional investigations were made in using Fenuron and Monuron. The results of earlier experiments conducted prior to the Broad Run investigation were used as basic data in determining the 4 herbicides to be used; other pilot studies were conducted at approximately the same time. Each of these supporting experiments revealed valuable information.

Monuron on Right-of-way

In a study conducted on a utility right-of-way in Bath County, Virginia, Monuron was applied to stems and clumps of stems at the rate of 5-grams per stem or per clump of stems (Chappel, *pers. comm.*). Treatments were made in June and October with three replications of each seasonal treatment. Table 12 shows the average per cent of kill for the three replications in each season. The effect of Monuron on some species of oaks and Red Maple was encouraging. Although the percentage of kill was lower on other species, it was favorable enough to warrant further investigation.

Table 12. Monuron* treatment on utility right-of-way, Bath County, Virginia, June and October, 1956

Species	Average of 3 replications					
	June treatment			October treatment		
	Total number stems	Number stems sprouting	Per cent killed	Total number stems	Number stems sprouting	Per cent killed
Red Oak	308	65	79	280	49	82
White Oak	73	0	100	46	3	93
Chestnut Oak	183	55	70	209	73	65
Black Gum	69	25	64	77	55	29
Red Maple	98	8	92	137	7	95
Sourwood	261	119	54	278	220	21
Pine	7	3	57	9	5	45
Other	819	70	91	799	133	83
Total	1818	345	81	1835	545	70

*5 gms./stem or clump of stems.

Clearing Maintenance

A limited amount of work was done on wildlife clearing maintenance. A section of one agricultural type clearing in Bath County, Virginia was treated with Monuron and a foliage spray. A 1/100 acre sample taken in the Monuron treated area indicated a lack of root sprouting (Table 13). Although a number of the plants were still green, growth was inhibited. Herbaceous growth immediately around the stems was killed, however, this constituted a very small portion of the total herbaceous material on the test area. The foliage spray later proved to be ineffective.

It appeared that Monuron could be used effectively in spot treatments for the maintenance of agricultural clearings unless woody vegetation was dense.

Concentration Levels of Fenuron

A field experiment to evaluate different concentration levels of Fenuron was conducted on a tract of State-owned land on Fort Lewis Mountain, Roanoke County, Virginia in June 1958. Two replications of 1, 2, and 4-grams of Fenuron per stem were made on 6 areas each 1-chain square.

The applications were made in the same manner as those on the Broad Run Research Area; the chemical was scattered at the base of the stems. Applications were facilitated since 1-gram of chemical is equal to 1-teaspoon. Plastic measuring spoons of appropriate sizes were used.

Part of this area was burned heavily in October, 1953. Although a number of stems were 4 to 8 inches d.b.h., a majority of the

Table 13. 1/100 acre sample plot in agricultural wildlife clearing, treated with 5 grams Monuron/stem, Bath County, Virginia, December, 1957

Species	Control	Monuron treatment, 5 gms/clump Number stems dead	 Number stems green, no resprouting	 Root resprouting
Red Oak	21	30	28	0
White Oak	37	47	28	0
Sassafras	3	7	0	0
Red Maple	5	0	0	0

vegetation was of low growth form about 5 years old. Except for Buffalo Nut (Pyrularia pubera), the species composition was similar to that on the Broad Run Research Area.

The first observations made, 10 weeks after the initial treatments, showed 11 species defoliated except Table Mountain Pine, this conifer was completely brown. Although the Buffalo Nut had been defoliated, it exhibited a rebudding tendency on the 1-gram treatment areas. A stem count by species was made after treatments. Table 14 shows the range in number of stems on the 1, 2, and 4-gram treatment areas. One plot, located in an unburned section, indicates a lower number of stems.

A second count was made in 1959 after one complete growing season. Tables 15 through 17 show the per cent of kill on each treated area. It is indicated that each successive greater level of concentration exhibited a slightly higher toxicity to a greater number of species.

Table 14. Stem density and rate of application of Fenuron on 1/10 acre plots, Roanoke County, Virginia, June 1958

Treatments	Number stems/plot Plot Number 1	Plot Number 2	Average number stems/acre
1 gm/stem	1006	1008	10,070
2 gm/stem	1002	1312	11,570
4 gm/stem	816	1087	9,520

Table 15. Effect of 1 gram Fenuron on woody species, Roanoke County, Virginia, June, 1958

Species	Replication number 1			Replication number 2		
	Total stems	Stems surviving	Per cent killed	Total stems	Stems surviving	Per cent killed
Red Oak	210	8	96	76	12	82
White Oak	107	4	96	107	8	93
Chestnut Oak	67	1	99	88	14	84
Sassafras	38	0	100	0	0	0
Black Gum	137	17	88	102	5	95
Dogwood	6	0	100	10	6	40
Black Locust	7	0	100	37	1	97
Red Maple	132	26	80	121	47	61
Hickory	4	0	100	69	10	85
Pine	0	0	0	3	0	100
Sourwood	162	96	41	100	80	27
Buffalo Nut	110	41	63	264	140	47
Total	980	193	80	977	323	67

Table 16. Effect of 2 grams Fenuron on woody species, Roanoke County, Virginia, June, 1958

Species	Replication number 1 Total stems	Stems surviving	Per cent killed	Replication number 2 Total stems	Stems surviving	Per cent killed
Red Oak	280	16	94	267	36	87
White Oak	115	7	94	214	1	99
Chestnut Oak	21	2	91	27	0	100
Sassafras	59	2	97	64	0	100
Black Gum	53	18	66	260	3	99
Dogwood	8	0	100	15	0	100
Black Locust	22	2	91	2	0	100
Red Maple	224	43	81	215	7	95
Hickory	0	0	0	12	0	100
Pine	1	0	100	1	0	100
Sourwood	193	58	70	201	78	60
Buffalo Nut	0	0	0	0	0	0
Total	976	148	85	1278	125	90

Table 17. Effect of 4 grams Fenuron on woody species, Roanoke County, Virginia, June, 1958

Species	Replication number 1			Replication number 2		
	Total stems	Stems surviving	Per cent killed	Total stems	Stems surviving	Per cent killed
Red Oak	40	4	90	161	6	96
White Oak	0	0	0	204	3	99
Chestnut Oak	160	9	94	148	4	97
Sassafras	110	2	98	83	6	93
Black Gum	213	30	86	106	16	85
Dogwood	24	0	100	7	0	100
Black Locust	14	1	93	8	0	100
Red Maple	90	2	98	133	20	85
Hickory	3	0	100	6	0	100
Pine	0	0	0	0	0	0
Sourwood	160	24	85	162	30	88
Buffalo Nut	0	0	0	0	0	0
Total	814	72	91	1018	85	92

SUMMARY AND CONCLUSIONS

Compartment E of the Broad Run Research Area was designated as the site to study the cultural and economic feasibility of establishing wildlife clearings through the use of herbicides. This compartment adjoins 3 other experimental compartments established to evaluate the effects of forestry and wildlife management practices on native wildlife populations. Agricultural type clearings and water holes had been established in these 3 compartments, but not in compartment E.

Ten herbicide test sites were selected and stratified for treatment. These areas ranged in size from .27-acres to 1.60-acres. Each area was square and was divided into 4 equal sections.

Four herbicides, Fenuron, Monuron, 2,4,5-T, and Ammonium Sulfamate were selected and applied to each proposed clearing, one per quarter-section.

The amount of herbicides used per quarter-section and per acre, the amount of time required for applications, and the cost of materials were tabulated. A comparison was made between the cost of herbicides, bulldozing, and hand-clearing as methods of establishing forest clearings.

A total stem count was made in each clearing immediately after application. A second count was made after one complete growing season to determine the effectiveness of each herbicide on the major woody species, expressed as per cent kill.

A 1/100-acre sample of herbaceous vegetation was taken in 4 representative clearings immediately after treatment and after one complete growing season.

An incidental experiment was initiated on a tract of State-owned land in Roanoke County, Virginia to determine the effects of varied levels of Fenuron on larger woody species. The levels of herbicide used were 1, 2, and 4-grams per stem or clump of stems. Two replications of each treatment were made on areas 1-chain square. Two woody vegetative counts were made.

Monuron and Fenuron applied at rates of 5 and 10-grams per stem or clumps of stems exhibited a kill of more than 80% on 10 of 14 species treated.

The cost per acre for Monuron and Fenuron treatments at the rate of 5 and 10-grams per stem was $82.90 and $149.10 respectively. It was shown in the Roanoke County study that an application of 1-gram per stem of Fenuron was sufficient to kill most major tree species. The cost for the 1-gram per stem Fenuron treatment was $28.35 per acre.

Ammonium sulfamate and 2,4,5-T in solutions were applied to frills by the use of 2-gallon sprayers. Ammonium sulfamate was applied at a rate of 7 lbs. of crystals per 2 gals. of water and 2,4,5-T at a rate of 12 lbs. (active ingredient) per 100 gals. of No. 2 diesel fuel.

Overlapping ax cuts were used in the ammonium sulfamate treatment while in the 2,4,5-T treatment they were spaced approximately 4 inches apart.

An 89% crown kill was obtained on all woody species in ammonium sulfamate treated areas, however, 66% of all treated stems resprouted.

This treatment was made at a cost of $42.49 per acre.

It is the writer's opinion that frills should be made near the root collar for a more complete kill.

A 15% kill was obtained on all woody species treated with 2,4,5-T. This treatment was made at a cost of $27.96 per acre.

2,4,5-T applied to ax cuts spaced 4 inches apart was not a satisfactory method of killing woody species; a complete frill is recommended.

Fenuron and Monuron were effective agents for killing most of the major tree species. Furthermore, these chemicals are easily transported into inaccessible areas impractical to transport liquid formulations.

Cost figures from the Broad Run Study for Fenuron and Monuron appear to be high, however, an excessive amount was applied to insure a satisfactory kill.

Fenuron proved to be a practical herbicide because of its quick action.

The herbicides 2,4,5-T and ammonium sulfamate have a place in the control of woody plants but techniques other than those used in this study should be employed. Both these herbicides may be useful where soil sterilants such as Fenuron and Monuron may be undesirable.

Herbicides have a definite use in game management in creating forest clearings and maintaining established open areas. Some of the herbicides which have proven practical compare favorably in cost with bulldozing and hand-clearing methods. The desired end result should determine which method is employed; each method has assets and limitations.

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Appendix Table 1. Common and Generic names of woody and herbaceous plants referred to in this study; nomenclature according to Gray's Manual of Botany: eighth edition

Woody plants		Herbaceous plants	
Common name	Scientific name	Common name	Scientific name
Azalea	*Rhododendron* spp.	Arbutus	*Epigaea repens*
Black Gum	*Nyssa sylvatica*	Galax	*Galax aphylla*
Black Locust	*Robinia Pseudo-Acacia*	Phragmites	*Phragmites communis*
Blueberry	*Vaccinium* spp.	Pipsissewa	*Chimaphila maculata*
Buffalo Nut	*Pyrularia pubera*	Sweet-fern	*Comptonia peregrina*
Chestnut	*Castanea dentata*	Teaberry	*Gaultheria procumbens*
Cucumber	*Magnolia acuminata*		
Dogwood	*Cornus florida*		
Grape	*Vitis* spp.		
Hawthorn	*Crataegus* spp.		
Hickory	*Carya* spp.		
Huckleberry	*Gaylussacia* spp.		
Mountain Laurel	*Kalmia latifolia*		

Appendix Table 1. Common and Generic names of woody and herbaceous plants referred to in this study; nomenclature according to Gray's Manual of Botany: eighth edition (continued)

Woody plants		Herbaceous plants	
Common name	Scientific name	Common name	Scientific name
Osage Orange	*Maclura pomifera*		
Oaks	*Quercus*		
Bear	*Q. ilicifolia*		
Black Jack	*Q. marilandica*		
Chestnut	*Q. Prinus L.*		
Northern red	*Q. rubra borealis*		
Post	*Q. stellata*		
Scarlet	*Q. coccinea*		
White	*Q. alba*		
Pines	*Pinus*		
Loblolly	*P. taeda*		
Pitch	*P. rigida*		
Red	*P. resinosa*		

Appendix Table 1. Common and Generic names of woody and herbaceous plants referred to in this study; nomenclature according to Grey's Manual of Botany: eighth edition (continued)

Woody plants		Herbaceous plants	
Common name	Scientific name	Common name	Scientific name
Pines			
Table Mountain	*P. pungens*		
Virginia	*P. virginiana*		
White	*P. strobus*		
Red Maple	*Acer rubrum*		
Sassafras	*Sassafras albidum*		
Serviceberry	*Amelanchier canadensis*		
Smilax	*Smilax* spp.		
Sourwood	*Oxydendrum arboreum*		
Tulip Poplar	*Liriodendron tulipifera*		
Witchhazel	*Hammelis virginiana*		

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ABSTRACT

of

TECHNIQUES INVOLVED IN THE USE OF CHEMICALS
IN AN ATTEMPT TO ESTABLISH WILDLIFE CLEARINGS

by

Harold A. Trumbo

Thesis submitted to the Graduate Faculty of the
Virginia Polytechnic Institute
in candidacy for the degree of
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in
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Major
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Blacksburg, Virginia

ABSTRACT

The main objective of this project was to determine the possibility and feasibility of creating wildlife clearings through the use of herbicides as compared to conventional methods of bulldozing and hand clearing.

The selected study area adjoined a series of 3 compartments designated as the Broad Run Research Area, designed to study various methods of habitat manipulation.

Twelve areas were selected for treatment and numbered consecutively. Two were abandoned; No. 1 because of its small size and No. 3 because of the value in its natural condition. A square clearing design was arranged in each of the remaining 10 areas.

Four herbicides were selected for testing, each proposed clearing was divided into 4 equal sections in order to apply the 4 herbicides to each clearing; one per quarter-section.

The 4 herbicides tested were Monuron, Fenuron, 2,4,5-T, and Ammonium sulfamate. Monuron and Fenuron, in granular form, were applied around the base of each stem at rates of 5 and 10 grams per stem. Stems 0-4.9 inches d.b.h. received 5 grams and stems 5 inches d.b.h. and larger received 10 grams.

Ammonium sulfamate and 2,4,5-T were applied to frills cut at waist height. The ax cuts in the 2,4,5-T treatment were spaced at 4 inch intervals, and in the ammonium sulfamate treatment were continuous and overlapping. These two chemicals were applied by the use of 2 gallon garden sprayers; ammonium sulfamate at a rate of 7 lbs. of crystals dissolved in 2 gallons of water and 2,4,5-T at a

rate of 12 lbs. active ingredient per 100 gals. of No. 2 diesel fuel. Frills were filled to overflowing.

The granular herbicides were applied in June and July 1958 and the frill treatments were made in August of that year.

Two stem counts by species were made on each entire area. The first was made immediately after treatment and the second after one complete growing season. The per cent of kill was computed for each herbicide based on the stem counts.

Herbaceous sample plots 1/100 acre in size, were established in 4 areas representing 4 topographical features. Two stem counts were made on each of these 4 areas.

An incidental field study using 1, 2, and 4-grams of Fenuron per stem revealed that most woody species can be controlled with 1 gram of active ingredient per stem.

Openings were satisfactorily established with Fenuron and Monuron; a lower rate of application could have been used.

Techniques used in frilling would have to be altered to obtain satisfactory results when using 2,4,5-T and ammonium sulfamate; complete frills are necessary for 2,4,5-T treatments and the ax cuts placed closer to the root collar in ammonium sulfamate treatments.

Sight observations revealed the areas were being used by deer, rabbit, grouse, turkey, and wood cock.